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CONTRASTING OIL SECURITY OBJECTIVES WITHIN A GRAND STRATEGIC FRAMEWORK: THE CASE OF THE UNITED STATES AND CHINA

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ABSTRACT OF THE DISSERTATION

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Energy is a critical component of a state's national security and economic considerations, and beginning in the 20th century, this focus has been acutely centered on oil. Having evolved globally, consisting of well-developed financial markets and maritime and pipeline routes traversing the world, the oil market provides massive amounts of crude to countries on a daily basis. However, not all states simply rely on the market for oil security, and instead take additional steps to secure their respective supplies. Oil supply security is a critical driver for large, consuming states, and merits further study. And, in terms of demand on the global supply, and sheer size, there are two giants that stand out, and deserve a closer look: the United States and China.

This research project approaches the task by understanding the grand strategies of both states. Using a grand strategic approach offers key advantages for analysis as both states pursue oil security in a strategic environment, and are forced to account for the various threats to supply, their own capabilities, and their ultimate security objectives.

The methodology used is a comparative, focused case study, in order to draw out differences and similarities between these two large consumers, and as a way of further

illuminating the oil security approaches of both states, this research generates an oil security rating system using weightings derived from a principal components analysis on multiple countries, among several indicators, over a 22-year period.

Ultimately, the aim of this study is to demonstrate in as clear terms as possible, how these states pursue their respective strategies and whether each state may pose a threat to the oil security of the other, now or in the future.

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ABBREVIATIONS AND ACRONYMS

/d	Per Day
/yr	Per Year
A2/AD	Anti-Access and Area Denial
AAR	Availability, Affordability, and Reliability
APAC	Asia-Pacific
ASCI	Argus Sour Crude Index
Bbbl	Billion Barrels
bbl	Barrel
BP	British Petroleum
BTU	British Thermal Units
CCP	Chinese Communist Party
CDB	China Development Bank
CENTCOM	United States Central Command
CNOOC	China National Offshore Oil Corporation
CNP	Comprehensive National Power
CNPC	China National Petroleum Corporation
EBIT	Earnings Before Interest and Taxes
ECI	Economic Complexity Index
EIA	Energy Information Administration
EXIM	Export-Import Bank
GDP	Gross Domestic Product
HDI	Human Development Index

HHI	Herfindahl-Hirschmann Index
IEA	International Energy Agency
IMF	International Monetary Fund
IOC	International Oil Company
LNG	Liquefied Natural Gas
LOOP	Louisiana Offshore Oil Port
Mbbl	Thousand Barrels
MCI	Ministry of Chemical Industry
MMbbl	Million Barrels
MPI	Ministry of Petroleum Industry
MPT	Modern Portfolio Theory
MRBM	Medium Range Ballistic Missile
MTOE	Metric Tons of Oil Equivalent
NATO	North Atlantic Treaty Organization
NOC	National Oil Company
NPC	National People's Congress
NSS	National Security Strategy
OIP	Oil-In-Place
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of the Petroleum Exporting Countries
OSR	Oil Security Rating
PCA	Principal Components Analysis
PLA	People's Liberation Army

PLAN	People's Liberation Army Navy
PRC	People's Republic of China
PSC	Politburo Standing Committee
RDJTF	Rapid Deployment Joint Task Force
ROACE	Return on Average Capital Employed
SINOPEC	China National Petrochemical Corporation
SLOCs	Sea Lines of Communication
Socal	Standard Oil of California
SOE	State-Owned Enterprise
SPR	Strategic Petroleum Reserve
SSN	Nuclear Powered Attack Submarine
SWI	Shannon-Weiner Index
TPEC	Total Primary Energy Consumption
TPES	Total Primary Energy Supply
ULCC	Ultra Large Crude Carrier
UN	United Nations
USAID	United States Agency for International Development
USD	United States Dollar
VLCC	Very Large Crude Carrier
VSTOL	Vertical Short Take-Off and Landing
WTI	West Texas Intermediate
WTO	World Trade Organization

CHAPTER I

INTRODUCTION

Introduction and the Research Question

As is the case with the study of all social phenomena, the future of the oil market is inherently difficult to predict, prone to volatility, and subject to political whim. This makes determining supply, demand, price, and market cyclicality a hazardous proposition even a few years ahead. For over two decades since the end of the Cold War, oil markets have witnessed bouts of business and investment cyclicality, political interruption, and technological change, resulting in sometimes radical shifts in supply, demand, and price. However, during this period, there was largely a broad array of factors and conditions constraining the global supply of energy resources. The combination of expensive, capital-intensive production techniques required for extraction,[1] higher reliance on heavier crudes, and increased demand placed on all sources of primary energy from China, Brazil, India, Eastern Europe and other emerging economies, strained remaining global supplies of energy, and oil in particular, causing a worrisome level of reserve depletion, resulting in higher overall prices and increasing volatility.

As such, this study does not fully account for the recent shale oil and gas revolution that is taking place at the time of this writing in late 2016 and early 2017, since

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[1] For instance, oil sands in Canada and global deep-water production.

the study focuses only up until the end of 2012, and shale only started to become a noticeable source of energy beginning 2010. Over the course of the research timeframe for this study, there were real increases in the supply of crude oil available on the global market, albeit at higher prices, but global reserve growth had slowed and stagnated, and there was substantial concern as to whether there would be enough oil to meet global demand at reasonable prices in the future. This confluence of events culminated in the extremely high price levels witnessed in 2008, when demand increases in the global oil market had even debilitated the ability of Saudi Arabia to play the role of surplus producer and balancer, denying the market a fully effective swing producer. This situation was highly problematic as it reinforced a focus on energy security over the 20-year period, and pressured states to fundamentally reexamine how they perceive and pursue their energy security strategies. Of notable concern, is the way one of the reigning global giants of energy consumption, the United States, adapted and adjusted to the rise of China over this 20-year period. In addition, understanding how China, starting at a distinct strategic and supply disadvantage relative to the United States, has chosen to pursue its energy security strategy, concomitantly with its growing power and global clout, is worthy of examination.

How these two colossal consumers, China and the U.S., pursue their respective strategies for energy security and supply is a highly complex, and multifaceted approach that is ultimately rooted in their respective national grand strategies. And, while the core period of this study takes place before the recent tight oil and gas boom in North America, followed closely by Asian demand stagnation, and the subsequent drop in oil prices since 2014, it still has strong implications for the behavior of both states in their future pursuit of energy supply security. These strategies have not changed as the result of low prices, primarily due to the reality of the oil market as noted in the opening lines of this introduction. There are already warnings regarding medium-term supply constraints,[2] and oil supplies cannot escape long-term demographic trends, increasing global economic growth, and multiple projections of long-term oil demand growth.[3] In addition, market supply and demand remains notably silent regarding the strategic considerations of competing consumers. An uncertain future means the framework developed over this 20-year period is the template moving forward, for both great powers. Understanding each state's pursuit of this strategic commodity can potentially be applied to analyses of other commodities as well. In any case, the shadow of the future looms large.

Competition over energy supplies and secure access, whether under current market conditions or orientation for future conditions, is a sensitive and volatile combination that deeply affects the global economy, especially since energy supplies are generally deemed strategic, vital resources by governmental security establishments. In particular, the key emerging energy relationship between China, a comprehensively

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[2] Andrew Ward, "Saudi Aramco Warns Investment Cuts Risk Long-term Oil Crunch: Crude Producer Says Overall Demand for Fossil Fuels Will Continue to Rise," *Financial Times*, October 11, 2016, https://www.ft.com/content/14ec741a-8f94-11e6-8df8-d3778b55a923 (accessed January 15, 2017); Matt Clinch, "Oil CEO Sees 'Significant' Impact on Capacity in the Coming Years," *Consumer News and Business Channel (CNBC)*, January 20, 2017, http://www.cnbc.com/2017/01/20/oil-ceo-sees-significant-impact-on-capacity-in-the-coming-years.html (accessed January 15, 2017).

[3] A good point of reference is the International Energy Agency's World Energy Outlook for 2016, found here: http://www.iea.org/newsroom/news/2016/november/world-energy-outlook-2016.html.

growing power, and the United States as the preponderant global military, economic, and political power, is consequential and affects the entire international system. Accordingly, the approaches to energy security developed over the 20-year study period will remain and intensify given the emerging security competition between these two states, and it this condition that motivates this research to foment an understanding, through the comparative method and statistical analysis, of the following guiding questions: *how do the United States and China approach the issue of oil security; where have they converged or diverged in certain areas; and whether their respective pursuits have posed a threat to each other's oil security needs. Ultimately, the proposed research aims at gauging if and how their respective approaches created an atmosphere whereby they affect or even prevent each other's energy security. If so, what would this imply for greater management of international life?*

Energy security is a complex topic, normally consisting of domestic and international dimensions. When it comes to foreign policy, the utilization of one's armed forces does seem to play a prominent role since this greatly impacts the physical availability of supplies and affects international markets by reducing threats from hostile forces. For instance, a cursory glance at the historical record and continued U.S. engagement overseas makes a cogent case that U.S. energy security policy has a strong overseas military component.[4] Continued U.S. political involvement and military engagements in the Middle East and persistent dominance of the Sea Lines of

[4] For instance, U.S. guarantees to Saudi Arabia beginning with President Roosevelt, the inception of the Carter Doctrine declaring the Persian Gulf a "vital interest" paired with the establishment of the Rapid Deployment Force (RDF), and continued dominance by the U.S. Navy of the global commons.

Communication (SLOCs), where a significant amount of global oil is transported, would seem to validate this appraisal of the U.S. approach, and would be indicative of the high priority attached to securing energy supplies. However, the approach taken by the United States is much more complex than the mere strategic deployment and application of armed force. Not only are there multiple dimensions to the approach, but the U.S. has even dramatically reduced energy imports from the global energy focal point, the Middle East, begging the following question: why does the United States continue to remain so active in this region?[5] As for China, a typical approach to energy security has been "oil diplomacy" and a series of bilateral deals with resource rich states, many times in the form of equity oil contracts,[6] political relationships, and other economic interdependencies. This coincides with the development of a limited ability to counter aggressive acts in surrounding waters and growing naval assertiveness over what they claim to be their own territorial waters, especially in the South China Sea, a key SLOC. But as with the United States, this misses the complexity and an understanding of key components of the Chinese approach. It does not even begin to engage their approach to security of long-range supply lines in the current environment. These two approaches do, however, demonstrate a more aggressive tone for energy security in the 21st century, but they also miss the broader and more intricate approaches taken by each state, and the various shrewd strategies taken to safeguard their energy supplies. China, for instance,

[5] As will be explained later in the research, this is primarily due to the U.S. stake in not only physical and regional supplies, but in the entire global energy market, which is dependent on Persian Gulf oil.

[6] Joseph Y. S. Cheng, "A Chinese View of China's Energy Security," *Journal of Contemporary China* 17:55, (2008): 297-317.

has clearly elevated the security of energy resources, and energy supply routes, to the highest level of its security considerations. Chinese force procurement and military posture indicates a growing desire to secure the critical sea lanes feeding into the South China Sea, with particular attention paid to the Malacca Straits, where the majority of its imported oil flows. Furthermore, even the highest levels of decision-making in China indicate some emphasis on energy. Amongst the highest-ranking members in the Chinese Communist Party (CCP), where energy related decisions are ultimately made, there is a continual presence of former and active members of the Chinese energy industry. For example, Zhou Yongkang, until recently a member of the Politburo Standing Committee (PSC), the highest organ of power in the party, is a former head of China National Petroleum Corporation (CNPC) from 1996 to 1998, served at the CNPC and the Ministry of the Petroleum Industry in various high ranking capacities from 1985 to 1996, and has been in the oil industry since the late 1960s.[7] In fact, every five years, with the formation of each new Politburo Standing Committee (PSC), there are always one or two members connected to the energy industry in China, whether oil, power, or chemicals.[8] The 18th Central Party Committee, with its new PSC members, has Zhang

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[7] "Zhou Yongkang," *China Vitae*, http://www.chinavitae.com/biography/Zhou_Yongkang (accessed July 5, 2015); Zhou Yongkang has been part of the oil industry for over 40 years beginning in 1961 as a student at the Beijing Petroleum Institute. He held numerous posts over the course of his career including with the Liaohe Oil Exploration Bureau, the Petroleum Administration, Tarim Oil Exploration Campaign Headquarters, the Ministry of Petroleum Industry, and China National Petroleum Corporation. He was involved in politics much of that time before leaving in 1998 to focus solely on politics.

[8] Author survey of Politburo Standing Committee members starting in 1992 with the 14th CPC Central Committee using information from: China Vitae, Reference Library, www.chinavitae.com/library. China Vitae is an excellent broad source on CCP personnel

Gaoli, who spent a great deal of time with SINOPEC and in the broader petrochemicals industry.[9] It is widely suspected that current heads of the respective national oil companies (NOCs) maintain active ties with members of the Politburo Standing Committee (PSC) and utilize it as an avenue for career progression.[10] The companies are deeply connected to top party officials and many see progression in these key state-owned companies (SOEs) as a way to advance their political careers in the CCP.

With similar levels of consumption, and strong oil interests in the Middle East, the possibility of both countries entering into a more conflict prone relationship over energy supplies is a growing concern. How the United States and China have chosen to pursue their energy policies may have a direct impact on the security of one another. The international system has experienced conflict and war over energy resources in the past, and the potential of this occurring for not be underestimated.

Both states had very different starting points and learning processes in terms of energy security in the 20th century. The United States began dealing with energy security after its shift from exporter to importer in the mid-20th century, and as a dominant, global military power post World War Two. China, on the other hand, was a constrained, autarkic, and contained power for much of the century, learning to cope in a world with

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and is affiliated with the Wilson Center's Kissinger Institute on China and the United States.

[9] "Zhang Gaoli," *China Vitae*, http://www.chinavitae.com/biography/Zhang_Gaoli (accessed July 5, 2015): Zhang Gaoli was with SINOPEC from 1970 to 1984, and then Maoming Petrochemical Company from 1984 to 1985, before moving strictly into politics.

[10] Eric Downs and Michal Meidan, Business and Politics in China: The Oil Executive Reshuffle of 2011, *China Security* Issue 19 (2011): 3-21.

the United States as the dominant global power and energy supplies that were increasingly difficult to secure. China retains the same problem through the study period as it attempts to cope with U.S. hegemonic power. The different starting points of both states, as they shift from exporter to importer, and their different geopolitical constraints, have given rise to a diverse set of approaches to energy security; approaches developed by both in accordance with their own specific constraints. Despite the differences, there is also a high degree of similarity between the two in certain aspects, and in many ways, both states may even be converging in their approaches to energy security as they both "learn" and adapt over time. China has also "learned" a great deal about how best to approach energy security during the past decade, and is clearly evolving its approach, in some cases modeling behavior more on U.S. methods, which in this case includes greater reliance on the global marketplace, increasing its military capabilities, and enhancing its political clout. The inherent complexity of the issue of energy security is further convoluted by the dearth of knowledge on the topic and poor understanding of the issue in policy circles, academia, and the media, both in the United States and China. With the U.S., there are constant reports of the need for energy independence, while at the same time decrying China's overseas expansion of its national oil companies (NOCs) as an attempt to "lock up" energy resources to keep from others.[11] On the Chinese side, the issues tend to be those of nationalism, sovereignty, and self-sufficiency as their firms scramble to lay claim to whatever global resources they can.

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[11] Christopher Swann and Wei Gu, "With Oil Deals, Merger Advisors Rejoice," *New York Times*, http://www.nytimes.com/2010/04/15/business/15views.html?dbk&_r=0, (accessed February 23, 2015).

The proposed research will focus on a single primary energy source: oil. This is due to the extreme importance oil has played in the global economy and global politics over the past 150 years, and its direct relationship to foreign relations and politics. The energy story of the United States and China over the past two decades has been one primarily of oil. Additionally, other energy sources will be excluded for the sake of an intensive focus on oil and to keep a manageable analytical scope in this study. However, it should be noted the importance and interconnectedness of the various sources of energy available to a state. What one source a state may lack, can usually be made up with the others, especially in the case of electricity generation. For instance, states that use more coal fired plants, have more petroleum and natural gas to use for transportation and space heating and cooking. Other sources could easily be included in the energy security nexus as well. Renewable sources of energy have the capacity to make a state more self-reliant while satisfying certain environmental objectives. Nuclear power is another source that is directly relatable not just to energy security, but to other security issues such as nuclear proliferation. Without a refined scope, the study would simply be too expansive.

Other reasons for the focus on oil is its place as the key form of primary energy that has been in high demand in both countries and it is the most susceptible to foreign pressure resulting in a direct impact on energy security. Oil plays an incredibly prominent role in both countries. For instance, a brief look at petroleum statistics for 2011 will show the United States consumed 18.9 million barrels per day and imported 8.8 million barrels per day which means approximately 47% of petroleum consumed in the

United States was from overseas sources.[12] With imports that high, a state becomes very susceptible to price and supply volatility. China was in a similar situation in 2011, consuming 9.8 million barrels per day and importing 5.5 million barrels per day, which results in importation of 56% of China's daily consumption.[13] However, the revolution in shale oil and gas will have a profound effect on global energy security, impacting the dependencies of both states on overseas sources of fossil fuels. Recent technological advancements have made it possible to extract vast amounts of fossil fuel resources that have been otherwise commercially unrecoverable. Commercial viability of shale resources has greatly enhanced the available reserves in both states, and added to global supplies. The impact of commercially available shale is just beginning to be felt, and as production increases in the United States, and the technology is diffused globally the effect will be increasing supplies and less dependence by both states on some overseas sources of energy. However, the extent of this impact is relatively weak during the timeframe of the study, and the full future impact remains uncertain.

The timeframe of the research is from 1993 to 2012. In 1993 China became a net importer of oil and marks the beginning of China's necessity to move security of energy supplies to the top of their agenda; energy demand became a larger issue due to rapid economic growth, placing the same constraints on China as those placed on the United States, and these constraints have only grown over time as Chinese dependence on foreign sources of oil has increased.

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[12] *International Energy Statistics, Energy Information Administration*, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm (accessed March 23, 2015).

[13] Ibid.

While not including sources of energy other than oil in this study, it will be important to reference other sources from time to time as their fluctuations possess the capacity to affect oil security. In these cases, it may be necessary to understand oil security in a broader energy context. For instance, it is difficult to understand China's domestic energy concerns without a consideration of coal, which has remained of the utmost importance in China, and will continue to be their dominant form of energy for domestic power for several decades. Of the 8.14 billion short tons of coal consumed in the world in 2011, China consumed 3.83 billion short tons, accounting for approximately 47 percent of global demand for coal.[14] This is a staggering amount, and accounts for approximately 70 percent of China's overall energy consumption.[15] Coal imports to China are low, given an abundance of domestic supply and matching production; however, emerging constraints over the last decade will be an important consideration for their internal security and cohesion, as well as for their energy security. China depends heavily on coal for power generation and heating; switching from coal to higher cost alternatives will be difficult, but necessary, and this will place additional strain on other energy imports, including oil.[16] Many coal plants have been built as the result of *ad hoc* policies of the part of the Chinese Communist Party (CCP), some of which have been frantic responses to energy shocks as happened with the severe power supply disruptions that occurred in China in the mid-2000s. Events like this are not quickly forgotten by the

[14] Author's calculations using previously referenced EIA data.

[15] *International Energy Statistics, Energy Information Administration* (accessed March 23, 2015).

[16] Ibid.

leadership, and can impact attitudes and approaches to the security of oil supplies. Other renewable and alternative sources of energy, generally used for power production and transportation may also be mentioned as these sources of energy directly impact overall energy consumption and production, levels of imports and exports, levels of energy efficiency, and in turn, oil production and consumption.

Another Sino-American energy relationship to consider is the emerging business structure of new energy technology development, where emerging technical knowledge is developed and researched in the U.S. and then co-developed and scaled-up in China. This has direct implications not just on energy security and oil consumption, but can be a point of cooperation or a source of friction in the Sino-American relationship. Cooperative development on projects of importance to both states may provide necessary common ground to tackle energy security; however, to some this may look like a transfer of U.S. technology to China, which could result in growing resentment and increased conflict. Both states at times appear myopic in their approach to energy security, focused only on physical products of oil and gas, but both have in recent years made important steps to approach energy security in the same way the Japanese did after the Second World War. When the Japanese lost the military option to secure energy supplies, they instead embarked on a campaign to advance their level of energy technology in all sectors, and made incredible gains in energy efficiency; this approach allowed for the peaceful pursuit of Japanese energy security over the past 60 years. Tracking the development of this approach in the United States and China is a major contributing factor to their levels of oil consumption.

In determining the points of comparison each state takes in their approach to oil security, the full range of issues pertaining to oil supply security will be examined including: energy efficiency, diversity of supply, the reciprocal impact of the international oil companies (IOCs) and national oil companies (NOCs), advancements in technology, and price volatility, among others. Researching key points of oil security, which will be explored in the literature review, will indicate how each state's approaches developed and evolved over time, why they share certain similarities and differences in their approaches, how they impact each other, and greater implications for the international management of global energy supplies, production, transportation, and consumption.

Literature Review

While a more thorough survey of the literature is included in the next chapter, it is important to understand some fundamental aspects of the body of research. The primary focus of this research is to determine Sino-American approaches to oil security, and why these approaches are different or similar despite the comparatively analogous situation of distinctly high consumption and pronounced reliance on foreign supplies. In order to assess the strategies adopted by these two great powers, there needs to be an assessment of not only the literature pertaining to U.S. and Chinese energy policies, but also a closer look at energy security in general and how it fits in the grand strategies of great powers in the international system. This is required since energy acquisition is a core concern for any state, more so for global or systemic players like the U.S. and China. Energy is fundamental to the security and economic well-being of the state. Further understanding each state's grand strategy will help to understand both states' approaches within a broader set of literature pertaining to both grand strategy and international political economy. This is important, since much of the literature addressing U.S. and Chinese energy security uses piecemeal analyses, missing crucial points of their energy security strategies, and usually utilizes narrow definitions. These approaches are faulty, and energy security would be better understood as part of a state's grand strategy. Only at the level of grand strategy can one fully comprehend how states, particularly great powers, fit this crucial aspect of security into their broader strategic approach. By utilizing grand strategy as a theoretical anchor, perspective, or context in this study, one can fully appreciate the political, economic, and security goals that are generally connected to the secure supply of energy resources, particularly oil.

Generally, the literature takes a simplistic approach to energy security and merely categorizes states as either producer or consumer, and then identifies their energy security requirements based on a narrow or broad definition. But, even the broad definitions do not place their arguments as part of a state's grand strategy, which is an important failing, or gap, that the proposed study aims to resolve and to fill satisfactorily. Analyzing U.S. and Chinese approaches under this framework will generate a more robust approach to recognizing their own unique energy security requirements. The approaches taken by each are also highly dependent on the Sino-American relationship itself. The literature treats all international political conditions as similar, certain countries and their respective approaches to energy security as categorically simple (*e.g.*, producer or consumer) and generates assumptions and approaches based on those categories; almost as though speaking of an energy security "black box" where everyone will operate in a typical fashion according to what type of state they are. But, what about the two largest energy consumers in the world, that do not have the same approaches to energy security, and view each other to be in competition for energy resources? According to the literature and the black box approach, their approaches should be similar and predictable. However, they are not similar in many ways and this is due to significant differences in their approaches to their respective grand strategies. The research will fill these holes in the literature by bringing grand strategy into the analysis and recognize that both the United States and China are categorically different from other states in the international system and cannot be treated as "typical cases" in their approaches to energy security. This research will ultimately argue that in important aspects, Chinese and American approaches to energy security are different, and to understand these differences, an understanding of their respective grand strategies must be taken into account. The United States views energy security as part of its broader grand strategy of reliance on economic liberalism, which directly clashes with the Chinese approach that cannot rely heavily on the market due to historical unease and internal politics. These different worldviews generate different grand strategies, and by extension, different views of energy security. When accounting for grand strategy, the approaches taken by each state make far more sense and become very understandable.

Energy security and grand strategy are inextricably linked to one another. Without sufficient energy supplies in the modern era, especially oil supplies, a state is unable to develop economically and cannot field a modern, effective military. Modern society relies on petroleum for cars, delivery trucks, power plants, asphalt, tanks, and fighter planes. These are all vital for a state to function. Without energy powering human activity, there isn't an economy or a military. This is such a fundamental resource, it must be accounted for in the grand strategy of a state and treated as a vital security interest that affects not only the economy, but the short and long-term security of the state as well. This threat is particularly acute for great powers, with systemic or global interests, like the United States and China. Analyzing energy security in the context of the grand strategies of two systemically significant powers with the capacity to affect one another's energy supplies, is a far more fruitful approach for examining energy security beyond the approaches covered in the literature review. Energy transcends all levels of grand strategy, cannot be ignored by any state, and provides the necessary approaches to take in securing energy supplies. The literature, and available models simply do not take grand strategy into account. In qualitative approaches this is done loosely, and the quantitative approaches do not even include military or power measures that would provide a security background.

Methodology

The United States and China are the only two states similar in their levels of consumption and obligation to pursue energy supplies globally. This leaves a very limited number of cases available for examination, resulting in the use of the comparative case study method to conduct this research. A key purpose of this study is to understand the reasoning behind the various approaches and motivations to secure oil supplies by the United States and China. This research will demonstrate that Chinese and U.S.

approaches to energy security are integrally rooted within their grand strategies, and are, thus, the result of their worldviews and relative power in the international system. China and the United States are both categorically different from other states in the international system. Based on their respective national demands, systemic political-economic influence, and central role in managing international life, they have similarly enormous energy requirements. Paradoxically, though, they exhibit some divergent approaches and policies. Accordingly, in-depth comparative case studies and careful process-tracing analyses are the most useful and appropriate methodology in order to understand and explain the reasons behind the similarities and differences in their respective approaches. The preliminary argument of this research is that the U.S. reliance on economic liberalism has been a cornerstone of its greater grand strategy and perceives energy security more in terms of markets and the free flow of supplies. China, on the other hand, cannot rely solely on the marketplace because of its dominance by the U.S. and the West, and it has been forced to find alternative means to secure its supply. As a component of grand strategy, their common and divergent approaches can be clearly explained.

As for the commonality that distinguishes the U.S. and China from most other states, their relatively similar and high levels of energy consumption are massive. The total primary energy consumption of the United States was approximately 95 quadrillion Btu in 2009.[17] In the same year, China's consumption was approximately 90 quadrillion Btu, a 6% percent rise from the previous year.[18] As a matter of perspective, India's

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[17] *International Energy Statistics, Energy Information Administration* (accessed March 23, 2015).

[18] Ibid.

consumption was 22 quadrillion Btu, Japan's was 21 quadrillion Btu, and Russia's was 27 quadrillion Btu. All of Europe (European Union) was 81 quadrillion Btu.[19] Both the U.S. and China face many of the same constraints and threats to their respective supplies, as consumption on that magnitude forces heavy reliance on overseas sources of primary energy, most notably, oil.

The comparative case study method will be used, since these are the only two states in the international system with such high requirements for energy sources, but more specifically, this study will employ something resembling a focused method of comparison given the existence of only two states that fit the parameters for the study. As a result this research will also have aspects of the intensive case study approach given the in-depth of examination for each case, much in a similar fashion to the methodological classic on deterrence by George and Smoke.[20] Each case will be handled by analyzing the various economic, military, and political approaches each state takes to ensure their security over their petroleum sources. This will allow for both similarities to surface, giving way to certain generalizations, as well as differences.[21] The differences will be especially important in this study, since detailing the differing circumstances for each case will allow for a deeper and structured examination into the multifaceted approaches states take to achieve energy security, possibly leading to "contingent

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[19] Ibid.

[20] Alexander L. George and Richard Smoke, *Deterrence in American Foreign Policy: Theory and Practice* (New York: Columbia University Press, 1974), 95-103; Alexander L. George, "Case Studies and Theory Development: The Method of Structured, Focused Comparison," in *Diplomacy: New Approaches in History, Theory and Policy*, ed. Paul G. Lauren, 43-68 (Free Press, 1979).

[21] George and Smoke, *Deterrence in American Foreign Policy: Theory and Practice*, 95.

generalizations."[22] These generalizations will allow a proper "fitting" within grand strategy, and will aid in our understanding of how grand strategy directs the security of energy supplies for larger consuming states.

Furthermore, this research follows a more developed approach to the structured, focused comparison drawn from more recent work on the subject.[23] Each case is drawn from the same class, or type, a well-defined research objective is established, and variables are used of theoretical interest for the purpose of explanation.[24] Standardized, structured questions are then asked reflective of the research objective and theoretical focus appropriate for that objective.[25]

Understanding approaches to energy security can be difficult to approach since it is an interconnected issue that may be linked to many others. Without the ability to approach the issue through experimentation or large-N case studies, a comparative rationale exists to determine common themes of energy security between the two states. These common themes or differences between the two states will contribute towards understanding how and why they approach energy security within their respective grand strategies in the way they do. For instance, great powers, operating in the international state system, are forced to rely more on overseas sources, from insecure countries, along vulnerable trade routes, and as a result rely more heavily on military force as a method to

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[22] Ibid., 96.

[23] Alexander L. George and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences* (Cambridge, MA: MIT Press, 2005), 67-124.

[24] Ibid., 67-69.

[25] Ibid.

ensure secure supply. Engaging these themes can provide useful information to understand how these states secure their supplies and how the modern conception of energy security has evolved over time. These common themes will also tell us typical approaches taken by large energy consuming states in order to secure their energy supplies, validating or discounting some prescribed approaches explored in the literature review. There are inherent limitations in the analysis of single cases, where current energy security generalizations are taken and used to analyze U.S. approaches to energy security and Chinese approaches to energy security individually. This simply does not provide a useful guide or general approach that states may use when their energy requirements are significantly high, at the levels of the U.S. and China. While single case studies "provide interesting insights, they do not by themselves provide clear guidance for generalization to other cases."[26]

Further rationale exists for this approach, as outlined by Lijphart, where he cites Stein Rokkan as writing that for cross-national analyses one typically pursues "macro hypotheses," being the "interrelations of structural elements of total systems," where there are a small number of cases available.[27] This focus on two states leads to the use of the comparative method, and the many similarities shared between the United States and China adds greatly to this reasoning. This case also requires the inherent flexibility

[26] Christopher H. Achen and Duncan Snidal, "Rational Deterrence Theory and Comparative Case Studies," *World Politics* 41:2 (1989): 146.

[27] Arend Lijphart, "Comparative Politics and the Comparative Method," *The American Political Science Review* 65:3 (1971): 682-693.

afforded to the comparative method where explanations of both similarities and differences will be examined.[28]

Despite the similar massive energy requirements of both states, the U.S. and China have in some respects approached energy security in different ways. The American reliance on the market and the Chinese approach of exercising greater control over the entire supply chain are generally byproducts of their grand strategies. Furthermore, the political and military capabilities, and geographic location of each state provide further constraints or enhancements to security. Mentioned above, a key difference between the two has been an almost mercantilist approach by China to ensuring secure sources of energy overseas. For example, the Chinese engagement in overseas equity contracts to supposedly "lock up" energy sources for its sole use, and bilateral deals, has been in direct contrast to the United States' market based approach relying on energy markets and a multilateral approach through the International Energy Agency (IEA) and the Organization for Economic Cooperation and Development (OECD).

The comparative analysis in this research will be conducted by examining the political, military, and economic approaches of both states to energy security, and by accounting for their similarities and differences in a systematic manner, in an attempt to draw out generalizations or contingent generalizations, as mentioned earlier. Specifically, this research will utilize a focused case study approach of multiple variables for both the United States and China, with data derived from several governmental, inter-

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[28] Robert A. Segal, "In Defense of the Comparative Method," *Numen* 48, no. 3 (2001): 339-373.

governmental, and private sector databases. Furthermore, as elaborated below, the United States and China will be rank-ordered, and compared to some other countries, in order to provide a rich comparison. These other states are mostly from Europe, due to data availability and levels of development, but other large consumers are included as well. Several variables will be used, including material military capability involved, access to the sea lines of communication (SLOCs), total primary energy supply (TPES) available to the state, energy demand, efficiency, and the technological capability to extract oil, among others. The features for examination here are not exhaustive, but representative of some of the areas where approaches to security will be similar, and areas that will vary between the two states. In order to complete this focused comparison, an examination will be made of the literature pertaining to the transactions and deals of both states and their energy policies, congressional and government records on the subject, and various business and financial databases for specific industry information.

How Do We Systematically Measure Oil Security?

How do we systematically gauge and measure energy security? While this is an inherently unique proposition for any given state, there are still a great number of overlapping variables that constitute a secure supply of energy for any one country. Just as a state's grand strategy is an inherently tailored blueprint for survival and security, there are certain features that can be measured, especially in great powers that allow us to determine an overall view of the security situation for a given state. But, concepts like security are difficult to quantify, since there does not exist a direct way to measure such unobservable indicators. This is the same for other abstract measures like development, power, or political risk. These measures are unobserved, or indirectly measured, by mathematical modeling of observable, or directly measured, variables. The product indicators derived through this process are generally referred to as "latent" variables. These measurements of such latent variables have always been a challenge, but can be of great importance not just in academia for theory building, but also in business or policy circles where decisions and comparisons must be made to great impact.

It is for this reason, many in academia[29] and government,[30] especially in the European Union,[31] have made attempts at creating a strong model for use in informing broad energy security policy, with some companies utilizing these techniques to inform business decisions.[32] These broader types of latent indicators are prevalent not only in academia and policy circles, but in business and finance as well. Take for instance the corporate or sovereign credit ratings generated by Standard and Poor, Moody's, or Fitch. These are all essentially multiple amalgamated indicators subjectively weighted into a

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[29] Edgard Gnansounou, "Assessing the Energy Vulnerability: Case of Industrialized Countries," *Energy Policy* 36 (2008) 3734-3744.

[30] Gail Cohen, Frederick Joutz, and Prakash Loungani, "Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies," (Working Paper, International Monetary Fund Research Department, 2011); Jessica Jewell, "The IEA Model of Short-term Energy Security (MOSES) Primary Energy Sources and Secondary Fuels," (International Energy Agency 2011).

[31] Anca Costescu Badea, "Energy Security Indicators," (European Commission Joint Research Centre, Institute for Energy Security Unit 2010) http://www.jrc.ec.europa.eu/.

[32] "Oil Security Index," *Quarterly Update*, (Securing America's Energy Future in partnership with Roubini Global Economics 2014).

new latent variable, producing a "rating" or "score" for each corporation or sovereign state.

This is also true in other areas of credit analysis, and especially in the areas of country risk, which rely on mathematical modelling of areas including sovereign, political, and transfer risk. Various banks and consultancies such as the Eurasia Group and the Economist Intelligence Unit generate similar latent variables, published as numerical ratings for individual countries. This is a widely used practice; however, it is always a challenge to decide which variables to use as inputs in these models and then how to give proper weight to the individual variables so as to produce an accurate and robust result, with minimal subjectivity. In these cases, the utilization of a quantitatively derived variable is able to eliminate as much subjectivity as possible. Hence, that is in essence the point of creating latent variables such as these: to generate a less subjective quantitative indicator that can be used to inform theory, business, and policy. It is important to note these indicators are not meant to be used to make definitive decisions on their own, but are meant to be mixed with a qualitative analysis, at least in optimal circumstances. Essentially, they are used to aid decision-making and provide condensed, comparatively less subjective, information to the decision maker, and to quantify the unobservable.

It still remains a difficult process to determine which variables to use as inputs to the model, and then how to weight, or transform, the variables into the final latent variable used for scoring, ranking, and comparison. Much work has been completed on this in the financial industry, especially pertaining to credit risk and many methods have been utilized within the country risk industry. Additionally, although in its nascent stages, this approach has recently been used to generate latent variables for energy security in organizations ranging from the International Energy Agency (IEA) to European Union's Joint Research Center Commission on Energy Security, both mentioned earlier.[33] However, more advanced approaches to generating latent variables for energy security, have emerged in recent years. These new approaches generated in academia are more technically robust, but that is part of their flaw, in that these scholars have spent more time on technical skill, and less on policy and political implications for the inputs. This is simply because many in this new way of research have different backgrounds, and therefore many of these models have not been created with sound policy or political science components, which ultimately weakens many of these same models.

Specific Problems in the Existing Literature

Most scholars that have applied these models to energy security are simply inclined to be from more technically oriented backgrounds. They tend to originate from mathematics, engineering, statistics, or quantitatively oriented energy programs. The statistical advancements made by these scholars and researchers while creating less subjective and more robust final results, are simply not as well versed in the political and

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[33] Jessica Jewell, "The IEA Model of Short-term Energy Security (MOSES) Primary Energy Sources and Secondary Fuels," (International Energy Agency 2011); Anca Costescu Badea, "Energy Security Indicators," (European Commission Joint Research Centre, Institute for Energy Security Unit 2010) http://www.jrc.ec.europa.eu/.

security considerations that ultimately should be included in any analyses of energy security. Or, at certain times, it is also just as important to know when to leave certain variables out owing to weakness or incompleteness. Examples of these flaws will follow in later paragraphs. It is simply important to understand the strength of these academic approaches in the technical advancement of latent variable generation in energy security, contrasted to the weakness of these approaches in understanding some of the fundamental issues vital to energy security from a political science perspective. In a sense, the methods are robust, but the inputs are in many instances, quite faulty.

For instance, some focus only on diversification as in a presentation by Chang and Chen. They argue for diversification as a core principle, and for measuring vulnerability and not just dependence, since the latter is an empty concept not telling much about the structure of imports, whereas the former gives much more information regarding sourcing and the supply chain.[34] This is a useful approach, but ultimately doesn't cover enough of what constitutes energy security. This is common, especially with the sole use of a diversification indicator, modified or otherwise.

This is true even in policy-oriented organizations as well. For instance, the United States Agency for International Development (USAID) has an acute interest in measurable energy security for its global development projects, focusing mainly on independent, formulaic indicators, but simply doesn't cover enough of what is considered energy security, opting instead for a simple, ground up approach, more appropriate for

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[34] Ssu-li Chang and Yen-yin Chen, "The Analysis of Oil Supply Security and Diversification Policy in Taiwan – A Shannon-Weiner Index Approach," National Taipei University Institute of Natural Resource Management.

development work.[35] In large part, diversification measures are based on Modern Portfolio Theory (MPT) in finance, and most variations draw inspiration from this source.[36] However, while diversification is extremely important, it is not the only component to energy, or oil, security. As will be discussed in the following chapter, there are many different issues areas impacting oil security. Everything from domestic production capacity, to energy efficiency, and material power affects oil supply security to state.

Another to use portfolio theory is Wu et al., with the twist that they attempt to build in a new proxy for transport risk, involving a measure of pirate attacks along the typical import vectors for Chinese supply.[37] This is innovative, but still suffers from the issue present with more subjective forms of energy security modeling and lack of variables. Additionally, good data on piracy is not always available.

Another scholar to use a diversification index is Cohen et al., where they simply adjust an Herfindahl-Hirschmann Index (HHI) for political risk and country size (as an

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[35] Prepared by the Center for Energy Economics (The University of Texas at Austin) and PA Government Services Inc. for USAID New Delhi, "USAID Energy Security Quarterly," USAID South Asia Regional Initiative for Energy, USAID SARI/Energy, (January 2008).

[36] Edwin J. Elton, Martin J. Gruber, Stephen J. Brown, and William N. Goetzmann, *Modern Portfolio Theory and Investment Analysis*, 8th ed. (Wiley Publishing, 2009); For a more in-depth look at the relationship between portfolio theory and energy security, consult S. Hayden Lesbirel, "Diversification and Energy Security Risks: The Japanese Case," *Japanese Journal of Political Science* 5, (2004): 9-13.

[37] Gang Wu, Lan-Cui Liu, and Yi-Ming Wei, "Comparison of China's Oil Import Risk: Results Based on Portfolio Theory and A Diversification Index Approach," *Energy Policy* 37, (2009): 3557-3565.

indicator or gross energy demand compared to global energy demand).[38] An important realization in this work is recognizing the difference in uses between two key diversification approaches, the Herfindahl-Hirschmann Index (HHI) and the Shannon-Weiner Index (SWI). Typically preference is given to the HHI, given its focus on the larger contributors, or suppliers, to a specific country, as opposed to the SWI's focus on smaller suppliers.[39]

Several energy or oil security models are based on sole diversification indices, or modified diversification indices, as with Xu et al, where they use a HHI modified with a Gini coefficient and make the interesting argument that a country, in their case China, should focus not only on diversifying current export sources based on annual production, but also on reserve amounts in each exporting country.[40]

Others like Le Coq, have a tighter focus on fossil fuels alone but focus on a modified HHI with inputs like political risk and dependency.[41] Ultimately, much of the focus is on the political risk involved, and not enough on the other variables, distorting the end product. Additionally, as a proxy for the risk of traversing long distances, including both land and water, Le Coq uses a simple measure of distance between the

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[38] Gail Cohen, Frederick Joutz, and Prakash Loungani, "Measuring Energy Security: Trends in the Diversification of Oil and Gas Supplies," Working Paper 11/39 (International Monetary Fund, 2011), https://www.imf.org/external/pubs/ft/wp/2011/wp1139.pdf (accessed March, 25, 2015).

[39] Ibid., 9.

[40] Jian Xu, Jin-Suo Zhang, Qin Yao, and Wei Zhang, "Is It Feasible for China to Optimize Import Source Diversification," *Sustainability* 6 (2014): 8329-8341.

[41] Chloé Le Coq and Elena Paltseva, "Measuring the Security of External Energy Supply in the European Union," *Energy Policy* 37, (2009): 4474-4481.

capitals of the producing and consuming states to indicate risk level.[42] This makes little sense given a short ride through the Strait of Hormuz is far riskier than a long voyage across the Atlantic. The measuring between state capitals is also problematic, given massive distances involved concerning a state's land area, the location of the capital, and the actual ports used to offload supplies. Washington D.C. doesn't do much good as a measure with oil that arrives on the Pacific Coast or shipments that end up in the Louisiana Offshore Oil Port (LOOP) facilities off the coast of Louisiana.

There is, however, a burgeoning trend to utilize multiple variables and conduct the weighting process using a multivariate analysis. This can take several forms, and serves the primary purpose of further reducing the subjectivity of the model. And the clear trend is towards a principal components analysis in addition to the use of a cluster analysis, which categorizes each country based on sensitivity.[43] But, again, one must be certain of the inputs.

For instance, while Gnansounou produces excellent work on the subject, the inclusion of certain measures, like CO2 reduction, simply do not conform to the core security aspect for a country's energy supplies. Furthermore, this work is far too broad, and consists of very few variables for work, given its breadth. Ultimately though,

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[42] Ibid., 4478.

[43] Christos Roupas, Alexandros Flamos and John Psarras, "Comparative Analysis of EU Member Countries Vulnerability in Oil and Gas, Energy Sources," *Part B: Economics, Planning, and Policy* 6:4, (2011): 348-356.

Gnansounou's work is an excellent step for model creation, utilizing a PCA and clustering techniques.[44]

There is one final issue that needs to be resolved. All the above studies, and similar studies not mentioned in the previous passage, conceptually engage in a comparative survey of energy security among multiple states. This means that each of the studies sought to take a large basket of states, one of the most typical being the European Union, and comparing their energy level scores amongst each other, for a single given year. Instead, the approach taken in this research is to generate additional data points based on the input scores given over multiple years, essentially the 20 years covering the study. This is done for two reasons: one, it is the most appropriate approach for this study given that there are only two states in question, the United States and China, and two, this will give a unique look at the long-term energy security trajectory of each state, allowing the research to pinpoint changes in the approach, and to understand how and why these changes took place, at a given point in time. This approach is distinctive since the final product will give a very close look at each state's security of supply over the span of 20 years.

Primary Approach Used in This Study

The primary source and methodology that will be used to generate the annual latent variables in this research is that of Gupta's Oil Vulnerability Index, developed in

[44] Gnansounou, "Assessing the Energy Vulnerability: Case of Industrialized Countries," *Energy Policy*, 3734-3744.

2008. Aside from generating a list of new variables for his index, Gupta utilized a new statistical technique, mentioned in the previous section,[45] for weighting the variables in an attempt to standardize the process and further remove subjectivity from method. As mentioned previously, this has always been a weak point; an area of high subjectivity as it is completely left to the user to determine the best weights attributed to each variable, or each category of variables. Gupta attempts to overcome this by using the statistical approach called Principal Components Analysis, which is an advanced technique used in multivariate statistics, where the variables also tend to be highly correlated, neutering the issues surrounding multi-collinearity, even creating new variables in the process.

This is a factor analysis, dimension reduction technique and not one typically applied in the social sciences. For instance, this technique is one of the primary approaches used in facial recognition software.[46] There are a high number of data points on the human face and ultimately, this data as a whole is reduced and transformed, from a 2-dimensional matrix to a 1-dimensional vector, essentially creating a lesser amount of new variables in the process. The object, however, of this research, as with Gupta's, is not necessarily data reduction and the creation of new "principal component" variables, but to use instead the weightings derived by the technique to determine the relative importance of each input variable. Through this process of dimension reduction, it is

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[45] This is one of the first times this technique was used to measure energy security.

[46] Kyungnam Kim, "Face Recognition using Principal Components Analysis," Department of Computer Science, University of Maryland College Park, http://www.umiacs.umd.edu/~knkim/KG_VISA/PCA/FaceRecog_PCA_Kim.pdf ; Federal Bureau of Investigation, https://www.fbi.gov/about-us/cjis/fingerprints_biometrics/biometric-center-of-excellence/files/face-recognition.pdf

determined mathematically, which input variables account for the highest degree of variance in the entire dataset, entitling them to higher weightings according to their relative importance to the data as a whole. This has been a very successful technique, and started to be used in other areas. It has even been proposed that better-known social science indices, such as the Human Development Index (HDI), utilize the Principal Components Analysis technique to determine the final composite score for each country in the index, which currently takes the geometric mean of the three normalized indicators, life expectancy, education, and income.[47]

Gupta derives his approach from an engineering based, infrastructure study conducted by Nagar and Basu[48] and while using Gupta's research as a primary source for developing the techniques used in this research, several important points were gleaned from Nagar and Basu's other work on human development,[49] given its more direct social science leanings.

Another point of consideration in this research, will be the use of the RStudio application to compute the correlation matrix, eigenvalues, eigenvectors, and ultimately the principal components of the data set. RStudio is a program built on open source R,

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[47] A. L. Nagar and Sudip R. Basu, "Weighting Socio-Economic Indicators of Human Development: A Latent Variable Approach," in *Handbook of Applied Econometrics and Statistical Inference* eds. A. Ullah, Alan T. K. Wan, and Anoop Chaturvedi, (New York: Marcel Dekker, Inc., 2002); United Nations Development Program, Human Development Report 2013, http://hdr.undp.org/sites/default/files/hdr_2013_en_technotes.pdf.

[48] A. L. Nagar and Sudip R. Basu, "Infrastructure development index: an analysis for 17 major Indian states," *Journal of Combinatorics, Information and System Science* 27, (2002): 185–203.

[49] Ullah and Wan, "Weighting," *Handbook of Applied Econometrics and Statistical Inference*.

which is used for statistical programming. Its ease of use, free access, and package flexibility will make results easy to calculate and duplicate. The visuals will also be generated using RStudio.

The Process

Ultimately, the composite variable in this case will be called the Oil Security Rating (OSR), and will be calculated for both the United States and China, individually and for each year, and is broadly represented by the following formula:

$$OSR = \beta_{1k}x_{1k} + \cdots + \beta_{10k}x_{10k} + \varepsilon$$

However, before we can arrive at that final equation, we must go through the process of generating the principal components from our normalized dataset.

The first step in creating the composite indicator is to draw on the raw data required. This presented many difficulties, especially concerning data availability for China, so in some cases proxy variables are more notably present. This is ultimately a linear model, generated using the causal inputs (the individual indicators), in this case represented by x. However, before the model can even begin to utilize the PCA process and determine composite ratings, the application of some light data cleaning and modification for accurate results is required. Inherently, data is quite messy, and making sense of hundreds, thousands, or even millions of data points will be inaccurate without proper cleaning and preparation. For the purposes of this research, it will be necessary to go through and perform data normalization, and in the process, creating re-scaled, range-bound variables for inputs into the model. This is not required for every variable, since several variables are already scaled on a 0 to 1 range; however, variables like the price of oil, where their scales are not range bound, nor an inherent upper limit, some data discipline must be observed. Normalization also more properly informs the scoring system utilized as the end product of this study, where scores will be arranged along a 0 to 100 scale, with one end being the state with a theoretical absence of oil security, and the other, a state with a theoretical completely secure supply of oil. And finally, through the cleaning process, the inputs will be positively correlated with oil security. This simply means all variables will be adjusted so higher values reflect a higher level of oil security. The normalization process is as follows:

$$x_{input} = \frac{x - x_{min}}{x_{max} - x_{min}}$$

The next step in this process is to generate a correlation matrix of the data. This ultimately creates an $n \times n$ matrix determined by the number of indicators, or variables, present. This is the first computational step that allows production of the eigenvalues and eigenvectors needed to compute the appropriate weightings of the data derived from their principal components.

After generation of the correlation matrix, we can then solve for λ in the following determinantal equation:

$$|R - \lambda I| = 0$$

Solving this equation produces roots from a polynomial equation, which ultimately results in the required eigenvalues. These are re-arranged by order of magnitude, and yield “scores” based on not just the values, but also the amount of variability for which each value accounts, as well as the cumulative amount of each value, ultimately ending in 100 with the final value, demonstrating the full scope of data variability. The measures for the eigenvalues and variability will be descending, while the cumulative amounts will be ascending to 100.

Finally, using the derived eigenvalues from the previous table, we can solve the following matrix equation for each λ:

$$\left(R - \lambda_j I\right)E_j' = 0$$

This, in turn, is used to produce the requisite number of eigenvectors corresponding to the same number of eigenvalues produced. Then, the principal components are generated by weighting the variables, or indicators, with their eigenvectors and corresponding eigenvalues using the following equation for each indicator as calculated here:

$$P_{1a} = x_a E_1' \cdots P_{na} x_a E_n'$$

The weightings used to compute the OSR will be determined after using a scree plot, and finding the values above 1, for each component. Relevant components are then used to generate the proper weights for each indicator.

Finally, the composite score is generated by a weighted sum, derived from the principal components calculated above with the formula:

$$OSR_k = \frac{\lambda_1 P_{1a} \ \cdots \ \lambda_n a}{\lambda_1 \cdots \ \lambda_n}$$

Using this final equation, an annual score for both the United States and China can be determined and ultimately compared. To be clear, a mathematical process generates these OSR scores after inputting the variables from the next section, into the linear equation described at the beginning of this section. So, for instance, the value of the first variable, oil intensity, will replace x_{1a} in $\beta_{1a}x_{1a}$ in the above equation, where the x_{1a} represents the variable and the β_{1a} represents the coefficient used for weighting the variables.

But, what variables are included in the equation? The model is only as good as the information included, and considerable effort has gone in to generating useful input. This discussion follows.

The Variables Representing the Observable Components of Energy Security

The full model, as described in the previous section, populated with the observable variables, termed the Oil Security Rating (OSR), generating a final OSR score, will include ten key variables used as inputs. Unless otherwise noted, all data is derived from EIA[50] and IEA[51] databases. The variables used follow.

Oil Intensity:

The first variable is oil intensity, which is a calculation that represents the amount of oil required to produce one unit of economic output. In order to arrive at this figure, we convert oil consumption in the economy to metric tons of oil equivalent (MTOE), and then divide by the country's gross domestic product (GDP) at market exchange rates, in

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[50] *International Energy Statistics, Energy Information Administration* (accessed March 29, 2015).

[51] *Statistics*, *International Energy Agency,* http://www.iea.org/statistics/ (accessed March 26, 2015).

constant 2005 dollars. For ease of access, this research drew from The Shift Project, an independent energy think tank based out of Paris, which draws its data for this figure from the EIA and UN.[52]

Production to Reserves:

This is an annualized ratio that ultimately demonstrates the potential amount of time left, usually indicated in years, to deplete a country's oil reserves at current production levels, and at economically viable levels. This is determined by dividing the reserve amounts by the level of production for the same year, both measured in barrels. The author completed the calculations with the data drawn from the EIA and IEA.

Import Dependence:

This is a frequently used metric for energy security, demonstrating the shortfall of domestic sources of petroleum to domestic consumption. This essentially measures dependence on external, overseas sources of oil, increasing the ratio with higher levels of external dependence. There are essentially two ways to measure this amount, represented by the EIA and IEA. The EIA simply takes net oil imports divided consumption, while the IEA calculates this ratio by taking the difference domestic consumption and domestic production. These allow arrival at nearly the same figures, but this research utilizes the

[52] *Energy Intensity of GDP, The Shift Project Data Portal* (Paris, France: The Shift Project) http://www.tsp-data-portal.org/Energy-Intensity-of-GDP#tspQvChart (accessed March 26, 2015).

EIA approach, simply dividing net imports of petroleum by overall oil consumption in the economy.

Oil in Total Primary Energy Consumption (TPEC):

This looks at energy consumption as a whole throughout the country, cataloging all primary sources, including fossil fuels (petroleum, natural gas, coal), renewables (solar, wind, hydroelectric), and nuclear. This measures all energy utilized in a country in given year, and the variable takes as a ratio the percentage that oil makes up of the whole economy's consumption. Oil consumption is simply divided by the amount of total consumption. This ultimately informs the level of structural dependence on oil as in individual source of energy in the target country. The author completed the calculations.

Oil Price Volatility:

For long-term security and economic interests, stability in the price of oil is essential. This variable is a normalized indicator accounting for the small variation in pricing between the WTI crudes and Dubai crudes, used for pricing exports to the United States and Asia, respectively. This indicator is a proxy for oil price volatility and uses the standard deviations of the previously annualized monthly averages for each type of crude, creating a range bound variable. The author using data drawn from the BP Statistical Database completed these calculations.[53]

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[53] "Statistical Review 2014: Data Workbook," *BP*, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html (accessed July 23, 2015).

Supply Diversity:

Using an approach mentioned heavily in previous sections, to measure the level of supply diversity, meaning the national and geographic level of import concentration for each country, this research will use a modified Herfindahl-Hirschmann Index (HHI). The HHI is in wide use for multiple purposes, however, its most notable use is by the Department of Justice for determining the level of market concentration in a given sector of the economy.[54] Just as in the same way the Department of Justice uses this method to determine which one single firm has gained too much market share and control in a sector or industry, this research uses the measure to determine when too much oil is coming from too few sources, meaning the individual supplier countries. Higher levels of concentration result in negative scores for the indicator. The following formula is used, with variables provided in more detail in Chapter III:

$$HHI = \sum_{a=1}^{n} c_a^2$$

In this formula, a indicates the number of each country from the first to the open ended last, represented by n, and c represents the actual country being analyzed. Each state's share of exports to the country under analysis is squared and added to all other export countries, originally resulting in scores ranging from 0 (the best theoretical score representing a purely competitive, atomized market) to 10,000 (representing a pure

[54] "Herfindahl-Hirschmann Index," *The United States Department of Justice,* https://www.justice.gov/atr/herfindahl-hirschman-index (accessed June 14, 2015).

monopoly). These scores are then rescaled for this research on a 0 to 1 scale and used for the input variables. These calculations were completed by the author using data derived from the United Nations Comtrade Database using HS Commodity Code 2709 (petroleum oils, oils from bituminous minerals, crude).[55]

Consumption to Proved Reserves:

This is a variable used to measure the amount of domestic sources available to the state, based on current pricing and consumption levels, for a given year. This is meant to simulate an extreme scenario and to understand how long a state can survive cut-off from overseas markets, without any decreases in consumption. It is calculated by dividing annual consumption over the overall proved reserves of the state.

Net Oil Imports to GDP:

This indicator tests the overall sensitivity of the economy to oil price and supply shocks. The larger the proportion of oil in the economy, the greater sensitivity the direct economy will have to any shocks. Energy touches all aspects of the economy indirectly, but this measure is meant to gauge the direct impact in terms of pricing to the overall economy. Net oil imports are derived from the EIA database while the GDP figures are at market exchange rate from the International Monetary Fund.[56]

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[55] *United Nations Comtrade Database, United Nations*, (New York: United Nations Statistics Division), http://comtrade.un.org/ (accessed July 17, 2015).

[56] "IMF Data," (New York: International Monetary Fund), http://www.imf.org/en/Data (accessed July 15, 2015).

National Power:

A power measurement is also incredibly important and one of the more notable features lacking in other energy security models. This is more representative of the capacity of a state to sufficiently respond to security issues involving the oil supply chain. This is the ability to rapidly respond to threats, and the resources to sustain those efforts over time. National power is perhaps the most thoroughly explored quantitative indicator in international relations, and as such, there are multiple studies regarding this measure, one in which one way or another, has been studied for several thousand years.[57] There is a diverse array of measures, ranging from the classics,[58] to the new and innovative,[59] but since this is an indicator being used as an input to another model, parsimony was given preference for the measure.[60] This research will use the preferred model by Chin-Lung

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[57] Karl H. Höhn, "Geopolitics and the Measurement of National Power" (PhD Dissertation (Dissertation zur Erlangung des Doktorgrades an der Fakultät Wirtschafts- und Sozialwissenschaften), Universität Hamburg, 2011): 53-58.

[58] Ray S. Cline, "The Power of Nations in the 1990s: A Strategic Assessment," (Lanham: University Press of America, 1994); Wilhelm Fucks, "Mächte von Morgen: Kraftfelder, Tendenzen, Konsequenzen" (Stuttgart: Deutsche Verlags-Anstalt, 1978); F. C. German, "A Tentative Evaluation of World Power," *Journal of Conflict Resolution* 4:1, (1960); David J. Singer and Melvin Small, "The Diplomatic Importance of States, 1816−1970: An Extension and Refinement of the Indicator," *World Politics* 24:4, (1973).

[59] Karl Höhn, "New Thinking in Measuring National Power," (paper presented at the 2nd Global International Studies Conference by the World International Studies Committee (WISC) at the University of Ljubljana, Ljubljana, Slovenia, July 23−26, 2008) (for instance, this particular work focuses on the overall balance of the national economy using the concentric mean); Gregory Treverton and Seth G. Jones, "Measuring Power: How to Predict Future Balances," *Harvard International Review* 27:2, (2005) (this model was built for long term projections, and the models and data are maintained through the University of Denver).

[60] For an exhaustive, recent study on attempts at modeling national power, reference Höhn 2008.

Chang.[61] The following formula is remarkably indicative of existing power relationships despite its parsimonious presentation, and the data is readily available.

$$power = \frac{critical\ mass + economic\ strength + military\ strength}{3}$$

Again, power in this case is primarily referring to hard power, including its latent potential. The individual components are calculated as follows:

$$critical\ mass = \left(\frac{country\ population}{world\ population}\right) \times 100 + \left(\frac{country\ area}{world\ area}\right) \times 100$$

$$economic\ strength = \left(\frac{country\ GNP}{global\ GNP}\right) \times 200$$

$$military\ strength = \left(\frac{country\ military\ spending}{global\ military\ spending}\right) \times 200$$

The author performed these calculations by using the IMF data for population, area, and (Gross National Product) GNP measures while the measure for military strength was derived using data from the Stockholm International Peace Research Institute (SIPRI).[62]

Massachusetts Institute of Technology Economic Complexity Ratings:

This is a fascinating indicator drawn directly from a special project and database supported by MIT which gauges the level of economic "complexity" in a given country. This project will rely on this indicator as a general measure, or proxy, of the overall level of economic advancement in the country, with special regard to the knowledge economy,

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[61] Chin-Lung Chang, "A Measure of National Power," Fo-guang University, Taiwan.

[62] Military Expenditure Database, (Stockholm: Stockholm International Peace Research Institute) http://www.sipri.org/research/armaments/milex/milex_database (accessed March 11, 2015).

and entrepreneurship. This is a necessary measure since technological advancements have ushered in extraordinary change in the energy sector, the recent tight oil boom only the most recent. These types of advancements can be most closely gauged by demonstrating a dynamic and flexible economy, these ECI ratings are meant to be an indicator of the capacity of meaningful technological advancement available to the entire state. This also adds a certain level of dynamism to the model accounting for the possibility that advances in the broader economy and the energy sector can significantly, and positively, impact oil security. Furthermore, many new indicators that attempt to gauge this might be sufficient, but only utilize data going back a few years or tend to be highly indirect at best. The economic complexity scores from MIT are much more direct, and they have generated these scores going back to the 1980s in many cases, with very few gaps. This represents perhaps the most complete way to measure these impacts with a sufficient time horizon. According to the information provided with the datasets, the conceptual reasoning behind the scores is based on Adam Smith's concept of the division of labor and the availability of the "multiplicity of useful knowledge embedded in it."[63] Additionally, they state that more advanced products "embed large amounts of knowledge and are the results of very large networks of people and organizations … [and] these products cannot be made in simpler economies that are missing parts of this

[63] AJG Simoes and CA Hidalgo, "The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development," Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence, (2011); References in this study are made specifically concerning data derived from the Economic Complexity website and database: *The Observatory of Economic Complexity*, http://atlas.media.mit.edu/en/resources/economic_complexity/ (accessed August 21, 2016).

network's capability set."[64] Finally, they express economic complexity as the "composition of a country's productive output and reflects the structures that emerge to hold and combine knowledge."[65] Utilizing a time-series measure of this nature is unique and adds increased robustness to the study, measuring the capacity for technological innovation that is otherwise absent from other studies on oil security. The scores generally range from 0 to 2 but for the model these are normalized on a 0 to 1 scale using all countries included in the study.

Concluding Remarks

Ultimately, all of these calculations will allow for arrival at a single composite oil security rating for both the United States and China, allowing for a more direct, and objective comparison between the two on a yearly basis. This will dramatically inform and enhance the research, giving empirical substance for debate and theory building. The composite scores, acting as the overall score will provide a broad indicator for overall security, and the individual indicators can be examined to understand their resulting impacts on the overall score, aiding in our understanding of how these two states have shifted their approaches over time.

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[64] Ibid.

[65] Ibid.

CHAPTER II

OIL SECURITY AND GRAND STRATEGY

> Generals with little experience wish to save everything: those who are wise consider only the principal point, seeking to ward off large blows and patiently suffering minor misfortunes in order to avoid large ones. He who attempts to defend too much defends nothing.
>
> Frederick the Great[66]

> The essential difference is that war is not an exercise of the will directed at inanimate matter, as is the case with the mechanical arts, or at matter which is animate but passive and yielding, as is the case with the human mind and emotions in the fine arts. In war, the will is directed at an animate object that reacts.
>
> Carl von Clausewitz[67]

Introduction

This chapter is a full account of how energy security operates within grand strategy, and why it is so vital to state security. A thorough understanding of grand strategy is required in order to appreciate how energy is important to a state's long-term security requirements, and how these policies are generated and altered by domestic actors, external diplomatic initiatives, and the short- and long-term and economic and

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[66] Frederick II of Prussia and ed. and trans. Jay Luvaas, *Frederick the Great on the Art of War*, (New York: Da Capo Press, 1999), 120.

[67] Carl von Clausewitz, eds. and trans. Michael Howard, and Peter Paret, *On War*, (Princeton, New Jersey: Princeton University Press, 1984), 149.

security environment. After consideration of the many aspects of grand strategy, a review of energy security will be required, and how similar constraints and issues that act on grand strategy, affect energy security as well. These are complex, interrelated issues, especially when dealing with great powers.

Policy constraints exist both internally and externally and must be fully accounted for in order to catalogue the changes and shifts in policy over time. For the domestic environment, interest groups, public policy, environmental costs, industry, and technology have significant impact on policy. The other more external aspects, such as diplomacy and the geopolitical environment of oil, will form the cornerstone of the research, and is of the utmost importance. Each state has its own advantages and disadvantages when dealing with respect to their supply security; however, this research will make the case that the United States has the clear advantage in this facet of energy security despite some high levels of domestic alarmism. This point, it will be argued, also has greater implications for the final chapter dealing with direct Sino-American energy relations and the broader relationship. It will also be argued that China is following a similar path as was followed by the United States, in its attempts to secure overseas sources of energy, although the path may at times be cautious and tepid.

Grand strategy is ultimately understood as a cost-benefit analysis in a world of scarce resources and hard fought security. Scarcity results in strategic interaction. This strategic interaction involves the interrelationship of several high-level categories of security, to which this research elevates energy security. Permeating these high levels, is also a complex set of objectives, threats, and capabilities that will ultimately determine grand strategic outcomes. All of this comes together to form a coherent, and more encompassing approach to energy security, that will be utilized by analyzing the approach between China and the United States in chapters three and four. The following section will begin with a more in-depth understanding of grand strategy, and why the intricacies of this approach more fully account for energy security approaches by states.

What is Grand Strategy?

In this study, the notion of grand strategy will serve as a sort of theoretical referent, or context, to anchor the study of energy security policy approaches by the U.S. and China. Accordingly, in order to demonstrate each state's respective energy security approaches, there must be a clear understanding of grand strategy. Grand strategy has generated many variances, with some scholars negating whether grand strategy is even separate from other areas of research.[68] So, what is grand strategy? What is it not? Why is it so important?

After a brief discussion of grand strategy, within a sub-section of the literature review in chapter one, it concludes by stating broadly that grand strategy is the national reconciliation of means and ends; the feasible objectives given the limited resources available to the state. It is the long-term approach to survival and security of a particular state, accounting for specific threats, utilizing all forms of statecraft at its disposal, whether it is military, economic, or political. Grand strategy essentially provides the "political" ends which guide Clausewitz's "war," or strategy. Despite this rather inclusive conceptualization, there is by no means a universally accepted approach or

[68] Referring primarily to Robert Art's conception of grand strategy, explained on page 63.

definition to grand strategy, making it at times difficult to compare. However, all states have one, even if not explicitly stated or in full cognizance, "because grand strategy is simply the level at which knowledge and persuasion, or in modern terms intelligence and diplomacy, interact with military strength to determine outcomes in a world of other states with their own 'grand strategies.'"[69] Whether accidental, concerted, planned, or confused, a grand strategy is present at the very least as the aggregate of state function and as bureaucratic reaction to other states' strategies. And, these should over time create a "coherent body of thought and action geared toward the accomplishment of important long-term aims."[70]

States cannot do without grand strategy because it is critically important and vital, which in the words of Edward Meade Earl is "the highest type of strategy,"[71] and as Christopher Layne points out beginning with his own explanation of grand strategy as "the most crucial task of statecraft."[72] Indeed, with grand strategy, it is at its very core concerned with the enduring survival of the state; it is crucial, and central to all other considerations.

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[69] Edward N. Luttwak, *The Grand Strategy of the Byzantine Empire*, (Cambridge, MA: Harvard University Press, 2009), 409.

[70] Hal Brands, *What Good is Grand Strategy? Power and Purpose in American Statecraft from Harry S. Truman to George W. Bush*, (Ithaca, NY: Cornell University Press, 2014), 6.

[71] Edward M. Earl, ed., *Makers of Modern Strategy*, (Princeton: Princeton University Press, 1971), viii.

[72] Christopher Layne, *The Peace of Illusions: American Grand Strategy from 1940 to the Present*, (Ithaca, NY: Cornell University Press, 2006), 13.

And, just as Posen points out that military doctrinal mismatch with the threat or political environment can end with poor results, it is the position of this research that blatant mismatch in any of the major categories of grand strategy can prove catastrophic, and failings at the grand strategic level are often the most difficult to overcome. Grand strategic calculations are made with "conflict unfold[ing] at separate levels – grand strategic, theater-strategic, operational, tactical – which interpenetrate downward much more easily than upward."[73] Just in the way Hitler's gross grand strategic miscalculation of allies and enemies couldn't be countered by the brilliant theater, operational, and tactical level victories of the German military,[74] no amount of multi-level successes and victories by General Lee and the Confederate Army could have overcome the weaknesses in all other areas of statecraft, eventually succumbing to the Union's superior supply lines, industry, and numbers, in a conflict essentially lost before it began.

Additionally, it's not just blatant mismatches in grand strategy that states must be concerned with, but other seemingly smaller issues that over time, can begin to decrease security, as with the conflation of capabilities and objectives. As Christopher Fettweis points out, "influence, presence, credibility – even alliances have all too often become the ends of policy in themselves, raising the possibility of conflict in the process."[75] This conflation of means and ends can have a deleterious, long-term impact on state security,

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[73] Luttwak, *The Grand Strategy of the Byzantine Empire*, 414.

[74] Ibid., 414.

[75] Christopher J. Fettweis, "Threatlessness and US Grand Strategy," *Survival* 56, no. 5 (2014): 56.

committing resources where they are not needed, sapping strength, and potentially creating new frictions and enemies along the way.

And, in the clear majority of cases, a state typically does not have the luxury to choose most components of its grand strategy, simply because there may be many fixed components to the threat environment of a state, out of which a state's strategy is derived, and in which it will become necessarily defined. For instance, the state of Israel cannot simply pick up and move elsewhere, and thus will have a grand strategy significantly defined by that particular threat environment. The same is true of, for instance, the Baltic states, with comparatively small populations, resources, and who cannot divorce themselves for the imposed strategic reality of their close proximity to Soviet successor state Russia. Fettweis refers to this useful concept as strategic flexibility[76] and as will be seen in later chapters, the United States does exist in a privileged state given its inherent strategic flexibility following the end of the Cold War, directly dichotomous to China which has several severe constraints on its grand strategy. So, how does statecraft produce an effective plan for survival?

Before tackling these questions, it should be noted there is an issue with a theoretical understanding of grand strategy: the rather fluid nature of the concept. A theory implies some universality that can be applied to related events or objects of study, under different circumstances. This means some degree of commonality must be identified; some causal logic that connects the seemingly unconnected. For example, one can examine the dominant theoretical strand in international relations, Realism, and note

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[76] Christopher J. Fettweis, "Free Riding or Restraint? Examining European Grand Strategy," *Comparative Strategy* 30, no. 4 (2011): 317.

a key underlying premise which is the distribution of material power, and then make causal predictions from that premise, ultimately utilizing its explanatory power to understand all states that fall under that rubric, which is at the very least, great powers. Alternatively, with the democratic peace theory, it is understood that this theoretical approach is meant to explain outcomes pertaining to war and peace among specifically democratic states. Grand strategy, and strategy in general, is much more problematic given the greater variance in actions and outcomes from one state to another. Security and survival is taken as the ultimate objective, but the capabilities, threats, and lesser objectives that "cause" security will be distinctive. In fact, John Gaddis ponders this point in one of his many writings on grand strategy. The fact that grand strategy is different and unique to every state, based on threat and capability, makes one wonder if a universal strategic logic exists; as Gaddis explains:

> Much of the confusion over whether strategic 'logic' exists or not stems from the fact that we have never made the criteria for 'success' in strategy – and particularly in 'grand strategy' – very clear. [Grand strategy] … requires the integration of military strategy with such non-military considerations as politics, economics, and psychology, law, and morality, and it involves doing so over indeterminate periods of time. Specifying what constitutes success under those conditions is indeed no easy task.[77]

Problems mount when accounting for what Edward Luttwak describes as the persistent "paradoxical logic of strategy," whereby frequently the "poor" option is the "best" and vice versa, all in order to gain surprise, or minimize risk and friction.[78] He

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[77] John L. Gaddis, "Containment and the Logic of Strategy," in Benjamin Frankel, ed., *In the National Interest: A National Interest Reader*, (New York: University Press of America, 1990), 20.

[78] Edward N. Luttwak, *Strategy: The Logic of War and Peace*, (Cambridge, MA: Harvard University Press, 2003).

typically begins with the oft quoted Roman proverb *si vis pacem, para bellum*, if you want peace, prepare for war, and gives numerous examples of these paradoxes, for instance: nuclear deterrence, where in order to defend one must be ready to attack at all times, and in order to be effective, one must not use the very costly nuclear weapons acquired.[79] To him, strategy lacks any degree of linearity, especially when one rises to the level of grand strategy and in a way echoes Liddell Hart's "indirect approach" with the application of energy where the enemy least expects. He ultimately draws on an approach to strategy as "the art of the dialectics of wills that use force to resolve their conflict,"[80] which seems to pervade much of his work on the subject.

Some criticize Luttwak's paradox by pointing out that to proceed logically, one must take context into account. For instance, he often utilizes the analogy of the long, unpaved road preferred to the shorter, paved road since that one will be guarded and expected an adversary, whereas the former (unpaved) road will not. However, with context considered, logically an armed force should not expect, during wartime, that the short, paved road would be the best road, but that the long, unpaved road would be preferable.[81] However, this isn't necessarily true, as the distinction between various contexts is often blurred in international politics and grand strategy, along with state perceptions of which "roads" are actually preferred and less preferred, a point which will be returned to in Chapter VI regarding China's specific energy security strategy. In a

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[79] Ibid., 1-15.

[80] André Beaufre, Introduction à la Stratégie, (Paris: Armand Colin, 1963), 16, in Edward Luttwak, *Strategy: The Logic of War and Peace,* (Cambridge, MA: Harvard University Press, 2003), 269.

[81] Gregory R. Johnson, "Luttwak Takes a Bath," *Reason Papers* 20, (1995): 121-124.

sense, that is the point of strategic interaction: understanding the best approach to a given problem while being conscious of the competitor's reactions in a murky context.

Not only that, but if per "context," the less preferred road is always the preferable route to take, as Gregory Johnson suggests, then there isn't any strategic logic since the choice is automatically made *ex ante* and the competitor will react accordingly, and predictably. This is reducing the process down to simple linear decision-making, something that cannot be done in order to achieve optimal strategic outcomes. Luttwak promotes an approach far more cognizant of the inherent temporal fluidity and fluctuating nature of strategy where a scheme one day is surprising, while the next it is commonplace.

John Gaddis, while elucidating his own opinion of grand strategy, suggests it as an enduring concept, more theoretical in nature, and in the same vein as Clausewitz's distinction between theory and practice, and something meant to stimulate thought, rather than be "carried into the field." But in a more direct sense, his core recurring theme for grand strategy is the fundamental difficulty in "balancing the risks against the costs of securing vital interests."[82] Gaddis goes on to state, with perhaps some of his own "paradoxical logic," that "Destruction, after all, can come either from the actions of adversaries or from what you do to yourself. These two priorities compete, because the things you do to minimize risks tend to drive up costs; but the things you do to minimize

[82] Frankel, "Containment," 23.

costs tend to drive up risks."[83] It's almost as if the logic of grand strategy carries with it an intrinsic equilibrium or balance that must be maintained per specific circumstance.

In Gaddis' conception, risk minimizing entailed attrition campaigns, large military presence, reliance on technology, industry, open-ended timeframe, but most importantly, "unlimited resources" and "steady political support."[84] Cost minimizing focuses on tactics, maneuver, surprise, technology to move conflict forward quickly, urgency, and importantly, "limited resources" and "limited political support."[85] And, at the level of grand strategy, these trade-offs still exist.

However, while Gaddis is correct in characterizing grand strategic decision-making as consistent with an inherent tension between risk and cost, this may not always be the case, nor will they always be mutually exclusive. Take the unambiguous instance of a state engaged in imperial overreach. In Gaddis's conception, this is a strategy of risk minimization, which results in more engagement for decreased risk, but at the price of increased costs. But, in the case of overreach, there's no tension; there is both increased risk and increased cost. If the political unit withdraws to maintain manageable boundaries, there will be less risk and reduced cost. The opposite would be low risk and low cost, clearly optimal as opposed to the other. But, perhaps aside from more extreme examples, this approach is instructive. For instance, as Gaddis would apply this tension to grand strategy, with the utilization of containment, there is typically symmetrical and asymmetrical containment. This is conceptualized in much the same way of risks and

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[83] Ibid.

[84] Ibid., 24.

[85] Ibid., 24.

costs, where the former "strategy expends resources in order to play it safe; the [latter] takes chances to avoid expending resources."[86] Containment of the Soviet Union followed much the same process with George Kennan's approach to emphasizing the psychological aspects over the physical, but with the final NSC-68 document emphasizing the physical over other asymmetric approaches.[87]

So, if each states' grand strategy is unique, determined by those capabilities, threats, and objectives, and there are inherent tensions and paradoxes, how does one approach this as a unifying concept towards the ultimate objective of state survival?

In a sense, there is no perfect answer. Just as there is yet to be a perfect theoretical understanding of the interstate system, grand strategy unsurprisingly itself rests in an indeterminate existence, with waters further muddied by "outcomes depend[ent] not only upon the quality of one's thought, or the efficiency of one's actions, but upon circumstances not wholly under one's control, most notably the actions of adversaries and the role of the unforeseen."[88] Perhaps this variance gives cause to reason that in order to grapple with grand strategic thinking, one must view it as an "ecological discipline,"[89] disregarding any pull towards "theateritis,"[90] and approach the study as a

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[86] Ibid., 26.

[87] John L. Gaddis, *Strategies of Containment: A Critical Appraisal of American National Security Policy During the Cold War*, (New York: Oxford University Press, 2005).

[88] Ibid., 21.

[89] John L. Gaddis, "What is Grand Strategy," (Yale University, New Haven, CT, February 26, 2009), 16.

[90] Ibid., 3.

"generalist"[91] and interdisciplinarian.[92] Grand strategy, simply put, requires versatility and flexibility.

Another important point to consider is whether conflict or direct confrontation is worth engaging in at all. This is a very common strand of thought throughout Liddell Hart's seminal text, *Strategy*, where he has a very strong focus on the costs of war and aversion to such costs. When attempting to find balance between ends and means, one must give serious thought to inaction or restraint as a serious course of action, especially if such actions do not result in a "better peace" for the state,[93] and in terms of strategy, the perfection of which "would be, therefore, to produce a decision without any serious fighting."[94]

While Liddell Hart did tend to focus on holistic grand strategy only under the auspices of conflict, he is one of the earliest to delve into the idea of grand strategy by stating:

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[91] Ibid., 9.

[92] Ibid., 15.

[93] B.H. Liddell Hart, *Strategy: Second Revised Edition*, (New York, NY: Praeger Publishers, 1991), 259-263.

[94] Ibid., 237.

> Grand strategy should both calculate and develop the economic resources and manpower of nations in order to sustain the fighting services. Also the moral resources to foster the people's willing spirit is often as important as to possess the more concreter forms of power. Grand strategy, too, should regulate the distribution of power between the several services and between the service and industry. Moreover, fighting power is but one of the instruments of grand strategy which should take account of and apply the power of financial pressure, of diplomatic pressure, of commercial pressure, and, not least of ethical pressure, to weaken the opponent's will. Furthermore, while the horizon of strategy is bounded by the war, grand strategy looks beyond the war to the subsequent peace.[95]

Hal Brands believes grand strategy to be the "intellectual architecture that gives form and structure to foreign policy," a "purposeful and coherent set of ideas about what a nation seeks to accomplish in the world, and how it should go about doing so," and is the "theory, or logic, that guides leaders seeking security in a complex and insecure world."[96]

William Martel finds grand strategy to be "a coherent statement of the state's highest political ends to be pursued globally over the long term. Its proper function is to prioritize among different domestic and foreign policy choices and to coordinate, balance, and integrate all types of national means – including diplomatic, economic, technological, and military power – to achieve the articulated ends."[97] Note in this definition, he is very inclusive of technological elements, perhaps more than others.

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[95] Ibid., 236.

[96] Brands, *What Good is Grand Strategy? Power and Purpose in American Statecraft from Harry S. Truman to George W. Bush*, 3.

[97] William C. Martel, *Grand Strategy in Theory and Practice: The Need for an Effective American Foreign Policy*, (New York, NY: Cambridge University Press, 2015), 32-33.

Martel even includes this in his lowest tier of levels of foreign policy, where grand strategy is, necessarily, at the top.[98]

In a recent work on grand strategy, *The Challenge of Grand Strategy*, Lobell, Ripsman, and Taliaferro use another John Lewis Gaddis' definition as a starting point, asserting grand strategy is "the process by which a state relates long-term strategic ends to means under the rubric of an overarching and enduring vision to advance the national interest."[99] This is also a good starting definition, but now some clarity is required, as the definition has become a little more detailed. What processes are included? Who calculates the strategic ends and means? How is the state's enduring vision and national interest generated? While broad, grand strategy can be quite detailed. Lobell et. al. then end with defining grand strategy as "the organizing principle or conceptual blueprint that animates all of a state's relations with the outside world, for the purpose of securing itself and maximizing its interests. It shapes the parameters of the specific foreign, military, and economic strategies states pursue toward particular states, toward specific regions, and toward other actors on the world stage,"[100] which is key to understanding both the broad nature of grand strategy, but also that it is an inherently unique approach that must be tailored to each individual state.

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98 Ibid., 30.

99 Steven E. Lobell, Jeffrey W. Taliaferro, and Norrin M. Ripsman, "Grand Strategy between the World Wars," in *The Challenge of Grand Strategy: The Great Powers and the Broken Balance between the World Wars*, eds., Jeffrey W. Taliaferro, Norrin M. Ripsman, and Steven E. Lobell, (New York, NY: Cambridge University Press, 2012), 14.

100 Ibid., 15.

Of all the approaches to grand strategy, Gaddis' approach is perhaps conceived of most broadly with "the calculated relationship of means to large ends" and how "one uses whatever one has to get to wherever it wants to go" with knowledge derivative of "war and statecraft, because the fighting of wars and the management of states have demanded the calculation of relationships between means and ends for a longer stretch of time than any other documented area of collective human activity."[101] However, he extends that even further when he states grand strategy is "potentially applicable to any endeavor in which means must be deployed in the pursuit of important ends" which can include anything from "surviving a summer internship" to "achieving success in soccer, football, [and] rowing."[102] This research, however, will stick to politics. He narrows this a bit seeing strategy as "the calculated relations of ends and means" and grand strategy as the "application of 'strategy,' … by states acting within the international state system, to secure their interests: it is what leads, if all goes well, to 'statecraft.'"[103]

While primarily a piece on military doctrine, Barry Posen's *The Sources of Military Doctrine* has an influential definition of grand strategy, and an applied follow-up discussion regarding the finer points of how a state's grand strategy must operate in concert with a state's military doctrine. Posen's approach to military doctrine, and his subsequent discussion of grand strategy, retains a preeminent position in the literature, and his framework and categories from his main work on military doctrine are heavily relied upon in this work. Significantly, he draws on a definition of grand strategy as "A

[101] Gaddis, "What is Grand Strategy," 7.

[102] Ibid.

[103] Ibid., 22.

political-military, means-end chain, a state's theory about how it can best 'cause' security for itself."[104] He elaborates further by mentioning, "A grand strategy must identify likely threats to the state's security and it must devise political, economic, military, and other remedies for those threats."[105] Posen further discusses the need to prioritize under anarchy given scarce resources.[106] And, specifically, he mentions the devising of, "political, economic, military, and other remedies for […] threats," with this research conceiving of energy security as an additional tool at this level. In addition, the identification of threats is mentioned in his approach, and elucidated throughout the work.[107] All these points add some greater, and more robust, dimensionality to the definition. This lifts security as the primary purpose, and crucially recognizes the use of non-military means in achieving the goals of a state's grand strategy. In fact, Posen goes at great length in his first chapter to describe the importance of integration of grand strategy, military doctrine, and political ends, along with a subsequent discussion on how they operate together, much the way this work conceptualizes energy security in relation to grand strategy.[108]

Taliaferro, Lobell, and Ripsman echo this approach later in their work when they write, "A grand strategy, in essence, is the organizing principle or conceptual blueprint

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[104] Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars*, (Ithaca, NY: Cornell University Press, 1986), 13.

[105] Ibid.

[106] Ibid.

[107] Ibid.

[108] Ibid., 24-25.

that animates all of a state's relations with the outside world, for the purpose of securing itself and maximizing its interests. It shapes the parameters of the specific foreign, military, and economic strategies states pursue toward particular states, towards specific regions, and toward other actors on the world stage."[109] In this approach, it is also important to note their inclusion of "other actors" which would include non-state actors. And finally, they state that grand strategy "is a future-oriented enterprise involving considerations of external threats and opportunities, as well as the specific material, political, and ideological objectives of the state." Crucially here, they include an internal, domestic dimension as well as the conscious inclusion of temporal considerations, and further echo an emphasis on specific threats.[110]

As Christopher Layne further describes grand strategy, it is, in "its essence […] about determining a state's vital interests – those important enough to fight over – and its role in the world. From that determination springs a state's alliances, overseas military commitments, conception of its stake in the prevailing international order, and the size and structure of its armed forces."[111] Grand strategy is inherently based on the threat of another state or group of states and rank ordering those capabilities and interests in relation to those threats.

It should also be noted, this preferred use of grand strategy in the provision of long-term security, is an expansive approach, utilizing all available tools of statecraft.

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[109] Lobell, Ripsman, Taliaferro, "Introduction: Neoclassical Realism," 15.

[110] Ibid.

[111] Layne, *The Peace of Illusions: American Grand Strategy from 1940 to the Present,* 13.

This means military power is not conceived as the only means to preferred grand strategic outcomes. While used as the preferred approach in this study, it should be noted other strategic scholars do give primacy to hard power and the military balance in their conceptions of grand strategy. For instance, while Robert Art concludes, correctly, that the purpose of grand strategy is security, he tends to focus on the means to that security purely through military force, distribution, and posture, as the only means to attain that security within a grand strategic framework.[112] For Art, this is due primarily to the "fungibility" of military power, and its spill-over effects into other areas of strategy. However, this document does not find this view of grand strategy compelling because it breeds reliance on a single avenue of statecraft when others might be more appropriate in other circumstances, or used more actively.

Just as Clausewitz sharpened the mind of the military strategist by emphasizing that war doesn't exist in a vacuum simply to tally wins and losses, but is ultimately a blunt political instrument, a grand strategist must recognize all the various elements of statecraft available towards the political ends of security. Security attainment should not be concerned with how it is attained; the ends in this case justify the expansion of means from material power to anything that can reinforce and secure the state. This leads to the utilization of all forms of statecraft. *A grand strategy requires uniformity of purpose and coordination and calibration so all parts of statecraft are working together towards this singular end*. Luttwak reminds one that synergistic grand strategies make optimal grand strategies:

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[112] Robert J. Art, *America's Grand Strategy and World Politics*, (New York, NY: Routledge, 2009), 7-32.

> All states must have a grand strategy, but not all grand strategies are equal. There is coherence and effectiveness when persuasion and force are each well guided by accurate intelligence, then combine synergistically to generate maximum power from the available resources. More often, perhaps, there is incoherence so that the fruits of persuasion are undone by misguided force, or the hard-won results of force are spoiled by clumsy diplomacy that antagonizes neutrals, emboldens enemies, and disheartens allies.[113]

In a sense, that is an indicator of good versus poor grand strategy. To think of grand strategy as the ultimate conception, or blueprint to pursue security in global politics, and to only pursue this strategy with military power, relegating other components of statecraft to the area of relatively aimless foreign policy, is a bit like fighting a boxing match with one hand tied behind your back and a leg strapped down with weights. Sure, that one arm is important, but so is everything else. All devices of statecraft matter in the pursuit of security, and therefore all should be pursued uniformly in order to achieve and retain security and survival. States with pre-dominant military power in the interstate system can sometimes get away with pursuing the military only approach, masked by overwhelming power, but eventually this lack of overarching, continuity inducing approach fails.

Luttwak is instructive in flexible and expansive use of grand strategy in his works on the Roman and Byzantine Empires. For instance, "In the imperial period at least, military force was clearly recognized for what it is, an essentially limited instrument of power, costly and brittle. Much better to conserve force and use military power

[113] Luttwak, *The Grand Strategy of the Byzantine Empire*, 409.

indirectly, as an instrument of political coercion."[114] Statecraft is meant to utilize all instruments at a state's disposal, as he goes on to explain that for Rome, "the dominant dimension of power was not physical but psychological – the product of others' perceptions of Roman strength rather than the use of that strength," displaying what was an incredibly sophisticated approach to grand strategy, ensuring the survival of Rome as a political entity for a millennia.[115] As for the Byzantines, even less traditional and indirect methods of statecraft were employed to great success. For example, the use of the growing popularity of Christianity by the Byzantine Empire is a well-documented case of grand strategic asymmetry. When the city of Constantinople was founded in 330 A.D., it certainly wasn't any special location within the world of Christendom, but that soon changed. Lineages of emperors and patriarchs purposefully pursued a strategy whereby the city was established and maintained as a preeminent site of Orthodox Christianity, with the construction of the Hagia Sophia in 537 A.D., along with hundreds of other churches, the acquisition of famous saintly relics and religious icons, and the active use of missionaries in surrounding areas.[116] All this effort, particularly the construction of the spectacular Hagia Sophia, made Constantinople into a "Christian city par excellence" and major pilgrimage destination for the faithful, establishing the city as a center in the world of Christendom, ultimately "widening the cultural sphere of the Byzantines."[117] It

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[114] Edward N. Luttwak, *The Grand Strategy of the Roman Empire: From the First Century CE to the Third Revised and Updated Edition*, (Baltimore, MD: Johns Hopkins University Press, 2016), 2.

[115] Ibid., 3.

[116] Luttwak, *The Grand Strategy of the Byzantine Empire*, 114-123.

[117] Ibid., 114-123.

was no longer a lone city to the east, but a central component of a larger world through the intense pursuit of prestige within Christendom. On its own, this might not matter much, but as part of a larger package of statecraft, it mattered greatly.

More recent examples of comprehensive approaches to grand strategy exist as well. For instance, diplomat George Kennan, the author of the prominent "X" article and generally considered the main architect of U.S. containment during the Cold War, conceived of containment in more expansive terms where he focused on repelling Soviet subversion and "psychological"[118] pressures with "measures short of war"[119] since the true danger is the "people of Western Europe and Japan, two of five vitals centers of industrial power, might become so demoralized … by war and reconstruction …to communist-led coups, or even to communist victories in free elections."[120] Kennan firmly believed much could be confronted on the psychological front, since to him "the communist threat lies largely in certain subjective deficiencies and vulnerabilities of Western society itself. War would not remedy those deficiencies and liabilities."[121] As Gaddis states, paraphrasing Kennan, "It was against this contingency that the strategy of

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118 "Measures Short of War (Diplomatic)," National War College; 1946 September 16; George F. Kennan Papers, Box 298, Folder 12; Public Policy Papers, Department of Rare Books and Special Collections, Princeton University Library; also see classics like *On War* and *Strategy* by Liddell Hart on the importance of psychology in strategy.

119 Ibid.; "Basic Factors in American Foreign Policy," Dartmouth College; 1949 February 14; George F. Kennan Papers, Box 299, Folder 23; Public Policy Papers, Department of Rare Books and Special Collections, Princeton University Library.

120 John L. Gaddis, *Strategies of Containment: A Critical Appraisal of American National Security Policy During the Cold War*, (New York: Oxford University Press, 2005), 34.

121 "Basic Factors in American Foreign Policy," Dartmouth College; 1949 February 14; George F. Kennan Papers, Box 299, Folder 23; Public Policy Papers, Department of Rare Books and Special Collections, Princeton University Library.

containment was primarily aimed – not Soviet military attack, not international communism, but rather the psychological malaise in countries bordering on Moscow's sphere of influence that made them, and hence the overall balance of power, vulnerable to Soviet expansive tendencies."[122]

Ultimately, the purpose of grand strategy is to secure the state from foreign powers and maintain national sovereignty. The security, or survival function, of grand strategy is essential to this definition, since without the possibility of compromised state security, or even the elimination of the state, there is no need for strategic interaction or the need to trade essential interests for those that are less essential. This understanding is extremely important to make an analytical distinction between grand strategy and foreign policy, two concepts that are often confused or used interchangeably. Generally, foreign policy governs essentially all interactions between states. It can be directed towards anything, and utilized for any purpose of state. Grand strategy is separate from this, in that a state may use many of the same tools available in foreign policy, but it is for the sole, ultimate purpose of providing long-term security for the state. Grand strategy is foreign policy, but foreign policy is not necessarily grand strategy. Foreign policy encompasses all interstate interactions, but only if these interactions involve some type of security consideration, can they be considered part of a state's overall grand strategy.[123]

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[122] Gaddis, *Strategies of Containment: A Critical Appraisal of American National Security Policy During the Cold War*, 34.

[123] In this sense, the United States is more likely to adopt a foreign policy initiative towards a state like Mozambique, since this country isn't integral to any security interests. However, the United States would implement policy in accordance with its grand strategic interests when dealing with a state like Russia or Vietnam, given its close proximity to China.

Grand strategy gives specific purpose to foreign policy. Kazakhstan has a foreign policy towards Guatemala, but grand strategy does not factor into the approach. Grand strategy exists with the real threat of force or ultimately the survival of the state. Kazakhstan would have a grand strategy for Central Asia and its survival as an independent political entity. In that sense, grand strategy entails continuity and longer-term goals, like national security and survival, that are, in turn, directly or indirectly pursued by achieving specific shorter-term and context-dependent foreign policy objectives—some of these more pressing than others, but, ultimately, these are cogently contained in the grand strategy projection of the state. Grand strategy provides the boundaries or context for the pursuit of foreign policy goals from means to ends.

This research argues that grand strategy generally establishes present and long-term state goals. It links immediate and future means, calculations, and decisions with enduring and longer-term state goals with respect to the rest of the world. In other words, grand strategy is the state's continuous position *vis à vis* the world and other states. Foreign policies effectuate the grand strategic purpose on a shorter-term basis. The latter is often affected by the historical context and the governing style or decision-making approaches of present executives, reflecting the decision-making processes, agendas, and objectives of different administrations and bureaucracies. A degree of continuity in grand strategy is key for a state's long-term survival, even if foreign policy varies over time. Foreign policy is ultimately in need of guidance, which would come from the grand strategy in place by a state. Ultimately, "Grand strategy involves the prioritization of foreign policy goals, the identification of existing and potential resources, and the selection of a plan or road map that uses those resources to meet those goals. Whenever foreign policy officials are faced with the task of reconciling foreign policy goals with limited resources, under the prospect of potential armed conflict, they are engaging in grand strategy. Levels of defense spending, foreign aid, alliance behavior, troop deployments, and diplomatic activity are all influenced by grand strategic assumptions."[124] These authors in combination touch on important aspects of the combination of the constituents of grand strategy and the imperative inclusion of threats and interests. It is because of the importance of this level, this research finds it necessary to include energy security.

Taking the previous passages into consideration, we can gain a fairly clear picture of grand strategy: *it is the national reconciliation of security related means and ends, consistent with all available resources to the state, under the constraints of an indeterminate future*. It is the state's overall approach for long-term survival and security, accounting for specific threats to the state, utilizing all available forms of statecraft. Furthermore, when considering the components of grand strategy, it is important for the purpose of this study to understand the role energy plays. It is the position of this research that energy plays an integral role in the formation and execution of each state's grand strategy. Without the necessary energy supplies, both states would not have the ability to field a military, or the capability to grow an economy and provide for its population. Energy is a foundational element of national power, and as such, a critical component of grand strategy. Given the enormous energy requirements for both

[124] Colin Dueck, *Reluctant Crusaders: Power, Culture, and Change in American Grand Strategy*, (Princeton, NJ: Princeton University Press, 2006), 9-13.

the U.S. and China, and their placement in the world, these energy considerations are magnified, and their respective approaches and policies directly affect one another.

Energy is integral to all state's grand strategies, including of course the United States and China, because without sufficient supplies, their economies and militaries simply do not exist in a contemporary format. With that level of importance attached to secure energy supplies, significant portions of both state's grand strategies are forced to revolve in many ways around the security of overseas energy supplies. Not only is energy important enough itself, but it also tends to intertwine with security pursuits in other areas of grand strategy as well. For instance, during the Cold War, China was forced to source a large amount of its energy supplies from the Soviet Union in order to meet levels of domestic utilization.[125] One could argue this forced China into a security arrangement with the Soviets to meet energy needs, even though the Soviet Union was a large, proximate, potentially threatening power to China during the Cold War. When China became self-sufficient in oil production, it was free to hold a more contentious relationship with the Soviets and then a new security arrangement with the United States in the early 1970s. Oil supplies were integral to security decision-making for the PRC throughout the Cold War, and served to both hamper and restrict policy-actions or to allow freer reign of PRC foreign policy actions *vis-à-vis* the Soviets. Indeed, this research will also argue that energy has been a large, looming foreign policy factor for the PRC since its inception, far more so than to the United States since its inception.

[125] Tatsu Kambara and Christopher Howe, China and the Global Energy Crisis: Development and Prospects for China's Oil and Natural Gas, (Northampton, MA: Edward Elgar Publishing, 2007), 23-24.

Since oil became a vital commodity, the U.S. has been far more blessed by geography in its secure sources than the PRC. As a result, China has had to elevate its energy security to extremely high levels in its grand strategy in order to approach its security at a satisfactory level. The United States, given its comparatively secure energy position for a great power, has had to pay less direct attention to this over the decades, opting for a more hands-off approach, even as its importance has remained high. Additionally, it is also crucial to note, that the *United States has the direct ability to interdict Chinese overseas energy supplies, whereas China does not have similar recourse, putting it at a significant disadvantage.* This may be one of the most important factors shaping foreign policy and international security in this current century, and will certainly provide a cornerstone of U.S.-Chinese relations. Over the course of the study, it is important to recognize that China "knows" its inherent weakness to control its energy supplies overseas and that the U.S. at any point could have interdicted these in a security crisis with China.

With these points in mind, we should be drawn to the point that when it comes to grand strategy and energy security, we do not necessarily have any "black boxes" nor does one approach fit all. Just as Poland's grand strategy and energy security approaches will be a specific fit to Poland, the United States and China will have their own grand strategies and energy security approaches for their own specific needs. It is particularly instructive to point to Posen's work on military doctrine, which, being a subset of grand strategy, as is energy security, is quite illustrative to demonstrate the state, and situation, specific requirements in order to attain security. As Posen explains, in 1973, Israel's military doctrine was "dangerously loose" with that of the state's grand strategy and resulted in some of the negative outcomes in that year's conflict.[126] When Israel engaged in an arms race with surrounding Arab states leading up to 1973, it was in dire need of a patron power to compete, since Soviet arms provision to Egypt was giving Israel's competitors a distinct advantage. The natural Israeli partner became the United States. This need for direct supplies and support from an outside power would cause a misalignment between existing doctrine and grand strategy, which would prove near catastrophic for Israel.[127] Israel's military doctrine was largely based on a defensive strategy reliant on 48-hours advance notice. However, failing the full 48-hour notice, it appears Israel was to rely on preemptive attacks by the air force against its Arab neighbors.[128] This was all meant only to occur in the event solid intelligence was received of an impending attack. This intelligence was received (and was accurate, albeit off by a few hours), and gave less than 48-hours for an impending Arab attack. However, the orders for a preemptive Israeli attack by the air force were never given. This was due to the tenuous partnership Israel had with the United States, and the realization they may not receive any further support against Arab attack if they waged a preemptive campaign against their neighbors. The United States would only allow Israel to respond after they had been attacked, eliminating the IDF's preemptive failsafe in the event of an impending attack. As Posen states:

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[126] Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars*, 27.

[127] Ibid., 28.

[128] Ibid., 29.

> Just as important as the absence of warning was the inability to use the air force effectively once it was known that war was imminent. The air force, as a capital-intensive rather than labor-intensive fighting force, was Israel's ever-ready ace-in-the-hole. It was the insurance policy against the possibility of surprise, the cutting edge of any preemptive strike. Yet at this moment of crisis, a hidden obstacle suddenly emerged. There was apparently no way to use the air force that was consistent with the major political change in Israel's grand strategy, the increased dependence on the United States. Thus, on the morning of October 6, Israeli military doctrine could not provide an answer to the state's predicament.[129]

Political and grand strategic disconnect can prove catastrophic. Just as a faulty military doctrine can prove disastrous for a state, so can faulty energy security strategy that fails to take all elements of grand strategy into account. Energy security strategy is a highly bespoke proposition for a state, as is military doctrine, and grand strategy in general. A consumer state will have starkly different energy security strategy from a producer state, with both of their objectives being resolutely opposite, aside from relative stability. A smaller state like Iceland will have a very different strategy and requirements as compared to a larger, great power like China or Russia. State size and capability play a significant role in this. A small city-state, like Singapore, with a relatively small, albeit advanced military imports all its energy needs from overseas suppliers. Singapore certainly does not have the capability to secure overseas supplies of energy with its military, and therefore has to rely on global energy markets and good diplomatic relations with some nearby oil-producers. It also would be beneficial to Singapore to take measures to support the global commons, and the global energy market, in which it is heavily reliant. The United States on the other hand, has the military capability to protect overseas sources of energy militarily, and has acted to protect these sources in the past.

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[129] Ibid., 29.

This has garnered a direct and indirect benefit to the United States in support of the greater market, and in turn, its own supplies of overseas petroleum. These states have similar objectives, but will employ unambiguously different means for attaining those objectives based on their capability and capacity to act, and their role in the international system.

What Are the Components of Grand Strategy?

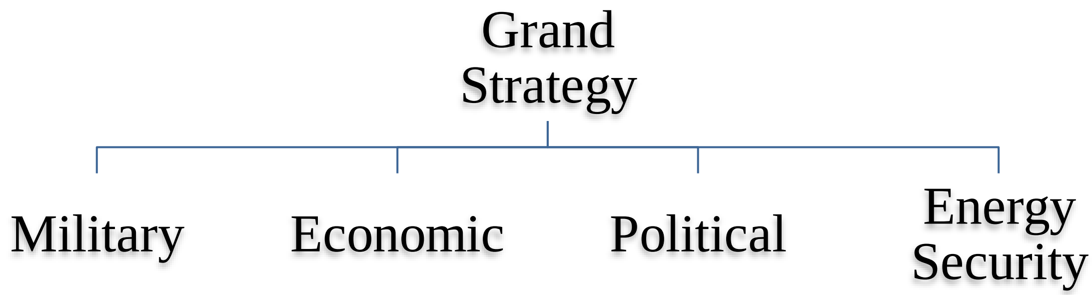
This research conceives of the organization of grand strategy in a somewhat traditional way, but gives more prominence to energy security as an individual component. This is because of its vital importance to every state. Looking back at Posen, a state will "cause" security for itself by identifying the best military, economic, and political approaches to satisfy that security requirement.[130] There is something striking about the high level of importance given to these components: without a satisfactory approach to one, the others will simply fail. Without a proper system to distribute and utilize scarce resources, there isn't the hardware, materials, or resources available to field a military, nor is there the ability to grow a developed, advanced economy, where the needs of the population are met and the political situation is stable. Similarly, without the necessary protection in place by the military, trade routes are not protected, and the people and the government are not secure. And without a stable political system, it becomes difficult to project power abroad or in some cases even field

[130] Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars*,13.

a modern military, and instability and weak institutions stunt economic growth, preventing sustainable advancement wealth, technology, and increasing standards of living. They succeed together, or they fail together when it comes to securing the state.

This research takes a similar approach, but expands on the political aspect and, of course, adds in energy security. The political aspect should be expanded to account for both domestic politics and diplomacy; this is important for both grand strategy and energy security. Taking note of the domestic situation will impact how easily a state crosses borders with its military, just as much as how much energy is required for the state to function properly. For instance, increasing a fuel tax in Europe will be much easier politically than in the United States and this is important because it directly affects how much energy is consumed and how it is consumed. It is also indicative of constraints on political elites, and may restrict actions. In a similar fashion, diplomacy will affect a state's security for more obvious reasons (elaborate). And finally, energy security needs to be at this level because of its vital importance to the functioning of the state. This will be elaborated further in the section on energy security. All of these elements are highly interdependent, and come together to impact the highest levels of statecraft. Essentially, the components of grand strategy, with energy security included, are organized according to the logic in Figure 2.1:

Figure 2.1: Energy Security Within Grand Strategy



A question may arise after reviewing the necessary placement of energy security, on par with issues such as how a state wields its hard power. Why not include energy security as a part of economic policy? Simply put, states do not treat it this way. It clearly holds a special place in policy, especially for great powers. The United States, China, any great power, or any state for that matter, cannot go for too long without keeping up the flow of energy. Energy is a necessity for everything in the state, society, and economy to function at even a minimum. Economic transactions serve as a coordinating mechanism for the broader economy, allocating resources and products to where it makes the most sense. These transactions include millions of products, on top of commodities, currencies, the financial and banking infrastructure, investments; essentially everything that keeps the economy liquid and growing. If any one of these components suffers, the resulting "shock" can usually even be absorbed. Even in the case of a major shock, such as the global financial crisis in 2008, the broader economy was able to adapt, sustain necessary function, and did not result in an existential threat to the state. Taken collectively, the economy as a whole can pose a threat to state security, as was the case with the failure of the Soviet economy during the Cold War. But, there typically isn't a single component of the "normal" economy that can be eliminated, resulting in an existential security crisis to the state, within a relatively short amount of time.

Essential State-Specific Dimensions of Grand Strategy

This discussion has thus far excluded another essential component of grand strategy alluded to earlier: state-specific approaches. All states will essentially have a grand strategy, with the components mentioned above. They will have the appropriate military, economic, political, diplomatic, and energy policies in place for long-term security. But what else do states need to consider in formulating their grand strategies?

To begin with, a state must identify its vital, or core, interests. These are the inherent interests to the state, that without, their existence would be put at stake, and something most of the previous authors emphasized. Most grand strategic writings will have interests ranked in order, demonstrating their relative importance to one another. In that rank ordering, when a state's core interests are threatened, they are typically worth open warfare to defend them. Every state must identify these interests, and while there will be considerable overlap amongst states, many states will have unique core interests not shared with others. Too many interests will lead to over-stretch and exhaustion of resources to protect, while not protecting enough will leave the state inherently vulnerable. At times a state can achieve clarity in core interests, and at other times it can be relatively hazy. Other times, core interests may be a political question, determined by domestic or other reasons, instead of purely security related considerations. China, in its determination to secure the entirety of the East and South China Seas, may even fall into this category.[131] Core interests need to be chosen by the state, just as core energy interests will need to be chosen.

The next calculation in a state's grand strategy is to assess the specific threats to the state. This will, of course, affect the state's considerations of core interests as well, making these two considerations highly dependent. These threats will also change over time, as core interests change, or as the state grows or shrinks. As Great Britain's power shrank considerably in the early 20th century, their calculations of threats and interests had to adjust, in order to accommodate the new reality of their capabilities. In the 19th century, encroachment by a foreign power on India may have constituted a threat to Great Britain, but in the 20th century, it did not. This process was not easy, and involved handing over interests and threats to the United States. This was starkly demonstrated as the United States used economic warfare against the French and British governments during the Suez crisis in the 1950s.[132] Properly identifying threats to the state are vital in a state's assessment of a grand strategy as it allows the proper allocation of military and other economic resources, and a realistic assessment of core interests that the state is actually capable of protecting.

A final assessment of the means and resources capable of meeting these threats and protecting interests is required as well. The means assessment is an obvious

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[131] Leszek Buszynski, "The South China Sea: Oil, Maritime Claims, and U.S.-China Strategic Rivalry," *The Washington Quarterly* 35, no. 2, (2012): 139-156.

[132] David S. Painter, "Oil and the American Century," *Journal of American History* 99, no. 1, (2012): 31.

assumption to make, and determines, realistically, what a state can and cannot do. A state the size of Jamaica, for instance, is hardly going to be able to project power outside of its region to protect energy and economic interests; it must meet these security goals in another way. An accurate assessment of capabilities is required and will negatively affect the assessment of threats and interests if not reviewed correctly. This can be difficult, as states at times have an inherent interest in capability inflation, either purposely or unintentional, which can potentially mislead an assessment of capabilities, resulting in negative grand strategic outcomes.[133]

Ultimately, any assessment of grand strategy, will involve an honest appraisal of a state's, core interests, threats, and their means and capabilities. All of these aspects together create a workable definition of grand strategy, and when necessarily ported over to the concept of energy security, creates a categorical, measurable definition for energy security. In the following sections, there will be a review energy security, and the measurable inputs of energy security, whose measurable outputs will be utilized for this research. Additionally, the high level of interconnectedness will be revealed and examined within the context of grand strategy.

What is Energy Security?

It is not surprising that most scholars and analysts miss crucial components of states' approaches to energy security, given the inherent difficulty in defining "energy

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[133] Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars*, 27-29.

security," and a lack of understanding of the interconnected nature of energy security and the broader security goals of a state, which is connected to a state's grand strategy. Daniel Yergin sums up the complexity of defining energy security when he affirms:

> Energy security may seem like an abstract concern—certainly important, yet vague, a little hard to pin down. But disruption and turmoil—and the evident risks – demonstrate both its tangibility and how fundamental it is to modern life. Without oil, there is virtually no mobility, and without electricity—and energy to generate that electricity—there would be no Internet age. But the dependence on energy systems, and their growing complexity and reach, all underline the needs to understand the risks and requirements of energy security in the twenty-first century. Increasingly, energy trade traverses national borders. Moreover, energy security is not just about countering the wide variety of threats; it is also about the relations among nations, how they interact with each other, and how energy impacts their overall national security.[134]

In the passage above, Yergin not only provides a helpful overview of the difficulty of defining energy security, but in the last sentence, he also brings up the importance of state to state relations and their respective security situations. In a sense, he is alluding to energy security nestled within grand strategy when he refers to national security. So, what is energy security and how do states go about achieving energy security? Above, Yergin mentions, "countering a wide variety of threats" before his point on state-to-state relations. The former component consists of much of what many scholars, analysts, and policymakers think of when they talk or write about energy security. Nearly everyone has a different notion of what should be included when talking about "energy security." This can result in wildly different ideas and approaches to energy security depending on the state and its structure, location, security situation, technological status, the proficiency of its energy industry, access to supplies, whether a

[134] Daniel Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World*, (New York, NY: The Penguin Press, 2011), 293.

producer state or consuming state, size of population and industry, composition of domestic consumption, energy intensity, and so on. It tends to be defined and examined in focused, narrow terms, which does a disservice to the wide variety of approaches taken by various states that have adapted to their specific energy situations, and usually do not include these focused areas as part of a broader grand strategy. Furthermore, it is necessary to understand the variety of approaches available, since the United States and China employ many of these.

The literature addresses many of these points; however, most scholars tend to give primacy to their own respective narrow viewpoints in many cases. Many fail to recognize the full range of energy vulnerability to states and in far too many instances believe there are threats where none exist. This variance in "energy security" lends itself to the weakness in the literature, and policy environment for that matter, of a proper understanding of states' various approaches to energy security. The literature also does not address new, specific threats to energy infrastructure such as cyber attacks aimed not at the retrieval of industry data, but the slowing or halting of production all together—political cyber attacks affecting security of supply are new to the industry, and have yet to be addressed. The recent cyber attack on Saudi Aramco, and subsequent attack on RasGas, in Qatar, has brought cyber security to the forefront of the energy industry, in a way not yet explored.[135] The weaknesses in the literature will be overcome by taking into account all aspects of energy security in this research, and building it into a grand

[135] Camilla Hall and Javier Blas, "Qatar group falls victim to virus attack," Financial Times, August 30, 2012, https://www.ft.com/content/17b9b016-f2bf-11e1-8577-00144feabdc0 .

strategy for each state, in order to determine what constitutes energy security for each respective state.

Further, energy security is a difficult concept to define, as it falls into a familiar trap in the social sciences where a lack of strict definition allows some to narrow it to the point where its specificity among a complex topic becomes a shortcoming, or broaden it to the point where there is no discipline and standards to set it apart from other concepts. Energy is also different and unique. It transcends, deeply, all aspects of grand strategy, since without reliable sources of energy all of the important pillars of grand strategy would crumble.

Most authors and scholars tend to approach energy security in very broad, undefined terms, or focus on narrower aspects of energy security. Deutch and Schlesinger, in their CFR report on U.S. oil dependency, give perhaps one of the most widely used, and succinct definitions of energy security: the reliable and affordable supply of energy.[136] Such broad definitions tend to be useful, since they afford a high degree of flexibility to understand how a given state pursues its respective energy security policy, within its own grand strategy or foreign policy. But, key questions are left unanswered. How do states pursue their affordable and reliable supplies? What do they consider affordable and reliable? And to whom is the supply going? And why do they choose to pursue it in the manner they do? In short, more specificity is required.

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[136] Chairs: John Deutch, James Schlesinger, David Victor, Council on Foreign Relations National Security Consequences of U.S. Oil Dependency Independent Task Force Report No. 58 3 2006.

Michael Klare finds most analysts tend to view energy security "as the assured delivery of adequate supplies of affordable energy to meet a state's vital requirements, even in times of international crisis or conflict."[137] This is a narrowing of the definition, but problematic since "vital requirements" will be viewed very differently depending on the state's goals in the international system. That is, the foreign policy objectives of Argentina, Bolivia, and Burundi are narrower and evidently distinct from those of states like the U.S., Russia, and China. Ignoring this difference is problematic. Further, Klare's definition also connotes that the state will be running on just the essentials, or the bare minimum required to operate the economy. But, the political elites in both states are forced to respond to domestic demands; consumer requirements in the U.S. and energy required for continued development in China. For these simple domestic reasons, the bare minimum amount of energy required is simply not feasible over the long-term. However, the inclusion of international crisis or conflict does add a useful dimension to the debate. In a sense, that is the reasoning behind strategic petroleum stockpiles held by many countries.

Michael Klare also views energy security as a very state centric proposition, where the government has a strong role. Many countries operate national oil companies (NOCs), where the state's involvement is obvious. But, the state also plays a large role in Western countries relying on private firms, albeit the role is not as overt as with NOCs. While a hands off approach is taken, governments tend have an active role due to the

[137] Michael T. Klare, "Energy Security," in *Security Studies: An Introduction,* ed. Paul D. Williams, (New York, NY: Routledge, 2008), 484.

importance of energy.[138] Klare also believes that the state's role should be making sure the correct inducements are in place for private energy firms to provide suitable supplies of energy, and when the private sector is unable to fulfill this role, the state must intervene.[139] Klare does begin to clue readers into the how and why of energy security. He makes a distinction between national oil companies and privately owned oil companies, and cites their different approaches as a result. But since this study involves two net oil-importing states, it doesn't make any actual distinction over the respective company approaches.

Another workable definition of energy security is "assurance of the ability to access the energy resources required for the continued development of national power. In more specific terms, it is the provision of affordable, reliable, diverse, and ample supplies of oil and gas (and their future equivalents)–to the United States, its allies, and its partners–and adequate infrastructure to deliver these supplies to market."[140] This is an all-encompassing approach, yet narrower in some key areas. The development of national power, assuming the inclusion of sustainable economic growth in line with Realist thought, is a good approach, since this would be the end goal. Another interesting aspect is the inclusion of not just the United States, but also its allies and partners. China has to worry about this less, but the United States certainly has commitments and stakes

[138] Ibid.

[139] Ibid.

[140] Jan H. Kalicki and David L. Goldwyn, "Introduction: The Need to Integrate Energy and Foreign Policy" in *Energy and Security: Toward and New Foreign Policy Strategy*, eds., Jan H. Kalicki and David L. Goldwyn, (Washington, DC: Woodrow Wilson Center Press, 2005), 9.

involved with its global allies. It is important not to forget this, as nearly all energy analysts do. Additionally, the inclusion of proper infrastructure is important as well. For instance, China may soon have new sources of natural gas available, but without the proper pipeline network to get the supplies to where they need to be, they may as well not have those sources in the first place. However, there is no framework in place in order to understand how this is accomplished and why states would choose separate paths in achieving these goals.

It's also important to understand that the majority of "everyday" threats to the supply of oil come from "revolution, civil unrest, economic collapse, and acts of terror … [and] these threats can only be addressed by conflict prevention and diplomacy, not by deterrence."[141] Furthermore, the U.S. is specifically engaged in the task of preventing major impacts or shocks on the global economy as the result of considerable supply disruptions or price volatility.[142] This is helpful, since it should be kept in mind that primary threats to the energy security of states may not be the result of state-to-state interactions, but more frequently the result of economics or terrorism. All of this must be included in the approach. This helps to broaden the concept of energy security and to understand it exists on multiple levels of analysis. But, why do states choose to develop resources in such tenuous parts of the world? Why does China do this in some cases, but not in others? What causes the United States to make similar choices?

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[141] Ibid.

[142] Ibid., 10.

With the core definition of energy security in mind – reliable supply at affordable cost – a more practical approach comes from Daniel Yergin, describing energy security as something that cannot be attained without proper global engagement. Developing robust security and economic programs and responses to a state's energy supplies overseas is essential to the security of those supplies. Developed as a reaction to the 1973 oil shock, he describes the current energy security "system" as designed to coordinate and inform the efforts of OECD countries to secure supplies and deter any future use of the "oil weapon," centered around the International Energy Agency, petroleum stockpiles, and emergency sharing.[143] Within this framework, diversity of supply, buffers against shocks, integration with the global oil market, information sharing, acceptance of oil market globalization, and full supply chain protection.[144] This is, and has been, a robust approach to energy security, especially for the OECD countries, but fails to take into account bilateral or unilateral efforts to secure energy supplies. This is especially important in the case of China, since they do not fully integrate their energy security policies with the IEA and OECD because of a lack of trust towards the West. Furthermore, energy security with that approach was designed to counter the use of the "oil weapon," which is of considerably less threat to the energy security of states today as compared to myriad other threats. It also does not fully account for the full spectrum of U.S. energy security policies, and leaves out responses made by China to secure their

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[143] Daniel Yergin, "Ensuring Energy Security," *Foreign Affairs* 85, no. 2, (2006): 75.

[144] Ibid., 75-77.

supplies. In that vein, why is China not integrated in the IEA as such a major energy consumer?

It is also important to note the interaction between China and the United States in terms of energy security. Yergin mentions that "some in the United States see a Chinese grand strategy to preempt the United States and the West when it comes to new oil and gas supplies, and some strategists in Beijing fear that the United States may someday try to interdict China's foreign energy supplies."[145] This will be explored in depth later in this research; not only are both striving to find ample energy at low enough prices for their respective economies, but their size and suspicion towards one another puts them in direct competition for global supplies. As with any strategic interaction, "each actor's ability to further its ends depends on how other actors behave, and therefore each actor must take their actions into account."[146] Energy will be a pillar of Sino-American relations for the next several decades, with the possibility of causing conflict. However remote that may seem, it is important to keep in mind that competition for energy will likely serve as an exacerbating feature in an already existing issue between the two consumer giants. This has the greater probably to draw these states into diplomatic or, even, military conflict, making energy security exceedingly important. A principal point is drawn from this: when two disproportionately large energy consuming states exist at

[145] Ibid., 77.

[146] David A. Lake and Robert Powell, "International Relations: A Strategic Choice Approach," in Strategic Choice and International Relations, eds., David A. Lake and Robert Powell, (Princeton, NJ: Princeton University Press, 1999), 3.

the systemic level, they will be put into direct competition with one another for energy supplies, threatening the energy security of each other.

Among the many ways to view energy security, or insecurity, is to examine political effectiveness or ineffectiveness and the resultant lack of a sustained policy approach. This is especially true in the case of the U.S., where "the lack of sustained attention to energy issues is undercutting U.S. foreign policy and U.S. national security."[147] Since 1973, the U.S. has approached energy policy in a very disjointed, *ad hoc* manner, whereas China has had a more concerted, steady approach to certain parts of its energy policy since 1993. This certainly affects the respective security of the two states. The Council on Foreign Relations piece, however, does not begin to approach the underlying issues that contribute to the different policy approaches by the two states.

Other approaches to energy security may even seem to be good, effective solutions; however, they are not. For instance, energy "independence" and equity deals made with producer states are also seen as a way by many, especially in the policy circles, to ensure energy security by analysts on each side. But as mentioned above, many approaches to energy security are poorly supported by the facts and are ineffectual. Phillip Andrews-Speed finds great fault with the idea of energy independence as a viable way to secure a state's energy future. He writes, "China's ignorance of the nature of international oil markets and its feeling that they were dominated by Western, especially

[147] John Deutch and James R. Schlesinger, *National Security Consequences of U.S. Oil Dependency, Independent Task Force Report No. 58*, Council on Foreign Relations, 2006, 3.

U.S., interests resulted in a reluctance to be dependent on these markets and a preference to seek a high degree of control over the full supply chain."[148]

In a similar vein, Yergin finds that for increased energy security, the entire global system must be viewed as a whole, and not just as individual states. Protection of the global infrastructure and supply will realize secure supplies for consuming nations far better than individual, mercantilist approaches.[149] On the U.S. side, per one of the earlier definitions, we have already pointed to weaknesses for U.S. energy "independence" for simple reasons such as global commitments and alliances. But other, lesser known reasons crop up as well. In 2005, after Hurricanes Katrina and Rita hit the gulf coast of the U.S., damage was widespread to the electric grid, shutting down refining capacity all along the coast, crippling the ability of the U.S. to refine and process petroleum, disrupting supply from domestic sources for a significant period of time.[150] Restricting sources of energy to the U.S. Southeast in this case reduced flexibility and diversity of supply in the face of a major disaster and prolonged energy shortages in the region. This situation illustrates the interdependence of energy infrastructure and turns energy independence on its head by demonstrating a weakness of that independence. Relative independence in this case meant a decrease in the diversity of supplies and energy sources available. While these scholars have rightly pointed out critical errors in

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[148] Philip Andrews-Speed, "Do Overseas Investments by National Oil Companies Enhance Energy Security at Home? A View from Asia," in *Oil and Gas for Asia: Geopolitical Implications of Asia's Rising Demand*, eds., Philip Andrews-Speed et. al., (NBR Special Report no. 41, 2012), 38.

[149] Yergin, "Ensuring Energy Security," *Foreign Affairs*, 78.

[150] Ibid.

approaches to energy security, many states still continue to pursue these somewhat futile paths to securing energy supplies, without offering any detailed reason as to why.

The meaning of energy security may also shift somewhat over time due to international politics and the evolution of energy markets. The pre-1990s system of cheap energy,[151] excess Saudi and OPEC capacity, lack of environmental concern, and a dearth of interest in oil efficiency, alternate sources of primary energy, and reductions in nation-wide oil intensity, has gradually given way to markets subjected to extreme price volatility, increasing capital requirements, environmental concern, all underpinned by the dramatic rise of consumption in Asia, along with the global growth and dominance of state-run national oil companies (NOCs) over global reserves.[152] There are more NOCs out there in control of more oil and gas than the independent, Western international oil companies (IOCs). Global warming and its calamitous potential have caused a great push towards efficiency and renewables. Importantly, "energy consumers, and many producers, now realize that the days when enhancing energy security was simply a matter of increasing the size and diversity of supplies are over: now energy security also means implementing policies designed to reduce the demand for energy."[153] These are not minor changes to the global energy landscape, and have altered approaches to security. And if, for instance, new issues like demand reduction are so important, why has the

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[151] Referring primarily to the oil supply glut in the 1980s.

[152] Andreas Wenger, Robert W. Orttung, and Jeronim Perovic, *Energy and the Transformation of International Relations: Toward and New Producer-Consumer Framework,* (New York, NY: Oxford University Press, 2009), 4.

[153] Ibid.

United States had such a lackluster response to demand, and why has Chinese demand continued to grow at such a high rate? These are questions left unanswered.

Aside from fundamental changes to the structure of global energy, short and long-term impacts of actions must be examined as well. For instance, in 1973, the oil weapon was able to extract short-term concessions, but OPEC oil producers in general suffered over the long run as a result. The shock led to a rapid rise in oil prices, and caused immense economic strain in Western economies; but overproduction and the drop in global demand brought down the price in the long run.[154] Any power gained by OPEC was illusory and short-lived, and ultimately the producers sacrificed their own energy security as a result. The system did not favor the producers over the next decade; they were too dependent on the West as an export market and for ensuring the security of maritime trade routes for oil supplies.[155] After the shocks of the 70s, the oil market settled into a system whereby the U.S. provides security and Saudi Arabia has to ship oil to market and maintain spare capacity.[156] Energy security for Saudi Arabia meant a military alliance with the United States in order to secure the safe transit of oil supplies and for overall demand security. "The Middle East was interested in preserving the Western market for its oil. In return, the West took increasing control over economic and military security in the Middle East region."[157] These efforts stabilized the global supply of energy and Europe leaned more on Russia for diversification. This favorable,

[154] Ibid., 29.

[155] Ibid.

[156] Ibid., 31.

[157] Ibid.

consumer dominated situation persisted until a short time after the Asian Financial Crisis, and put the issue of energy very low on the agenda of the West. This period witnessed dependence on the part of producers towards their Western consumers: these customers were so secure that they would even apply energy sanctions and deny investment in many producing states.[158] And, given this narrative of the security situation in oil over the past 40 years, why is China consistently increasing reliance on Middle East oil during a time when power has adjusted more in favor of the producing states? Why is China not doing more to integrate in the global energy system to balance against possible negative outcomes? And, why does China seem to be so generous to many of these producing states as opposed to others?

The approaches to energy security discussed here are not exhaustive and mainly explore security from the consumer state's point of view. But, they tend to be representative of the typical approaches mentioned earlier. Some are quite broad and all inclusive, which at times lacks the ability to fully understand the full spectrum of possibilities, consequences, and trade-offs to certain approaches to energy security. Some other approaches are narrow and focused, but lacking in a way that would be appropriate for state policy on a national scale, and certainly not in a comparative approach between the United States and China. However, a common thread throughout these analyses is a dearth of understanding of the underlying dynamics of both states that drive them to take, and forgo, certain actions in pursuit of energy security. There are many different avenues to pursue in order to secure the supply of energy, but specific

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[158] Ibid., 32.

approaches are tailored to the specific situation of the state, and their resulting strategy for maintaining the overall security of the state. A broad approach must be taken with the necessary inclusion of grand strategy in these analyses.

And, should we care where our energy comes from? As Levi and Clayton note, there are essentially two camps approaching this issue: the economist that says no, oil is a single market with a more or less unified global price, and the strategist that says yes, it is a point of vulnerability.[159] It is the position of this research that the view of economists dominate under normal market and political conditions, however, the view of the strategist will ultimately prevail under times of political turmoil. In addition, states must prepare for future international political difficulties even if they are not experiencing them currently.

How Is Energy Security Connected to Grand Strategic Elements?

The components and assessments used to determine a proper grand strategy for a state permeate the levels of grand strategy horizontally and vertically, making all highly interconnected on another. As such, energy security, as a branch of grand strategy, has many of the same required calculations that must be made in order to properly assess and secure the state's energy supplies. Here, an appraisal of the military, economic, political, and diplomatic dimensions must be completed, along with a proper review of core interests, threats, and capabilities.

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[159] Blake Clayton and Michael Levi, "The Surprising Sources of Oil's Influence," *Survival* 54, no. 6, (2012): 107-108.

Much of the analysis of this research will be focusing on the heavily discussed availability, affordability, and reliability (AAR) components of energy security, since these actually tend to be measurable over the course of the study. However, before getting to AAR's measurable constituents, there are a few more steps for understanding the energy security of the state. First, look to the interests, threats, and capabilities (ITC) of the state. Any good grand strategist knows ITC must be kept in mind at all times, and at all levels of consideration. Wavering from these core concerns jeopardizes energy security, and national security.

Referring once again to Posen's work, he made reference to the different tools available to policymakers in order to meet their grand strategic objectives. These components rely on energy in the following ways:

Military Interest of Energy

The direct interest in energy of the military, and hard power assets of a state, is quite obvious. As General Patton put it, "My men can eat their belts, but my tanks have gotta [*sic.*] have gas."[160] A modern military runs on fuel. Without fuel, the air force would not exist. The navy would not exist. Support and supply vehicles, responsible for keeping service members on the ground in fighting condition, would not exist. Since the use of combustible fuels was put to widespread use beginning in the late 19th century with coal, fuel has been a major requirement for a military. Before the use of mechanized and

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[160] Chester Wilmot, *The Struggle for Europe,* (Westport, CT: Greenwood Press, 1972), 473.

industrial level warfare, the hi-tech predecessor in warfare was the horse, which reigned supreme as the premier battlefield combatant for nearly 6,000 years, since their domestication and widespread use. It was only little over a mere century ago that we made the jump from horseback to tanks, and sails on naval vessels to steam engines, and the combustion engine on warships. Without proper supplies of fuel in place, the military takes a century's step backward, placing it squarely in an antiquated, past generation of war fighting capability. Clearly, the military has direct, and myriad indirect reasons to support the secure acquisition of fuels.

Economic Interest of Energy

Energy as a national security interest is quite clear, given the state's direct interest in economic growth, which supports the overall resources and technological development of the state. This is the most proximate requirement for energy security: supporting the state through economic growth and advancement. Without energy for power plants, there is no power not just to keep people warm in their homes during a cold winter, and cook their food, but also to power the myriad industrial plants and manufacturing centers that support a modern economy. Additionally, the temperature control to keep normal working conditions, the lights so a worker may see, and a power outlet to plug in a laptop are all necessary components of an information age knowledge economy on the micro level. These same power sources power transportation throughout a city, whether by automobile or public transport in the form of a metro or dense bus network. These same fuels also power cargo transport giving rise to an industry where thousands of trucks crisscross the roads of every country picking up and delivering all types of goods. Transport by rail is widely used requiring yet more power, and this all does not even include the global shipping industry which accounts for the vast majority of world trade, where massive vessels cross the oceans and traverse the waterways of the world supporting an incredibly dense and flexible international trade network. Without energy, this all grinds to a halt; and, in particular this all is not possible without petroleum. Fuel used to underpin the global trade fleet is reason enough for petroleum to have a massive global impact, but it even goes beyond that. There are a staggering number of everyday and industrial products that require petroleum, or petrochemicals, either as part of the production process or as a necessary component, or ingredient.

Political (Domestic and International)

The population and political elite have an interest in energy as well. It's simple for the elites: the people need energy, and they need to deliver. Whether in a democracy, where a politician can be voted from office, or a dictatorship where if discontent becomes widespread enough, is able to overwhelm the state's security services, the elites need to be concerned about delivering the necessary fuels to the population at an acceptable price level. The population requires access to affordable fuels as part of their daily routines and commutes, and for many other purposes. Not only is fuel required for automobiles, but also is required for cooking and space heating. Transportation is integral to the economy and cooking and heating in some situations can be a matter of living a dying. As this is being written, the new president of Ukraine is engaged in a dispute with Russia over deliveries of natural gas. This affects not only Ukraine, but several European states as well. This is because a threat to the lives of the population when the gas does not arrive, and many people end up freezing to death.

The international component varies mainly along producer and consumer state lines, where the former is going to be concerned with maximizing not only profit from resource sales, but also political and even coercive power, and the latter is concerned not only with cheaper resources but also minimizing political entanglements and coercive power of producing states. In fact, the current structure of the global energy market is a direct consequence of the 1973 oil shock and the countermeasures employed by the Organization for Economic Cooperation and Development (OECD) states in the aftermath.

Political Climate

Perhaps one of the most detrimental failures of current and previous energy security scholarship is the lack of differentiation between variations in the political climate, which fundamentally alters a state’s approach to energy security. Take China as an example. China recognizes the efficiency and effectiveness of the global oil market, but does not rely on it completely because of security considerations. Under normal political conditions, China has no problem accessing, and profiting from these markets. However, if global politics were to shift, China would most likely need to rely on these markets far less than they have in the past 30 years if their principle adversary is the United States, which dominates global energy markets. In an extreme political scenario, China may be locked out of these markets, and will need to pursue energy security by falling back on bilateral agreements with resource suppliers around the globe. This does not even broach the subject of energy security in a completely hostile environment, constituting open warfare. These differing conditions need to be included in any analysis of energy security, for a full understanding of the energy security situation of a specific state. Many scholars and analysts, as seen in the section on energy security, do not take the “energy security” argument to its logical end, which is open warfare. The same goes for quantitative studies on energy security, where they typically even lack a minor conversation on the military component of energy security. That is, however, what is referred to when discussing the “security” of a state; steadfast preparation for war is crucial is to state security, and most arguments for energy security do not consider the “war” aspect in their conceptions. The following description gives a full understanding of this relationship:

Political Scenarios for Oil Security:

Normal political conditions: rely on market and typical ES mechanisms to provide energy security. Under this scenario, the global oil market is the most efficient means of oil security for both states.

Politically adverse/antagonistic conditions with the U.S./West: this is a scenario that includes an abnormal political climate, up to and including sanctions and other forms of economic warfare. This is the scenario that China has been preparing for over the past 20 years—a way to resist the first level of oil scarcity from the market. This is where more politically risky suppliers come in, continuing to provide oil to China, regardless of pressure applied by Western powers.

Open warfare: While China has been able to attain oil security in the previous areas, it is still woefully unable to compete in this zone, and will be for some time, since at this level there is direct military competition. China's comparatively weak military in terms of personnel, technology, doctrine, and joint operations capabilities, among others, simply do not allow meaningful competition outside its own littoral environment, putting at risk any overseas supplies within the reach of U.S. naval power.

Depending on the current operating environment, the states in question will require different approaches to securing energy supplies. A proposed comparative model of the United States and China follows in Table 2.1. Please note that this model could also be applied to numerous bilateral energy relationships.

Table 2.1: Political Scenarios and Supply Reliance

Political Climate	United States	China
Normal Political Conditions	Market	Market, Bilateral Deals
Politically Adverse Conditions	Market	Restricted Market, Bilateral Deals, Political Clout, Economic Influence
Open Warfare	Military, Market	Military, Political Relationships, Bilateral Deals

After accounting for the ITC of a state, and the operating political climate, we can begin to see the end results of these approaches as outputs in a state's energy availability, affordability, and reliability (AAR). Now a closer look at the AAR of a state is required to further analyze and compare. It is the outputs of these specific components that will be analyzed in the following chapters. While many of the indicators may not be directly related to these items, they will typically be connected in some way. For instance, the "sufficiently current extractable reserves" category listed below will have outputs measuring oil imports and domestic reserves, as well as the production of those reserves. It should also be noted many of these items do not fit neatly into single categories, can be used interchangeably.

A Note on Specific Energy Security Components

Most scholars tend to stop at availability and affordability when assessing energy security approaches, followed by a few issue areas, like the security of the Hormuz Strait, but this simply does not allow one to grasp the complexity of attaining energy security for the state, nor is it at the proper depth for an accurate analysis. In order to appropriately formulate policy approaches to energy, this research takes on a modified framework akin to that presented by Jonathan Elkind.[161] Utilizing that framework will allow a better grasp of the full range of objectives, threats, and capabilities afforded to various states in the system, and in particular, to the United States and China. The framework adopted here is reliant on Elkind's categorization; however, for the purposes

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[161] Jonathan Elkind, "Energy Security: Call for a Broader Agenda," in *Energy Security: Economics, Politics, Strategies, and Implications*, ed., Carlos Pascual and Jonathan Elkind, (Washington D.C.: Brookings Institution Press, 2010), 121-130.

of this research, it was modified to include some new components, and in other cases, some of the original components, especially those that constituted significant enough overlap, were eliminated. Notably, Elkind's entire section on sustainability was removed, because this was much more of an environmental discussion, something this research concluded does not belong in the security deliberations for energy supplies.

In this conception, we see the inclusion of a third branch, reliability, in addition to the typically discussed availability and affordability. This is preferred because separating this allows us to create a further distinct section apart from the politics and economics that are more dominant in the availability and affordability section. Breaking this third piece off allows a section that is more in tune to the military and security interruptions that can take place, ultimate thwarting a state's supply security. This is an important distinction to make, since these are clearly different issue areas, requiring vastly different assessments and responses by the state. It also makes more sense viewing the category as separate in light of its inclusion in grand strategy. A reliable, or resilient, energy security apparatus is clearly distinct from availability and affordability, as it is attempting to gauge how well the apparatus holds up against actual shocks, and how well it is prepared for such shocks in the future, without grossly affecting the availability and affordability of the source. Conceptually, this is important in order to consider the importance of time and adverse, unaccounted shocks to the energy market.

Essential Components for Energy Security

Availability

Sufficient physical infrastructure: this includes both domestic and cross-border energy related infrastructure. Oil doesn't do much good for a country if it does not have the requisite pipeline network to compliment petroleum inflows. The United States has a dense, highly developed pipeline network for oil, centered on Cushing, Oklahoma, which in turn reaches out all over the country. Most states do not typically have such a comprehensively developed internal oil infrastructure, and as such, is an import measure to gauge. Additionally, the United States continues to develop and attempt to develop this network internally, and across state borders.[162]

Sufficient currently extractable reserves: in this context, this includes both reserves from supplier states as well as domestically held extractable reserves. While reserves in supplier states can be important, this study will only consider extractable reserves which are domestically held proved reserves (1P or P90), meaning the reserves have a 90% probability of being developed at current technological and price levels.[163]

The ability of consumers, producers, and intermediate countries to agree on transit and price: this is a highly political matter. Economics provide a base platform for

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[162] Steven Mufson and Juliet Eilperin, Trump Seeks to Revive Dakota Access, Keystone XL Oil Pipelines, January 24, 2017, https://www.washingtonpost.com/news/energy-environment/wp/2017/01/24/trump-gives-green-light-to-dakota-access-keystone-xl-oil-pipelines/?utm_term=.dfa96bf804e1 (accessed February 15, 2017).

[163] Joseph F. Hilyard, *The Oil and Gas Industry: A Nontechnical Guide*, (Tulsa, OK: PennWell Publishing, 2012), 15.

negotiations, but many times the politics surrounding this area are quite volatile. Take the European Union, Ukraine, and Russia as a stark, case in point. In 2014, the new Ukrainian administration was refusing to pay Russia the higher cost of gas supplies sourced from Russia's state-owned natural gas company, Gazprom. These costs were mainly in the form of past debts and accumulated natural gas consumption that Russia is attempting to recoup, or extract, from Ukraine for political purposes.[164] At the time, Ukraine wasn't even allowing natural gas to flow through their network, and into the European Union network, which relies on Russian gas for the majority of its externally sourced domestic energy consumption. To compound issues, as with this case, these disputes usually flare up as winter approaches, increasing the bargaining power of the exporting country. A drastic political shift in Ukraine sparked this situation, and it only settled in an unstable state, with the constant possibility of renewed outbreak in hostilities between Ukraine and Russia. Europe needs gas and so does Ukraine. The transit state is the key, and can make or break supplies for an entire region.

Technological solutions and advancements throughout entire supply chain: while Elkind includes this component only in the availability section, it can be used all throughout the energy utilization process, from exploration all the way to consumption. For instance, vessel support and refining capacity are two other important areas that can be important and levered to technological advancement.

Capital investment: there must be a dense financial network available to support oil and gas operations, which can include everything from exploration and drilling, to financing

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[164] Paul Kirby, "Russia's Gas Fight with Ukraine," *British Broadcasting Corporation*, October 31, 2014, http://www.bbc.com/news/world-europe-29521564.

for research and development in smaller and midsize firms. Capital availability is crucial to these operations as is the efficiency of the use of capital itself. This can be skewed more towards capital provided by the state or by financial markets and other source of private capital.

Strong legal and regulatory framework: ensuring a level playing field and a strong institutional structure is important not only to energy, but to the overall functioning of the state, and economic development.[165] Perhaps more important, it is the competitive advantage this provides to foreign energy companies that require a stable environment in order to make investments that may last several decades.

Affordability

Low price volatility: stable energy pricing, for both the long and short term, is imperative for economies to run efficiently and effectively. If the price for a barrel of oil is $50 one week, and next week it shoots up to $90 a barrel, this can throw an inordinate amount of domestic consumers, industries, and companies into complete disarray.[166] Any companies involving transportation, or relying on transportation for pick-up and delivery of products – which is nearly the entire economy – would have to radically alter their estimates of profit and loss, not mention readjust pricing for all their products. Prices would be revised upwards, affecting inflation, and myriad sectors. This is a far bigger

[165] Daron Acemoglu and James A. Robinson, *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*, (New York, NY: Crown Publishing, 2012), 70-95.

[166] Robert McNally and Michael Levi, "A Crude Predicament: The Era of Volatile Oil Prices," *Foreign Affairs* 90, no. 4, (2011).

issue than simply driving up to the pump, and finding the fuel you put in your car has risen in cost by a significant amount. Without proper, stable, predictable pricing, there cannot be future planning, which would drastically impact investment and finance.[167] Having the huge price swings in oil witnessed in 2008, resulting in the commodity's record high of $147 a barrel on July 11th, is simply not feasible to have on a regular basis, while expecting a stable economy.[168]

Realistic expectations of future price: this accounts for the long-term pricing of oil. Whereas the previous pricing item dealt with short-term impacts on pricing, usually unforeseen, or political events, this deals with long-term expectations. Whatever would impact the cost 20 or 30 years from now needs to be reasonably accounted for and factored into economic and financial considerations.

Transparent pricing: readily available pricing information, which is not always necessarily accurate and available, is important to maintaining competitively priced imports, and maintaining steady costs over time. Much of this market relies on price reporting agencies (PRAs) like Argus and Platts, but even their methodology can be clouded at times, and there are significant areas of the energy market that do not have readily available pricing, or simply rely on reports from the companies and shipping agencies.[169]

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167 Bassam Fattouh, *Oil Market Dynamics Through the Lens of the 2002-2009 Price Cycle*, (Oxford Institute for Energy Studies: WPM 39, 2010), 18.

168 Catherine Clifford, "Oil's Record High, One Year Later," *Cable News Network*, July 2, 2009, http://money.cnn.com/2009/07/02/markets/year_oil/index.htm.

169 Bassam Fattouh, *An Anatomy of the Crude Oil Pricing System*, (Oxford Institute for Energy Studies: WPM 40, 2011), 30-35.

Prices that reflect full costs: primarily, this is in reference to states that spend large sums to subsidize oil and gas consumption among their population. This is very frequently found in states with energy abundance, since they can easily provide fuel at a lower price compared to market rates. This can be problematic, in that it has the tendency to drive up consumption and distort the overall energy market and pricing throughout the economy.

Reliability

Diversified sources along supply chain: this is perhaps one of the most important, and readily recognized, aspects of energy security. Churchill said it best when he stated, "On no one quality, on no one process, on no one country, on no one route, and on no one field must we be dependent." He went on to succinctly state, "Safety and certainty in oil lie in variety and variety alone." Diversification is one of the most important concepts with energy security, and was pursued early in the 20th century after Churchill recognized the inherent vulnerability in relying on overseas sources of oil, after converting the British fleet to use petroleum instead of coal. This should be diversity of source and fuel type.[170]

Reserve capacity for entire supply chain: without proper reserve capacity throughout the entire value chain, from source to gas pump, and small shock to the system will be unnecessarily magnified, and will result in price shocks. This can be national emergency

[170] For an analysis of diversification for oil-importing countries, see: Vlado Vivoda, "Diversification of oil import sources and energy security: A key strategy or an elusive objective?" *Energy Policy* 37, (2009): 4615-4623.

capacity, as with a country's strategic petroleum reserve, or spare production capacity as with Saudi Arabia's typical role as swing producer, maintaining a stable level of global spare capacity.[171]

Short and long term protection from political interruptions and terrorist attacks: nearly all countries have to deal with these issues and their impacts on energy either directly, or indirectly. For instance, the threat of an attack on Saudi oil infrastructure from domestic elements is a relatively frequent occurrence. The Saudis have developed many countermeasures for this, and these effective countermeasures serve to reduce Saudi risk as an exporter, but these threats can be potentially significant and should be taken seriously. If an attack occurs, decommissioning a pipeline in eastern Saudi Arabia, which brings petroleum from their mammoth Ghawar field to port in the Persian Gulf for transit, it has the capability to take millions of oil off the market daily.[172] Interruptions along the entire supply chain can impact supply and pricing.

How Can We Properly Conceptualize Energy Security Within Grand Strategy?

All of the categories listed in the previous section are important components that come together to form the intricate and complex web of energy security. They are highly interconnected, and transcend the military, economic, political, and diplomatic levels of

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[171] U.S. Energy Information Administration, "What Drives Crude Oil Prices? Supply OPEC," http://www.eia.gov/finance/markets/supply-opec.cfm (accessed July 23, 2015).

[172] Justin Williams, "Ghawar Oil Field: Saudi Arabia's Oil Future," *Energy and Capital*, Feb 19, 2013, http://www.energyandcapital.com/articles/ghawar-oil-field/3101.

grand strategy. Energy security in the context of grand strategy is something elevated to the utmost height of a state's security, meaning, access to adequate supplies (in the case of consumer states such as China and the United States) is a vital national security interest, ultimately resulting in a situation where these states will go to war over access to these supplies, and will treat significant supply interdiction as a primary threat to national security. Energy, and oil in particular, is something that will, in and of itself, force states to go to war, and as such, states go to great lengths to secure their energy supplies, taking multiple steps towards security, just as they secure themselves militarily, economically, and politically.

A grand strategy requires an understanding of state interests, threats, and capabilities to meet current and future threats, and for each of these, the state utilizes all political, diplomatic, and military resources at its disposal to meet these objectives. With the first, state interests, it should also be noted that energy security of some sort is considered a vital interest for all states in the international system, although how much and in what way will be determined on a case-by-case basis. For the purpose of this study, it is important to clarify that energy security, broadly speaking, is a vital national interest to both the United States and China. Additionally, their immense domestic energy needs and military, economic, and political capabilities oblige and allow both states to have aggressive and evolving energy security agendas designed to provide as much security as possible to each state. With this consideration in mind, viewing energy security on par with the other components of grand strategy is essential, and is viewed as such in this work. The same process applied to understand grand strategy, is applied to understand energy security. All of these concepts loosely come together in Figure 2.2:

Figure 2.2: Energy Security Determinants

Again, many of these concepts are interrelated and constitute grey areas that can easily have them found in other components of this model. So, this represents a best-fit, conceptual model of the process of energy security as a component of grand strategy. Energy is essentially on the same level as military and economic considerations when determining grand strategy. A state's ITC guides strategy at every level, and constitutes many unique components for each state. Further constraining a state's pursuit of energy security is the operating political climate, which can dramatically alter a state's pursuit of energy security. Finally, the output of the preceding components of the model can be seen and measured in the AAR after accounting for the political climate. However, since this study focuses on the 1993-2012 period, the analysis will focus on the "normal" political relationship, given this has been the state of affairs over the research period. It should be noted, however, that each state continually prepares for potential deterioration in the political climate, hence China's strong bilateral relationships and military buildup.

Chapter Summary

It should not escape the reader that grand strategy and energy security are vital to any state in question, shifting and posturing for potential future security or supply disruptions of any kind. This posturing is not just military posturing since that is not the only threat to energy security. Posturing can also include the economic and political dimensions. Changes in economic policy and taxation of companies may affect their ability to retrieve oil. Politics may deteriorate resulting in sanctions or cold war style containment policy affect the economic dimension as well. Internally, political order may deteriorate making extraction and export of strategic materials infeasible. Energy security consideration are inextricably integrated into all facets of state power and as such it is preferable to integrate energy security as its own domain within a grand strategic framework for any state, accounting for the specific energy related interests, threats, and capabilities appropriate for that state's specific national security profile. The following chapter will introduce indicators and measures of energy security as applied to the United States, following a short historical overview of U.S. specific grand strategy and energy security.

CHAPTER III

THE OIL SECURITY APPROACH OF THE UNITED STATES

> I said to you once that, next to winning the war, the most important matter before us as a Nation was the world oil situation. I feel this more strongly than I did when I made this statement … Despite everything, our supplies are falling below demand. Therefore, it behooves us to find supplies of crude oil elsewhere … this war has already demonstrated that, we cannot snuggle up to ourselves on the American Continent. We have assumed obligations in the world upon which we must make good. This means that we should have available oil in different parts of the world.
>
> Secretary of the Interior Harold Ickes, Letter to President Franklin D. Roosevelt, August 18, 1943[173]

Introduction

In the early 20th century, before China was reconstituted into a coherent state, unhindered by civil war and foreign incursions, the United States had gradually ascended to great heights of industrial and economic power, translating that wealth into a burgeoning middle class, heralding the era of the combustion engine and the automobile, and ever thirsty for oil. Given the domestic expertise developed in oil extraction and refining, the United States engendered a privileged position that endured through much of the century, witnessing political, military, and economic dominance underpinned by ample domestic sources of petroleum, the capability to secure overseas sources when

[173] Harold Ickes to President Franklin D. Roosevelt, August 18, 1943, Box 50, Folder "Saudi Arabian Pipeline," Series 3: Diplomatic Correspondence, FDR Library and Marist College, http://www.fdrlibrary.marist.edu/archives/collections/franklin/?p=collections/findingaid&id=502 (accessed April 2, 2017).

required, and the expertise needed to extract from ever more difficult sources. From the early development of the U.S. petroleum industry in Pennsylvania in the late 19th century to the supply availability in World War Two,[174] and to the naval dominance of the commons, the United States has been one step ahead of any conceivable competitor, dominating both industrial and technological power, and oil supply. The oil supply aspect of American power during the 20th century is essential, and integral.

The History of U.S. Oil Security

A coherent energy security policy on the part of the United States essentially begins with, and centers around, oil. Much of the approach for the United States was formulated during the initial global oil booms not only in response to the burgeoning auto industry, but later as recognition of the importance of oil to broader industry and military applications.

As with many oil discoveries in the 19th century, finding these resources was almost accidental. Oil seepage from the ground in Pennsylvania would eventually be developed and harnessed by a multitude of oil developers, and after the long process of whittling down competition amongst hundreds of drillers, the industry was quickly consolidated, mostly under the auspices of Rockefeller's Standard Oil,[175] and with the

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[174] Daniel Yergin, *The Prize: The Epic Question for Oil, Money, and Power*, (New York, NY: Free Press, 2008), 369-389.

[175] Roger M. Olien and Diana D. Olien, *Oil and Ideology: The Cultural Creation of the American Petroleum Industry*, (Chapel Hill, NC: The University of North Carolina Press, 2000), 21-54.

understanding the multiple developers under intense competition on the same oil patches, were quickly and prematurely depleting their own resources.

By this time, most U.S. concerns for oil were mostly domestic and being a relatively new country to be proactive overseas, the United States was a bit late to stake out claims in the Middle East, lagging behind the British and French. After spending much of the opening years of the 20th century at war with the oil industry, spurred on by Ida Tarbell's expose on Standard Oil, this quickly changed due to a single event: World War One. The war was important because it demonstrated that oil was emerging as an integral component to a country's defense materials, and therefore, this meant countries like the United States would need as much oil as they could possibly find. The post war world saw the Wilson Administration move to support and assist domestic oil companies in their efforts to go abroad for new sources. This was the beginning of the symbiotic relationship between government and the oil industry, and resulted mainly from pragmatic conclusions arrived at by the administration which understood not only the importance of oil to the military and industry, but also that the country was facing (perceived) domestic oil supply shortages (before Texas oilfields were developed), combined with drastic rises in demand, both of which resulted in rapid price increases.[176] This was also combined with the realization that other states were similarly developing their own overseas oil resources in order to enhance and maintain their own military power, especially the British, who famously under the auspices of Winston Churchill, then First Lord of the Admiralty, began converting the British fleet from coal power to

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[176] Yergin, *The Prize: The Epic Question for Oil, Money, and Power*, 199.

oil, even before the war. In short, after the war, there was in imminent and recognized need to pursue these resources wherever able on the part of the U.S., in stark contrast to the pre-war desire for these same companies to pursue overseas markets.

As the roaring twenties commenced, oil began to find a new demand outlet in the automotive industry, among others.[177] This was not a sure thing, as gasoline engines had to compete with both electric and steam driven automobiles, but the gasoline fed internal combustion engine finally won out, providing a new market for petroleum, in addition to the already existing lamp oil market. Further development of the oil industry was now not just a military matter, but a domestic matter as well, giving further impetus to expanding overseas.

Although the British were already established in Persia, U.S. oil companies made a dash for Middle East oil throughout the 1930s led by Standard Oil of California, which first struck oil in Bahrain, in 1932. The finds in Bahrain and Kuwait catalyzed increased interest in the Arabian Peninsula, and Standard Oil of California's (Socal) first discovery in eastern Saudi Arabia in 1938 caused an even more frenzied dash throughout the Arabian Peninsula, drawing out competition between the British and the Americans, vying for concessions from Ibn Saud. Oil was a primary overseas concern, right up to and throughout the Second World War, when the dash for Middle East oil was temporarily halted, where some areas had Allied orders to cement wells for fear of German capture, or where other areas were even bombed.[178]

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[177] Brian C. Black, "Oil for Living: Petroleum and American Conspicuous Consumption," *Journal of American History* 99, no. 1 (2012).

[178] Yergin, *The Prize: The Epic Question for Oil, Money, and Power*, 304.

The Japan situation is perhaps the first time where energy security deeply affected the material security of the United States by the accidental cut-off of oil exports to Japan in 1941,[179] catalyzing the subsequent actions taken by the Japanese Empire to redress its disadvantage in oil supplies. The direct consequence of the oil based leverage exerted by the United States led directly to an attack on its military facilities in Pearl Harbor, consolidation in Manchuria, and the effective loss of an entire oil-producing region, the Netherlands East Indies.

At this point, it's important to recognize the limits of using oil for coercion, as demonstrated by the strategic interaction between the United States and Japan during the lead up to the Second World War. There exists what can be termed a coercive threshold whereby once the state finally proceeds to carry out its oil threats, this in turn pushes the beleaguered state towards a rapid kinetic response before current fuel supplies run dry. Out of fuel, and out of options, the strained state will act like an injured animal backed into a corner; it will lash out because it simply has nothing to lose, and no other recourse.

As the Second World War wore on, another critical aspect of the war effort involved the United States ferrying supplies to the British. Despite their best efforts in Persia, and the greater Middle East, to source enough secure supplies of petroleum, and transport those supplies back to the island, they were simply unable to source enough of the needed supplies. Along with an assortment of much need war materials and desperate supplies, the United States ended up sending large quantities of oil to the British. And, as

[179] Irvine H. Anderson Jr., "The 1941 De Facto Embargo on Oil to Japan: A Bureaucratic Reflex," *Pacific Historical Review* 44, no. 2 (1975): 201-231; It should also be noted, at that time, Japan received approximately 80% of its oil imports from the United States, so any cessation of exports would prove to be fatal to Japanese oil supplies.

Daniel Yergin points out, it critically wasn't just oil, but refined petroleum products, in particular a new high octane blend that allowed British fighter planes to heavily out-perform their German attackers in the air.[180] Oil supplies were vital to the defense of Britain.

During this time, the development of long range pipelines were also developed as a countermeasure to the constant sinking of oil tankers by German U-boats, where a pipeline stretching from Texas oilfields to the east coast was constructed by 1943, bypassing the costly routes hugging the U.S. coast.[181]

Eventually, as the United States shifted into open warfare against the Axis powers, and abundant U.S. based oil proved to be even more vital to all the allied countries. U.S. oil flowed through all theaters of war, supplying the war effort against the German and Japanese forces. In direct contrast, the Axis powers simply did not have the necessary fuel to properly prosecute the war. Recognizing this weakness, Allied forces would eventually engage in a deliberate bombing campaign of German and Japanese oil infrastructure, targeting refineries and oil storage depots in their respective territories. The qualitative and quantitative oil and fuel advantage enjoyed by the Allied powers in the Second World War was a deciding factor in the outcome of the conflict. This was a hard truth learned: oil had been lifted to a preeminent position, and was absolutely vital to not only a country's economy, but to its military capacity.

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[180] Yergin, *The Prize: The Epic Question for Oil, Money, and Power*, 385.

[181] Ibid., 378.

After the war, both the U.S. and the British, more than ever, understood the importance of oil, and began to take further measures in the Persian Gulf to provide overseas supplies for domestic consumption, as well as for the rebuilding of Continental Europe. The United States quickly formed a relationship with the Saudis, solidified by President Roosevelt's secret trip after the Yalta Conference to meet Ibn Saud himself on a U.S. naval vessel near the Suez Canal. This high level meeting was a stark recognition of the importance of oil in the future of the United States and the world, and so one of the world's more interesting relationships was born.[182]

Middle East oil factored heavily into Cold War strategic concerns, not only to keep NATO countries supplied, but to also deny surplus supplies to Warsaw Pact countries,[183] and the United States ended up developing great sensitivity to any Soviet encroachments on the Gulf oil supply, beginning with their expulsion from Iran immediately after the war. Additionally, Marshall Plan assistance called for great amounts of oil to be shipped to Europe, generating new markets for Gulf producers (along with the oil companies) and creating energy sources for a continent embroiled in ideological struggle. And, as David Painter points out, there was further encouragement on the part of the U.S. government, when the emergence of fifty-fifty profit sharing was

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[182] Michael T. Klare, *Blood and Oil: The Dangers and Consequences of America's Growing Dependency on Imported Petroleum*, (New York, NY: Henry Holt and Company, 2004), 37-45.

[183] "Painter, "Oil and the American Century," *Journal of American History*, 29.

set to raise production costs for U.S. oil companies, the Treasury stepped in to absorb those costs through tax breaks.[184]

Despite the arrangement between the U.S. and Saudi Arabia,[185] there was, an emerging difficulty in the relationship between the United States and Middle Eastern producers: the partition of Palestine and the creation of Israel. This aspect of the relationship, as well as misadventures in places like Iran, would sour relations with the region, fomenting a difficult and contentious relationship that still exists today. It was also crucial for some of these states to maintain governments friendly to the United States, resulting in further complications and involvement in domestic affairs.[186] In addition to these political issues, many countries around the globe would begin to reassert their sovereignty over their own resources from multinational oil companies that were extracting and exporting supplies at favorable prices.[187] Broad assertion of states and renegotiation of contracts, in conjunction with political tensions would lead to another seminal moment in U.S. energy security: the 1973 oil shock, and the short lived shift of power from consumers to producers.

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[184] David S. Painter, Oil and the American Century: The Political Economy of U.S. Foreign Oil Policy, 1941-1954, (Baltimore, MD: John's Hopkins University Press, 1986), 165-171.

[185] Walter Pincus, "Secret Presidential Pledges Over Years Erected U.S. Shield for Saudis," *Washington Post*, February 9, 1992, https://www.washingtonpost.com/archive/politics/1992/02/09/secret-presidential-pledges-over-years-erected-us-shield-for-saudis/8252af1b-f6f6-43c1-985b-5385b59f90c2/ (accessed March, 7, 2016).

[186] Toby C. Jones, *Desert Kingdom: How Oil and Water Forged Modern Saudi Arabia*, (Cambridge, MA: Harvard University Press, 2010), 54-89.

[187] Valérie Marcell, *Oil Titans: National Oil Companies in the Middle East*, (Washington, D.C.: Brookings Institution Press, 2006), 37-53.

If anything, the Gulf States grew in importance to the United States, especially as it became clear the region was necessary to maintain stability in global oil markets. So important was Saudi Arabia, the Saudi government, with encouragement from the United States, heavily promoted Wahhabism, an extreme version of Islam, throughout the entire country and abroad, in order to short up domestic support, draw a contrast between The Kingdom and Iran, and to provide ideological fodder opposite communism which was slowly creeping towards the peninsula, especially with the Soviet War in Afghanistan.[188]

The shocks of the 1970s, especially the quadrupling of prices in 1973, demonstrated a need to revamp energy security and implement new policies designed to reduce dependence in the future. This was a learning process for Saudi Arabia as well, since they hindered their own long-term export security by taking these actions and alienating customers in the West. The U.S., however, engaged in a multinational effort through the Organization for Economic Cooperation and Development (OECD), composed of largely advanced industrialized, Western energy consumers, to create the International Energy Agency (IEA), based in Paris. The IEA would serve primarily as a coordinating mechanism for oil reserves from participating consumer states so that they would optimally prepare for, and react to, threats to energy supplies. This system is still in place today, and has been relatively effective, especially in its reserve requirements for all member states. However, the significance of these achievements pale in comparison to the market fallout from the politically orchestrated price increases. Through higher prices and government encouragement, multiple new non-OPEC producer states began

[188] Rachel Bronson, *Thicker Than Oil America's Uneasy Partnership with Saudi Arabia*, (New York, NY: Oxford University Press, 2006), 170-171.

exporting supplies to OECD countries, most notably from the North Sea and Alaska. For instance, within a month of the imposition of the price increases and embargo, President Nixon on November 16th, 1973 signed into law the Trans-Alaska Pipeline Authorization Act, removing any hurdles to the establishment of a pipeline from Alaska to the continental United States,[189] and a few days later, proclaimed the goal of energy "self-sufficiency" in an address to the nation.[190] While self-sufficiency remains elusive, the pipeline was completed by 1977. In addition, demand had dropped as a result of the crises by causing new levels of conservation[191] and the development of new technologies[192] to reduce consumption, most notably in automobiles. Both supply and demand were working against the OPEC producers, and even as they normalized exports to the West, there wasn't anything to be done, other than brace for the depressed prices of the 1980s.

The Carter Administration also had a prominent role to play in crafting an energy security response. Most notable was the explicit declaration that the Persian Gulf is a vital interest to U.S. national security, and any armed incursions would be met with a

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[189] United States Code, *43 U.S.C. 1651: Congressional Findings and Declaration, Chapter 34 Trans-Alaska Pipeline*, Pub. L. 93–153, title II, §202, Nov. 16, 1973, 87 Stat. 584, http://uscode.house.gov/browse.xhtml (accessed February 23, 2016).

[190] Richard Nixon: "Address to the Nation About National Energy Policy," November 25, 1973, eds. Gerhard Peters and John T. Woolley, *The American Presidency Project*, http://www.presidency.ucsb.edu/ws/?pid=4051 (accessed February 23, 2016).

[191] Especially through Corporate Average Fuel Efficiency (CAFE) standards implemented in the 1990s.

[192] Howard Geller, Philip Harrington, Arthur H. Rosenfeld, Satoshi Tanishima, and Fridtjof Unander, "Polices for Increasing Energy Efficiency: Thirty Years of Experience in OECD Countries," *Energy Policy* 34, no. 5 (2006).

military response. This led to the creation of the Rapid Deployment Joint Task Force (RDJTF), which would eventually become Central Command (CENTCOM). In President Carter's own words:

> The region, which is now threatened by Soviet troops in Afghanistan, is of great strategic importance: It contains more than two-thirds of the world's exportable oil. The Soviet effort to dominate Afghanistan has brought Soviet military forces to within 300 miles of the Indian Ocean and close to the Straits of Hormuz, a waterway through which most of the world's oil must flow. The Soviet Union is now attempting to consolidate a strategic position, therefore, that poses a grave threat to the free movement of Middle East oil … It demands the participation of all who rely on oil from the Middle East and who are concerned with global peace and stability.[193]

He proceeds to state explicitly: "Let our position be absolutely clear: An attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force."[194] After a decade of deteriorating U.S. ability to shape events in the Middle East, and Soviet encroachments on the region, the explicit nature of Carter's proclamation was quite important, and represented the culmination of several years of effort.[195] These shifting strategic and energy dynamics in the 1980s, along with the explicit declaration of Persian Gulf oil as a vital interest to the

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[193] Jimmy Carter: "The State of the Union Address Delivered Before a Joint Session of the Congress," January 23, 1980, eds. Gerhard Peters and John T. Woolley, *The American Presidency Project*, http://www.presidency.ucsb.edu/ws/?pid=33079 (accessed February 23, 2016).

[194] Ibid.

[195] U.S. Department of State, Office of the Historian, *Foreign Relations of the United States, 1977–1980, Volume XVIII, Middle East Region; Arabian Peninsula*, https://history.state.gov/historicaldocuments/frus1977-80v18/ch1 ; many documents here show an emerging trend of more and more concern for U.S. security in the region, and the establishment of increased military presence in the region based largely on Persian Gulf oil.

United States, lay much of the groundwork and operational capability for the United States in the Middle East in the 1990s and 2000s.[196] While the RDJTF was fashioned as a contingency based, non-NATO, joint operation global task force,[197] it was mainly developed for carrier-based deployment to the Persian Gulf as a deterrent force to the Soviet Union. Later, the designation would be modified, becoming U.S. Central Command (CENTCOM), and would act on its explicitly stated purpose to protect the Gulf by taking military action in 1991, halting Saddam Hussein's southern advance, and ejecting his military forces from Kuwait.

This force structure, strategy, organization, and business environment carried over into the modern area, and was merely solidified and refined, making adaptations and adjustments where needed. Although there were blunders along way, this strategy and the system it produced has been remarkably successful and continues to endure.

The Grand Strategy of the United States

The literature available on the grand strategy of the United States is well developed and coherent, with many similar themes, and fairly recent since the concept of grand strategy itself is rather new. One can surmise the explicit and implicit objectives of the United States from multiple sources. But, one objective is clear in the majority of the

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[196] Klare, *Blood and Oil: The Dangers and Consequences of America's Growing Dependency on Imported Petroleum*, 45-50.

[197] Paul K. Davis, *Observations on the Rapid Deployment Joint Task Force: Origins, Direction, and Mission*, (Santa Monica, CA: RAND Corporation, 1982).

literature: secure access to Persian Gulf oil and maintenance of global oil markets is paramount in America's grand strategic calculations. This grew primarily out of the need to "fuel" Europe's post-war development through the Marshall Plan, and since it has taken on a broader role for the markets as a whole. In addition, opposite China, the United States retains a high degree of strategic flexibility,[198] as the only true state that is not forced to derive and implement its grand strategy under significant security constraints in the post-Cold War period. This may be the defining feature of U.S. grand strategy in the contemporary era as a lack of peer competitors or even compelling threats to the country's interests and its citizenry, do not exist in a serious way, creating issues of their own, especially with the shift from threat-based strategic and military planning to capabilities-based planning,[199] which is lacking in strategic thought entirely, along with the propensity to manufacture threat.[200]

Despite deficiencies, there is still great continuity in U.S. grand strategy, with key aspects that stretch back nearly a century. A good place to start may be with an important overview of U.S. grand strategy from Robert Art, who has clearly delineated everything from the use of force,[201] to a current and past look at America's grand strategy,[202] to his

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[198] Fettweis, "Free Riding or Restraint? Examining European Grand Strategy," *Comparative Strategy*, 317.

[199] Christopher J. Fettweis, "Threatlessness and US Grand Strategy," *Survival* 56, no. 5 (2014): 53-55.

[200] Christopher J. Fettweis, "Threat and Anxiety in US Foreign Policy," Survival 52, no. 2 (2010): 73-77.

[201] Robert J. Art, "To What Ends Military Power?" *International Security* 4, no. 4 (1980).

[202] Art, *America's Grand Strategy and World Politics*.

proposed approach for a more effective grand strategy for the United States.[203] Over time, he has developed a rank-ordered list of grand strategic objectives that the United States has pursued for several decades.[204] First on his list is to prevent an attack on the American heartland. Threats to the heartland are meant to have the fiercest of military responses available. His second interest is the maintenance of an open economic order and to combat protectionism. Ranked third is the preservation of access to reasonably priced and secure supplies of oil from the Persian Gulf. In previous iterations of these rank-ordered lists,[205] Art specifically mentions oil from the Persian Gulf as a priority of vital importance to U.S. grand strategy even as a couple other components have shifted and changed. For instance, extremely important to U.S. grand strategy, and previously occupying the number two spot on Art's list is the prevention of great power Eurasian wars and the security competitions that make such conflicts increasingly likely. This he ranked as highly important, and would merit a military response, as was done in the two previous world wars and throughout the Cold War. His recent list places this at number four and shifts the language to simply the prevention of certain wars. In this category he places Europe, Asia, as well as attacks on Israel and South Korea. He rounds off his list with the promotion of democratic institutions where feasible and the support of humanitarian values. Art's list is important to this study for its consistence in ranking oil supplies from the Persian Gulf as vital to grand strategy and for his clear attempts at

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[203] Robert J. Art, *A Grand Strategy for America*, (Ithaca, NY: Cornell University Press, 2003).

[204] Art, *America's Grand Strategy and World Politics*, 190-192.

[205] Art, *A Grand Strategy for America*, 45-81.

reconciliation between not only interests but also the threats and capabilities of the United States to meet those threats, concepts that sorely need incorporation in the energy security literature.

With Art's rankings, one can clearly disseminate a hedging strategy through the various post-World War Two theoretical strands in pursuit of security and prosperity taken by the United States. The combination of realist and liberal approaches were determined to be the best way forward. The utilization of hard power with deterrence and military force where needed, in combination with the pursuit of a liberal interdependent global economy, and peace based on adoption of democratic governmental systems is the direct application of these theoretical principles developed over decades.

Other scholars like Christopher Layne promote a relatively more simple approach to U.S. grand strategy as being based primarily on expansion and hegemony,[206] but also highly inclusive of oil. Much of this expansion occurred during the Second World War, but the next phase occurred as the United States recognized its new interests in oil, specifically, Middle East oil. Layne believes that since the conclusion of World War Two, the United States has assiduously embarked on a campaign of expansion, and this expansion has naturally led the U.S. to bid for hegemony in the important regions of Western Europe, East Asia, and the Persian Gulf.[207] Layne makes the point several times, that this was an endogenously derived policy, developed by planners during World

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[206] Layne, *The Peace of Illusions: American Grand Strategy from 1940 to the Present*, 3-5.

[207] Ibid., 3.

War Two, and before the Soviet Union presented a major threat to U.S. security.[208] This he terms, "extraregional hegemony," and then clarifies the meaning of hegemony as being primarily about hard power and economic supremacy.[209] A hegemon has great military capability in a region and no other power can seriously damage that hard power. Economic hegemony consists of a "preponderance of material resources" securely available to the state.[210] As the war ended, the framework was in place before the emergence of the Cold War, and the U.S. acted quickly to establish a "postwar network of overseas air bases […] intended to ensure that the United States would not be stopped by water from projecting its power into Europe, East Asia, and the Middle East to prevent any potential rival […] from attaining hegemony in Europe or Asia, or threatening America's Open Door interests by cutting off access to Eurasian markets and raw materials."[211] The prevention of hegemony and extreme economic turmoil were advanced as key interests to U.S. security due to the accepted reasoning that such turmoil eventually has the capacity to contribute to conflict and war. But in particular, Middle East policy was oil driven and the emerging requirement to secure U.S. access to oil from the Middle East, including the sea lines of communication (SLOCs), generated new

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[208] This concept draws heavily from neoclassical realism. For an excellent source on the topic, reference: Steven E. Lobell, Norrin M. Ripsman, Jeffrey W. Taliaferro, *Neoclassical Realism, The State, and Foreign Policy*, (Cambridge, MA: Cambridge University Press, 2009).

[209] Layne, *The Peace of Illusions: American Grand Strategy from 1940 to the Present*, 7-10.

[210] Ibid., 4.

[211] Ibid., 45.

security commitments and concerns.[212] The Gulf particularly even drove Washington to include Greece, Turkey, and Iran as part of their security policy in the region, providing a line of buffer states that would assist in shielding Gulf oil from the Soviet Union. Layne explicitly states "America's regional strategic objectives – gaining control over Middle Eastern and Persian Gulf oil, and establishing the United States (at Britain's expense) as the region's dominant power – were fixed during World War II, well before U.S. policymakers became concerned about the Soviet threat."[213] The United States recognized the importance of retaining control of these regions for their own supply security, but also to deny that security to others, in order to increase dependence on the United States. As Layne points out, the United States worked to prevent Britain's re-emergence as a hegemon by forcing currency convertibility, opening British markets, and gaining control of Britain's raw materials resources, such as oil concessions in Iran, making the U.S. the dominant power in the Middle East.[214] As the Cold War progressed, the United States worked to prevent both Eurasian industrial production and additional natural resources, especially oil, from being harnessed by the Soviet Union and distributed to Warsaw Pact countries. Had Soviet expansion on this scale occurred it might have been able to overcome its industrial and resource deficiencies, enabling power projection outside its periphery.[215]

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[212] Ibid., 46.

[213] Ibid.

[214] Ibid., 47.

[215] Ibid., 55.

Colin Dueck catalogues the expanse of U.S. grand strategy since the beginning of the 20th century, bringing a degree of continuity based on the marriage between realism and constructivism as determinants of strategic culture. The manifestations of this are built on classical liberalism[216] and the idea of limited liability (the avoidance of costs and commitments),[217] generating grand strategic "sub-cultures" that shift over time, whether internationalist, nationalist, progressive, or realist.[218] The most recent iteration of this approach coalesces into a mostly unchanged strategy carried over from the Cold War. This, Dueck argues, is due to the "success" of the grand strategy (i.e., ending the Cold War) and the absence of any compelling reason for change, which meant a lot of the existing framework was allowed to persist, alongside a resurgence of the limited liability approach, leading to many half-hearted overseas ventures.[219] But, this still does mean the United States is incredibly active overseas, laboring to secure overseas assets.

More sources seem to corroborate many established grand strategy tenets of the U.S. For instance, leaked defense documents in 1992 demonstrate the desire to prevent peer competitors from rising to challenge U.S. dominance.[220] Due to the backlash from these leaks, the next guidance on defense strategy had to be modified so as to be more

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[216] Dueck, *Reluctant Crusaders: Power, Culture, and Change in American Grand Strategy*, 21-26.

[217] Ibid., 26-30.

[218] Ibid., 31-33.

[219] Ibid., 115.

[220] Patrick E. Tyler, "U.S. Strategy Plan Calls for Ensuring No Rivals Develop," *New York Times*, March 8, 1992, http://www.nytimes.com/1992/03/08/world/us-strategy-plan-calls-for-insuring-no-rivals-develop.html?pagewanted=all (accessed May 23, 2016).

palatable to liberal notions, and culminated in the release of new guidance from then Secretary of Defense Dick Cheney watering down the more aggressive components,[221] but still stating the U.S. desire to "preclude any hostile power from dominating a region critical to our interests"[222] and in reference to the Middle East and the Persian Gulf, to safeguard "access […] to the region's important sources of oil."[223] This is again demonstrated in the 2002 version, where it is again made clear the United States will not tolerate security threats, and will utilize preemptive measures to prevent such threats, among others.[224] George W. Bush's first National Security Strategy (NSS) also mentions vital interests and briefly mentions the enhancement of energy security.[225]

Bill Clinton's term was marked by a tug of war of differing grand strategies given the end of the Cold War and the primacy of the United States in its "unipolar moment."[226] Without a major threat to confront policy vacillated with a certain degree of indecision, but nevertheless formed a more or less coherent policy of "selective primacy."[227] As Posen and Ross demonstrate, cooperative security, selective engagement, and primacy all

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221 Secretary of Defense, Department of Defense, *Defense Strategy for the 1990s: The Regional Defense Strategy*, Washington, D.C., 1993.

222 Ibid., 4.

223 Ibid., 21.

224 The White House, *National Security Strategy*, Washington, D.C.: The White House, 2002, 12, 19, 20.

225 Ibid., 19-20.

226 Charles Krauthammer, "The Unipolar Moment," *Foreign Affairs* 70, no. 1 (1990), 23-33.

227 Barry R. Posen and Andrew L. Ross, "Competing Visions for U.S. Grand Strategy," *International Security* 21, no. 3 1996): 44.

had roles to play in U.S. grand strategy over the given period, and much of this is demonstrated in Clinton's National Security Strategy, *A National Security Strategy of Engagement and Enlargement*, where the language curiously shifts between these various aspects of grand strategy.[228] Impressively, when it comes to energy security, the security document is not shy about stating the importance of oil[229] and its place as a "vital interest" to the security of the United States and its allies.[230]

In George W. Bush's National Security Strategy 2006, there is mention of the typical security interests, but also explicitly mentions the dependence of the United States and its allies on foreign oil from unstable parts of the world as a key security challenge,[231] proceeds to dedicate an entire section to "Opening, integrating, and diversifying energy markets to ensure energy independence" by focusing on key energy security imperatives.[232] Interestingly, the 2006 NSS also unambiguously states concerns over the China-energy nexus. The administration cites non-transparent military

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[228] Ibid., 44-46; The White House, *National Security Strategy*, Washington, D.C.: The White House, 1995.

[229] There are 12 mentions of the word "oil" in document, more than any of the other national security documents surveyed. Furthermore, these mentions are in the context of supply security, without any concern for their environmental impact or attempts to shift towards renewables as we see in later documents. These mentions are in the context of deterrent threats designed to mitigate the danger posed by oil shocks and potential military incursions on the Saudi Peninsula.

[230] The White House, *National Security Strategy*, Washington, D.C.: The White House, 1995, 21.

[231] The White House, *National Security Strategy*, Washington, D.C.: The White House, 2006, 27.

[232] Ibid., 28-29.

expansion, China's attempts to "'lock-up' energy supplies around world," and the unqualified support of autocratic, resource-rich countries.[233]

Barack Obama's NSS is perhaps the least reflective of grand strategic and realist tenets. The loose reference to overseas security exists and there were references to energy security, although mainly regarding the diversifying of the domestic energy mix for a new energy economy and to combat climate change.[234]

The overall picture of U.S. grand strategy is one of select rank orders, defensible, vital interests, made secure by an internationalist, or expansionary foreign policy. At the core of these assessments of U.S. grand strategy is oil and the Persian Gulf. The overseas security apparatus of the United States has moved assiduously over time in order to secure key energy centers for it and the broader oil markets. This is a particularly secure position today, whereby the U.S. actually controls three of the key zones in the world that retain the greatest amount of oil and gas reserves: The Persian Gulf, Venezuela, due to U.S. dominance in the Western Hemisphere and close proximity to the U.S.,[235] and North America, including the United States, with its own sizable reserves.

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[233] Ibid., 41-42.

[234] The White House, *National Security Strategy*, Washington, D.C.: The White House, 2010, 1-6, 45, 47.

[235] It should also be noted, in the case of Venezuela, the reference is not to direct political control over the country, especially given the recent contentious political relationship between the two countries. It is strategic due to close proximity to U.S. shores, and commercially, Venezuela has limited options due to physical distance to other markets. Additionally, refining infrastructure elsewhere in the world that is capable of processing Venezuelan crude is non-existent or limited, leaving the U.S. as one of the few countries in the world that can process this crude in large quantities.

An Assessment of U.S. Energy Security

The United States has methodically worked to secure overseas sources of oil supplies as seen with its high level inclusion in grand strategy, and more specifically, military and political action in the Persian Gulf beginning with the stronger relationship forged by President Roosevelt and ibn Saud at the end of the Second World War. Eventually, the United States would become engaged in many areas to secure its oil supply both overtly and covertly. This has been a continuous security staple, and the United States has had the ability to dedicate the necessary resources to such a task; however, as the 21st century drags on, one of the biggest issues on the horizon is how the United States will respond to its oil and gas challenges in an increasingly multipolar world.[236] But, in the immediate past, the U.S. has clearly enjoyed a reign of preponderant military, economic, and political power. Using key aspects elucidated in the previous chapter, the strength of U.S. oil security begins to take shape.

Availability

Domestic Production:

A primary measure of availability is the amount of production occurring within a state's boundaries. Here, the United States, while blessed with reserves and production in

[236] Tyler Priest, "The Dilemmas of Oil Empire," *Journal of American History* 99, no. 1 (2012): 236-251.

the past, went into a state of steady, secular decline beginning in 1985. As a matter of fact, 1986 would be the last year U.S. production would surpass 10 million barrels per day until 2013. Over the course of these 27 years, some which are logged in Table 3.1 below, the United States reached a production low of 6.83 million barrels per day in 2006, and begin to slowly increase, until massive production increases beginning in 2011-2012 resulting from shale and tight oil production. Globally, production was increasing through the course of this study (except from 2005-07); however, so was demand, and global proved reserves were increasingly slow to be discovered, or were in decline, and of the fields that were discovered, they were less economically viable, and less suitable for production.[237] It was this supposed convergence between increasing production (the increased velocity at which oil is being removed from the ground) and declining reserves (the actual oil left in the ground) that fueled worries over "peak oil" by many analysts.[238]

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[237] James D. Hamilton, Causes and Consequences of the Oil Shock of 2008-08, Brookings Papers on Economic Activity, Spring 2009; James D. Hamilton, Oil Prices, Exhaustible Resources, and Economic Growth, October 2012, Prepared for Handbook of Energy and Climate Change by Routledge.

[238] Richard G. Miller and Steven R. Sorrell, "The Future of Oil Supply," *Philosophical Transactions of the Royal Society A* 372, no. 2006 (2014); David L. Greene, Janet L. Hopson, and Jia Li, "Have We Run Out of Oil Yet? Oil Peaking Analysis from and Optimist's Perspective," *Energy Policy* 34 no. 5 (2006): 515-531; Colin J. Campbell and Jean H. Laherrère "The End of Cheap Oil," *Scientific American*, 1998.

Table 3.1: Annual Domestic Oil Production (Mbbls/d)

Year	Production	Year	Production
1992	8,868	2003	7,362
1993	8,583	2004	7,244
1994	8,389	2005	6,903
1995	8,322	2006	6,828
1996	8,295	2007	6,862
1997	8,269	2008	6,783
1998	8,011	2009	7,263
1999	7,731	2010	7,552
2000	7,734	2011	7,868
2001	7,670	2012	8,892
2002	7,626	2013	10,003

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil Production, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

In Table 3.1, we can clearly see a 23% decline in production from the 1992 peak to the 2006 trough. Average production through the study was 7.87 million bbls per day with a standard deviation of .78 million bbls per day (780,000 bbls per day). The United States continues to lead in the development of new production technologies, and apply these advancements to enhance domestic and overseas production. The shale boom is only the latest, and perhaps most dramatic example of this occurring. Production ability and continuous innovation is a distinct advantage to companies originating in the United States.

Concerning refining operations, it is particularly interesting to note both the dominance of U.S. refining operations, paralleled to the massive increases in domestic refining capacity witnessed in China. For instance, global refining capacity had China at 4.1 percent of the total in 1992, while the United States had 20.4 percent of total global refining capacity. Fast-forward to 2013, when the United States had a slight drop to 18.8

percent of global refining capacity, while China's capacity grew to 13.3 percent of the global total, the result of a massive expansion of refining infrastructure. This is a 413 percent increase in refining capacity for China over the study period, while the United States witnessed a 15 percent increase over the study period. And, there is a great deal of continuity through slow growth on the part of the U.S. refining industry, as demonstrated in Table 3.2.

Table 3.2: Country-level Refining Capacity (Mbbls/d)

Year	Daily Amount	Year	Daily Amount
1992	15,120	2003	16,894
1993	15,030	2004	17,125
1994	15,434	2005	17,339
1995	15,333	2006	17,443
1996	15,452	2007	17,594
1997	15,711	2008	17,672
1998	16,261	2009	17,584
1999	16,512	2010	17,736
2000	16,595	2011	17,322
2001	16,785	2012	17,824
2002	16,757	2013	17,818

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil: Refinery Capacities, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Energy Infrastructure:

Core energy infrastructure in an international context is inherently those processes and equipment that move crude across national boundaries, and then efficiently and effectively distribute that product domestically. For the purposes of this study, only pipelines and ports will be examined. Without this restriction, it would be easy to then catalogue such items as highways and traversable roads throughout the country, where a tallied tanker fleet moved crude and refined products to their destinations. Or to count railroad tracks and the ability to move crude via rail. Cataloguing this would be excessive, especially since these components have other primary uses far beyond the transportation of energy products. But, ports and pipelines are eminently important and directly connected to energy security. Additionally, they are more directly connected to the global market as they are the primary points of ingress for crude.

Additionally, collecting data on pipeline length and capacity, as well as the number of available ports along with their capacity to offload crude, for use in a time series analysis has proven quite difficult due to data availability. However, it is possible to capture some of this information for various moments through the progression of each state's oil security. It also may be irrelevant, since the number of ports, lengths of pipelines, and their varying capacities are generally going to be unique to the requirements of the specific the country. Another problem with ports is the same problem mentioned above with highways and trains: they're not used just for oil, but for the millions of other products that pour in and out of both countries every year.

For those that believe pipelines are a vulnerable component of the supply chain, this may not necessarily be true. For instance, after decades of dealing with adverse internal conditions, Saudi Arabia has developed the capability to repair damaged pipelines within 36 hours with replacement materials placed along pipeline infrastructure and a rapid response by security forces.[239] Pipelines may be vulnerable during wartime,

[239] Anthony H. Cordesman and Nawaf E. Obaid, *National Security in Saudi Arabia: Threats, Responses, and Challenges*, (Westport, CT: Praeger Security International, 2005), 305-324.

but there is a cost to targeting these lines since they inherently would require constant strikes to keep them offline, given their ease of repair. They, however, would be invulnerable under normal or antagonistic conditions. The domestic oil and natural gas pipeline network in the United States is highly developed, and has been an effective means of oil transportation in and out of country, and around the country for many decades.

Ports have been an integral part of the economic success of the United States, and have been developed and renovated at increasing rates since the founding of the country. The cognizance was always in place that in order for the United States to maintain its own security, it would have to look towards the oceans on either end of the continent to find this security: both security from physical harms and economic security. Particular to oil, many ports were capable of taken in overseas crude, but this was taken into further account beginning in the 1950s when the United States began to import more oil. Since that time, the super tanker has come to dominate the seagoing crude trade, which is an important distinction because only large, deep-water ports are viable suitors for such large vessels to offload this cargo. The United States has several such ports, but relies primarily on the Louisiana Offshore Oil Port (LOOP) when importing from overseas.

Current extractable reserves:

Not too long ago, global extractable reserve growth was set to decline and many fields had declining production or were already in long-term decline,[240] which would have ushered in a new era oil scarcity, reducing overall supply and driving up prices dramatically in the face of increased global economic growth. However, new technology and techniques have been developed that drastically altered the amount of extractable reserves the United States, and indeed the world, could draw upon. In particular, the ability to profitably extract from tight oil deposits, particularly shale, has dramatically increased domestic reserves, reversing the potential scarcity that would have existed otherwise.

Reserves, for the purposes of this research, adhere to the strict definition utilized in the energy industry. Reserves here do not simply include oil-in-place (OIP), within a given territory, or under the control of the specific country or company. The definition here is the actual amount of recoverable oil that can be extracted at economically permissive levels, and is located within the sovereign's territory. Therefore, proved reserves, also referred to as 1P or P90, are utilized for the study, indicating petroleum that

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[240] Aleklett, Kjell, and Colin J. Campbell, "The Peak and Decline of World Oil and Gas Production," *Minerals & Energy* 18, no. 1 (2003): 5; Fatih Birol, "World Energy Outlook 2008," *International Energy Agency*, (Paris, FR, 2008) 37-49, 221-248; John Vidal, "The End of Oil Is Closer than You Think," *The Guardian*, April 21, 2005, https://www.theguardian.com/science/2005/apr/21/oilandpetrol.news (accessed April 10, 2016); Nick A. Owen, Oliver R. Inderwildi, and David A. King, "The Status of Conventional World Oil Reserves, -- Hype or Cause for Concern?" *Energy Policy* 38, no. 8 (2010); R.W. Bentley, "Global Oil and Gas Depletion: An Overview," *Energy Policy* 30, no. 3, (2002).

is profitable to produce with current technology and at current price levels. This is petroleum that has a 90% chance of being produced under current conditions. Probable (2P or P50) and possible (3P or P10) reserves, may be referenced, and it will be noted when either of these are used. Domestic reserves are, of course, given a premium in terms of energy security, given their strategically secure location within a country's borders. However, the reserves available to individual companies is eminently important as well, contributing to overall energy security under normal market conditions.

Especially interesting to note, in Table 3.3, is the trajectory of available proved reserves in the United States. There is a slow, but steady decline, with the occasional relapse, through the 1990s, and then a general plateau from 1999 to 2009, before rapidly climbing higher due to both higher prices and the U.S.-based shale revolution. The climb in reserves from 2009 to 2010 was 13%, 2010 to 2011, 14%, and 2011 to 2012 was 11%, meaning over the 2009 to 2012 period, proved reserves surged by 43%, giving the United States an important advantage in secure, domestic supply.

Table 3.3: U.S. Proved Reserves of Crude Oil (Bbbls)

Year	Proved Reserves	Year	Proved Reserves
1992	31.2	2003	29.4
1993	30.2	2004	29.3
1994	29.6	2005	29.9
1995	29.8	2006	29.4
1996	29.8	2007	30.5
1997	30.5	2008	28.4
1998	28.6	2009	30.9
1999	29.7	2010	35
2000	30.4	2011	39.8
2001	30.4	2012	44.2
2002	30.7	2013	44.2

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil – Proved Reserves History, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

In the interest of devising quantitative comparisons, the reserve amount is not as useful as it might seem. To understand this better, the reserve amount needs to be compared to other measures, especially since what may be large reserve levels for one state, may be exceedingly low for another. Energy demands owing to levels of development will be a critical factor to understand reserve amounts better. Alone, the amount simply doesn't reveal much about the level of dependency of the country on those oil reserves. For this, one could potentially use some metric, such as consumption in conjunction with the reserve measure. For this, a simple reserves-to-production ratio, modified to use consumption instead of production, is used to gauge the amount of time a country could survive cut-off from outside sources. The use of consumption instead of production should prove more accurate for energy security measures, since consumption is the true measure of the oil required for a country in a given year, instead of production, which may be modified for any number of reasons including increases or decreases in different refined fuel blends or products exports. In this sense, a country like Kuwait will have large production levels for export, despite having low consumption rates, meaning it is an inaccurate measure for its own domestic oil security. The study establishes the reserves-to-consumption ratio by measuring the amount of reserves in a given year by consumption levels in the same year, and can be found in Table 3.4. The output, given in years, may be a contentious figure, given consumption projections, price volatility, supply and demand, but it is a useful measure nonetheless. The amount of supply available given a set year of consumption can give a rough conception of the potential of an economy to run with a possible supply cut-off from overseas supplies of crude oil.

Table 3.4: Reserves-to-Consumption

Year	Annual Consumption (MMbbls)	Years of Supply	Year	Annual Consumption (MMbbls)	Years of Supply
1992	6,217	5.02	2003	7,312	4.02
1993	6,291	4.8	2004	7,566	3.87
1994	6,467	4.58	2005	7,592	3.94
1995	6,469	4.61	2006	7,550	3.89
1996	6,682	4.46	2007	7,548	4.04
1997	6,796	4.49	2008	7,113	3.99
1998	6,904	4.14	2009	6,851	4.51
1999	7,124	4.17	2010	7,000	5
2000	7,190	4.23	2011	6,891	5.78
2001	7,171	4.24	2012	6,748	6.55
2002	7,212	4.26	2013	6,893	6.41

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil: Consumption, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html
Author converted daily consumption figures to annual, and then calculated years of supply by dividing reserves by the annualized consumption figures, for each year.

Proved reserves are increasing in the United States, at the same time that broader consumption of petroleum and petroleum products is decreasing, increasing the years of available petroleum in the ground for eventual consumption by nearly 20 percent from 2011 to 2012. The majority of the period saw the average years of available supply at 4.6 years, and from 1992 to 2010, the period before the shale boom, the average was 4.3 years. This is a relatively stable amount, given the growth in demand and production over the period.

The stability of the reserve levels for the United States underscores perhaps a careful approach to the development and production of energy in the United States. There hasn't been a "rush" in the 20% century to develop reserves, and exploration and production has been kept steady. Only certain amounts of exploration and production of domestic sources has been allowed, and has maintained the stable level over the period of the study.

Capital Investment and Efficiency:

Without the necessary capital to fund operations and make costly investments, an oil company cannot operate, and its performance will suffer over the long-term.
U.S. energy companies have access to multiple sources of capital, and typically are able to raise funds for investments and purchases when required. However, this is dependent on the market, and all forces subject to it. In an environment, such as the 2007-2008 financial crisis, where credit was scarce, this may serve to hamper and restrict operations and capital investment, forcing companies to forgo opportunities and market share, in place of fiscal discipline. Capital markets, while plentiful and highly developed in industrialized economies, have the potential for volatility, owing to market fluctuations, which can be a potential risk to energy financing. Access to capital, but also the effective use of that capital is incredibly important. There is a widely accepted measure, popularized by Exxon Mobil, for capital efficiency in the oil and gas sector: return on average capital employed. This measure effectively demonstrates company profit as a percentage of the capital utilized in company operations. A company with a higher percentage indicates that it is able to get more profit out of its operations for every dollar spent. The average amount of capital is derived from the mean of the current and previous year’s capital employed in operations. The return is essentially net income with financing expenses added back in, taken as a percentage of the capital employed in the

given year. It should also be noted each company computes this metric differently, which means the ROACE listed on balance sheets is not fit for direct comparison between companies. The approach used in this research most closely follows the methodology utilized by Royal Dutch Shell, but is still modified for clarity and data availability.[241] The formula used is as follows:

$$\frac{net\ income + interest}{\begin{array}{c} total\ stockholder\ equity + short\ term\ debt + long\ term\ debt \\ + minority\ interests + capital\ leases\ (if\ available) \end{array}}$$

This is essentially a compromise measure based on an examination of this measure's use in the company reports of multiple oil and gas firms and more textbook oriented equations, with the results demonstrated below in Table 3.5. For instance, some will include special items, one-time expenses, or use earnings before interest and taxes (EBIT) interchangeably with net income.

[241] Ryan Opsal, "A Key Tool For Energy Investors," *Oilprice.com*, August 18, 2015, http://oilprice.com/Finance/investing-and-trading-reports/A-Key-Tool-For-Energy-Investors.html (accessed June 19, 2016).

Table 3.5: Return on Average Capital Employed (ROACE)

Year	ExxonMobil (XOM)	Chevron (CVX)	ConocoPhillips (COP)
2005	0.3	0.19	0.22
2006	0.33	0.23	0.19
2007	0.32	0.23	0.12
2008	0.36	0.27	-0.16
2009	0.17	0.11	0.07
2010	0.22	0.18	0.14
2011	0.26	0.22	0.15
2012	0.28	0.19	0.1
2013	0.18	0.14	0.12
Average for All Years	0.27	0.19	0.1

Source: Author's calculations based on data from company reports, Bloomberg Terminal company data, Morningstar, www.morningstar.com and NASDAQ, www.nasdaq.com. Company reports available at Exxon Mobil, http://corporate.exxonmobil.com/en/; Chevron, https://www.chevron.com ; Conoco Philips, http://www.conocophillips.com/Pages/default.aspx.

With these results, there is actually quite a range between the companies in terms of their capital efficiency. Exxon Mobil is, by a significant margin, the most capital efficient of the three, reaching an average almost three times that of Conoco Philips. These averages are then bundled together in a single efficiency ratio for the United States.

Affordability

Pricing and Volatility:

Supply and demand ultimately determine the price of petroleum; however, advanced financial markets promote the efficient pricing of commodities and at times can have more influence on pricing than overtly evident. In this case, the United States has the most advanced energy financial network in the world, centered on the WTI benchmark.

Export prices and volatility are both important components for the proper functioning of oil markets. Both affect everything in the market, from the final price paid by consumers to the ability to plan ahead into a stable or unstable environment. For instance, stable pricing is needed in order for companies to plan projects several years in advance, or for countries to plan geopolitical responses to adverse events impacting the supply and price of oil. In order to gauge these outcomes, it is import to recognize the required disaggregation of the "oil price" into proper terms. There isn't a single unified price of oil all over the world, albeit it is similar within specific categories of petroleum grades. For example, a heavier grade of petroleum will be priced similar to other heavier grades, and lighter oils will be priced accordingly as well. For this section, it is best to use the ubiquitous West Texas Intermediate (WTI) price for crude in the United States. This is the primary benchmark for oil produced in the United States and is used in some cases for imports from abroad. However, it is no longer used for oil imports from Saudi Arabia, and has been supplanted by the Price Reporting Agency (PRA) Argus Media's index, the Argus Sour Crude Index (ASCI), given its more accurate assessment for oil from the Middle East to the United States. However, this change only occurred in 2011, and the impact would be negligible to switch from WTI to ASCI for 2012, so WTI will be used as the main pricing mechanism for the price of oil in the United States. Looking at the price of WTI over the course of the study, shown in Table 3.6, one can plainly see the variations in the price of oil, and how difficult it is to predict with any certainty where the price will be too far in the future. However, owing to market mechanisms discussed here, the price of WTI has been relatively stable, with intermittent volatility as the market adjusts to face new realities. This is essentially how anyone would expect a market to operate, and oil bears this out.

Table 3.6: Annual Price of WTI Crude (West Texas Intermediate, 40 API, Midland Texas), USD per Barrel, and Volatility (Annual Standard Deviations)

Year	Price	Volatility	Year	Price	Volatility
1992	20.56	1.24	2003	31.1	2.21
1993	18.46	1.65	2004	41.45	5.62
1994	17.18	1.59	2005	56.44	6.01
1995	18.43	0.77	2006	66.05	5.24
1996	22.13	2.06	2007	72.29	12.64
1997	20.59	1.7	2008	99.59	27.78
1998	14.42	1.39	2009	61.69	13.18
1999	19.17	4.55	2010	79.4	4.56
2000	30.32	2.54	2011	95.05	7.36
2001	25.87	3.42	2012	94.14	7.19
2002	26.12	3.05	2013	97.93	5.02

Source: Quandl, WTI Crude Oil Price (ODA/POILWTI_USD), https://www.quandl.com/data/ODA/POILWTI_USD, sourced from Open Data for Africa, African Development Bank Group IMF Primary Commodity Prices August 2015, http://opendataforafrica.org/efkgejg/imf-primary-commodity-prices-august-2015, and International Monetary Fund, IMF Primary Commodity Prices, http://www.imf.org/external/np/res/commod/index.aspx , author took the simple average of the end-of-month price for each year to calculate annual price. Author also calculated the standard deviations for each year.

The data demonstrate a relatively stable price for the commodity over the first half of the study, from 1992 to 2002. The pricing remained largely smooth, averaging a price of $21.20 per/bbl with a standard deviation of $4.39 per/bbl, giving a range of approximately 21 percent on a barrel of oil over the ten year period. The second half of the study is where the numbers become more volatile. The primary reason for this price surge and volatility is emerging market demand growth, in particular, Chinese demand growth. The average price for the second ten-year period is $72.28 per/bbl with a standard deviation of $22.36 per/bbl yielding a range of approximately 31 percent on a barrel of oil. And, when accounting for not just annual averages, but for the monthly price, the standard deviation rises to $24.97 per/bbl, resulting in a 35 percent variation in the price per barrel.

Prices have increased beyond the level of inflation reflecting supply and demand and volatility has increased over the first ten-year period, almost reverting back to levels seen in the 1980s, where the standard deviation was $15.71, or 33 percent on an average of $48.10. While not that important, the price of oil is destined to change drastically over a twenty-year period, as we have seen with this study. When speaking of price stability, it is not necessarily a concern that the price rises or falls, even by significant amounts, so long as companies and economies have the necessary time to adjust to changes in pricing. No one would realistically attempt to predict twenty, or even ten years ahead, what the price of oil might be; this would be a fool's errand at best, and potentially destructive to anyone that would rely on such numbers. However, companies and economies should be able to project a few years ahead, with a certain degree of accuracy, what their energy costs will be, within a certain bounded range. Broken up into smaller data chunks, we can see the cost of WTI maintains stability and keeps with slow adjustments, except for 2008.

Short-term oil price is primarily the consideration of not only long-term supply and demand fundamentals, but the amount of excess supply in the system at a specific moment in time. This is the primary purpose of Saudi Arabia's vast reserves, used to stabilize and suppress prices if the situation calls for it.

It should also be pointed out that price volatility can take two forms; both pertinent for the U.S. and China. Oil price volatility is essentially a two-level situation where prices occur at the international level and the domestic level. Similar levels of price volatility will be seen at the international level for both countries; however, the domestic levels will differ due to domestic controls. Namely, many price swings and gyrations that occur then filter down to the consumer in the United States, positively, or negatively, impacting household income levels. However, in China, the companies themselves bear much of the brunt of higher commodity prices as they are still required to sell to domestic consumers, but at a capped price level, resulting in some cases, serious financial losses. This additionally demonstrates why Chinese companies are attempting to operate abroad as much as possible, in order to diversify their sources of income away from China, in order to reduce financial losses in such situations. The result, however, is that much of the price volatility in China is shielded from the consumers, owing stability to price fixing by the state.

Pricing for oil consumed in the United States is also mostly transparent. The pricing for oil arriving is generally derived from market conditions, reflecting the spot price of WTI or Brent Crude. The oil market also derives pricing indirectly from many long-term contracts that have been established, some of which have published information, many of which do not. Oil market intermediaries, most notably Argus Media Corp based in the United Kingdom and Platts, a division of McGraw Hill, based in the United States, both have a very involved role in pricing global oil supplies, as many of the global financial contracts, and most in the United States, are derived from pricing data generated by these two firms. For instance, Saudi Arabia, when contracting oil deliveries to the United States utilizes the Argus Sour Crude Index, relying heavily on the interpretation of the firm in the pricing of oil supplies. Much of the processes for pricing within both these organizations are transparent except for pricing derived from individual, forwards contracts in some cases.[242] The WTI and Brent markets represent the most sophisticated oil markets in the world including futures, options, and OTC derivatives, and contribute to the effective pricing of products and ample market liquidity.

It is also worth noting the increase in oil price volatility reflecting the increase in demand and tighter conditions in the global market. The standard deviations steadily increase over the study period, ultimately breaching double-digits in the 2007-2009 period, before dropping to still historically elevated single digit levels. This could be cause for some alarm if the trend of increasing volatility continues, as some suggest.[243] While tight market conditions resulting in increased volatility have yet to be realized, primarily into the tight oil and gas revolution we are currently going through, future demand increases and demographics mean this is a real possibility over the long-term.

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[242] For instance, reference Argus Media's Methodology: Argus Sour Crude Index (ASCI), 2015, Methodology and Specifications Guide, http://www.argusmedia.com/methodology-and-reference/ ; And see Bassam Fattouh, "An Anatomy of the Crude Oil Pricing System," *The Oxford Institute for Energy Studies*, WPM 40 (2011): 52-60.

[243] Robert McNally and Michael Levi, "A Crude Predicament: The Era of Volatile Oil Prices," *Foreign Affairs* 90, no. 4 (2011).

Reliability

Diversified Sources:

The United States has been heavily diversified in its overseas sources for many decades, and this diversity had somewhat plateaued during the period of the study. However, some sources where the U.S. increased its dependence, like Canada, are extremely secure and well established.

One of the more important sources of energy security is the diversity of supplies provided to the state. Diversity in an energy context not only means the number of external states exporting energy to the consuming state, but also diversity among the primary energy sources utilized throughout the government, business, and consumer sectors, the ability to switch between different fuels, as with new vehicles and some power stations, and the ability to use a diverse supply of petroleum products throughout the economy as well. However, in the context of this study, the focus will remain on the geographic aspect since we are dealing primarily with crude oil imports to the United States and China, and the diversity of geographic suppliers will remain the most risk-laden component.

There are surprising numbers of ways to look at diversity of supplies from a state's perspective. However, many of these approaches are flawed, and as such the approach developed here will attempt to refine some of these approaches. As a first step, the raw number of states supplying crude oil to the United States is a promising gauge: the more suppliers, the better. If one state is unable to supply the necessary oil, whatever the reason may be, there are plenty of other suppliers ready to step in and fill the gap. Table 3.7 shows the number of oil suppliers to the United States from 1992 to 2013.

Table 3.7: Total Number of States Exporting to the U.S. by Year

Year	Number of States	Year	Number of States
1992	46	2003	46
1993	45	2004	48
1994	45	2005	46
1995	55	2006	52
1996	50	2007	45
1997	44	2008	48
1998	41	2009	46
1999	52	2010	43
2000	43	2011	50
2001	44	2012	41
2002	46	2013	42

Source: United Nations Comtrade Database, United Nations, Trade Data Extraction Interface, HS Commodity Code 2709, Petroleum Oils, Oils from Bituminous Minerals, Crude, http://comtrade.un.org.

The number of U.S. suppliers is remarkable steady over the course of the study. There are some aberrations, but the United States steadily maintained suppliers from 41 to 55 throughout the course the entire period. This averages to 46.3 suppliers over the research period, with a standard deviation of 3.6, showing a tight band for the number of suppliers. Furthermore, there is no indication of changing patterns in the 1990s or the 2000s. The average number of suppliers from 1992 to 2000 is 46.8, and the average from 2001 to 2013 is 46, indicating a comfortable diversity of supply for the United States to be in the mid 40s. Interestingly, the lowest number of suppliers for the U.S., at 41, has been reached two times: the first, in 1998, potentially reflecting weakening global economic conditions, and the other, in 2012, most likely the result of the increases in domestic shale oil production. In 2013, the U.S. only added one supplier, and one could expect this trend to continue over the next decade, perhaps even witnessing the number of suppliers dipping below 40. The number of suppliers can be a telling figure, especially when compared to other states with the same energy demands, or when compared to other great powers.

However, in order to conduct a more in depth examination, going beyond the number of suppliers will be required. The United States has been able to approach diversity of supply from a privileged position compared to China, and has even been able to turn down supplies in the past if the political structure of the states was not acceptable to the U.S. and the West in general. For example, Sudan was frequently rebuked as a supplier because of the internal political issues.

Another innovative approach to measure diversity of supply is a technique borrowed from microeconomics and portfolio theory in finance. In this case, the Herfindahl-Hirschman Index (HHI) measures the variety of the supplies, and balances against the entire "portfolio" of suppliers. In finance, this measure is typically applied by asset managers to determine whether a portfolio is over-exposed to certain company sizes (small, medium, large cap), sectors (technology, energy, consumer durables), or geographical location (domestic and foreign, in addition to particular regions), and allows the manager to plan and adjust accordingly. In microeconomics, this approach is typically used to determine market concentration. This approach has been adapted and refined since introduced as a potential measure for energy security, but further refinement is needed. In this section, a basic HHI approach will be used, and further modifications will be made to produce a composite result in chapter 5. Using the standard HHI approach, with the following equation introduced in Chapter I, we can gain a better understanding of supplier concentration:

$$\text{HHI} = \Sigma\ ((\text{export share}_c / \text{total imports}) * 100)^2$$

or

$$HHI = \sum_{c=1}^{n} es_c^2$$

Where es is the export share of that particular country, c is the country in question, all of which is taken as a percentage over total imports multiplied by 100, and squared for the final product. This formula is applied to all suppliers to the country, regardless of supply amount, and calculated for each year from 1992 to 2012, as demonstrated in Table 3.8.

Table 3.8: Annual Herfindahl-Hirschman Index (HHI) Score

Year	HHI Score	Year	HHI Score
1992	1,336	2003	1,057
1993	1,082	2004	1,030
1994	1,069	2005	1,005
1995	1,104	2006	1,027
1996	1,094	2007	1,055
1997	1,135	2008	1,037
1998	1,077	2009	974
1999	1,005	2010	1,008
2000	1,061	2011	1,145
2001	1,088	2012	1,214
2002	1,044	2013	1,467

Source: Author's own calculations using UN Comtrade Data (United Nations Comtrade Database, United Nations, Trade Data Extraction Interface, HS Commodity Code 2709, Petroleum Oils, Oils From Bituminous Minerals, Crude, http://comtrade.un.org) and above HHI equation derived from multiple sources, including the U.S. Department of Justice (https://www.justice.gov/atr/horizontal-merger-guidelines-08192010#5c), but for a more detailed look, reference Stephen A. Rhoades, The Herfindahl-Hirschman Index, Federal Reserve Bulletin, Volume 79, Number 3, March 1993, pp 188-189.

Recalling from earlier, the lower the number, the better the score. In 1992, The United States started out with a relatively higher concentration of suppliers with a score of 1336, and then dropped to 1082 the following year. Starting in 1993, the United States remained in a tight band of approximately 1000 to 1100 for nearly 20 years. The highest level of diversification was achieved only in 2009, and afterwards, the U.S. broke out of the band in 2011, and as of 2013, has less diversity of supply than in 1992, owing to the adjustments resulting from the shale boom and increasing domestic supply. For all years, the average score is 1096, with a standard deviation of 111. From 1993 to 2011, the standard deviation was only 44, as a result of the tight diversification band achieved during those years, a remarkably stable number.

Short and Long Term Protection from Political Interruptions:

The ability of the United States to unilaterally respond to overseas political interruptions is perhaps unparalleled by any other country, and has acted to overtly and covertly guard global oil markets, and maintain the security of the Arabian Peninsula, in the past. Aside from military action, the ability of the United States and the protected market structure, to respond to politically induced oil shocks is high and resilient. As Gholz and Press go at great lengths to describe, the global oil market itself has four adaptive mechanisms that mitigate the risks to political disruption.[244] These mechanisms are: increases in production; private inventories; government controlled inventories; and

[244] Eugene Gholz and Daryl G. Press, "Protecting 'The Prize:' Oil and the U.S. National Interest," *Security Studies* 19, no. 3 (2010).

re-routing transportation.[245] All four of these mechanisms are nearly automatic based on the self-interest of market participants and have been tested for durability and robustness multiple times over the past 40 years. Due to the diversification of oil production beginning in the 1980s, increasing production in other parts of the world can typically offset, in a relatively short timeframe, any production loss in another country. Multiple global producing assets can fill this role,[246] and Saudi Arabia typically plays the role of swing producer, increasing output in case of interruptions or if prices climb too high or too rapidly. After production from a set of regional assets, oil is then transported with a flexible and resilient system of tankers capable of shifting routes if necessary. In many cases, the marginal cost increases of re-routing tanker traffic is not entirely prohibitive. These vessels are strong as well, many absorbing missile and mine strikes during previous conflicts, and still surviving with only light damage and casualties, ultimately able to deliver their payload.[247] And, there is no reason to believe this is any different today along key oil transport vectors, especially in the Gulf region.[248] Production and transport resiliency is key to bring in additional product, and then the private and government-controlled inventories allow for quick drawdown, providing crisis supplies

[245] Ibid., 457-463.

[246] Even more sources are available with tight oil and gas production at higher levels.

[247] Martin S. Navias and E. R. Hooton, *Tanker Wars: The assault on merchant shipping during the Iran-Iraq conflict, 1980-1988,* (New York, NY: I.B. Tauris and Co., 1996), 101-131.

[248] Joshua R. Itzkowitz Shifrinson and Miranda Priebe, "A Crude Threat: The Limits of an Iranian Missile Campaign against Saudi Arabian Oil," *International Security* 36, no. 1 (2011): 167-201.

giving time for the supply chain to re-orient and adjust.[249] This system has been a remarkably effective strategy where even global actors benefiting from higher prices are naturally incentivized to increase output in response to price rises.

Table 3.9: Government-Controlled Petroleum Stocks (SPR), Industry-Controlled Petroleum Stocks, and Total Petroleum Stocks (MMbbl/yr)

Year	Government-Controlled	Industry-Controlled	Total Stocks
1992	N/A	N/A	1,591.97
1993	587.08	1,060.14	1,647.22
1994	591.67	1,061.12	1,652.79
1995	591.64	971.21	1,562.85
1996	565.82	941.60	1,507.42
1997	563.43	996.33	1,559.76
1998	571.41	1,075.57	1,646.98
1999	567.24	925.69	1,492.93
2000	540.68	926.87	1,467.55
2001	550.24	1,036.11	1,586.35
2002	599.09	948.82	1,547.91
2003	638.39	929.92	1,568.30
2004	675.60	969.21	1,644.81
2005	684.54	1,013.06	1,697.60
2006	688.61	1,030.90	1,719.51
2007	696.94	968.40	1,665.35
2008	701.82	1,034.92	1,736.74
2009	726.62	1,049.76	1,776.38
2010	726.55	1,067.55	1,794.10
2011	695.95	1,055.54	1,750.09
2012	695.27	1,112.51	1,807.78
2013	695.97	1,065.40	1,761.37

Source: Energy Information Administration, International Energy Statistics, Annual Stocks, (https://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=5&aid=5&cid=regions&syid=1992&eyid=2013&unit=MBBL).

As can be seen in Table 3.9, both government and industry controlled petroleum stocks have enjoyed relative stability over the course of the study. The total crude stocks

[249] International Energy Agency, "Energy Supply Security, Emergency Response of IEA Countries, 2014," (2015): 29-37; Note: The government stocks typically need to be at least 90 days of oil consumption if part of IEA/OECD system.

of the United States comfortably exceed the minimum amount required by the IEA with plenty to draw on in the case of a crisis. And, the data show these levels continue to climb, with total stocks rising by 9.5% over the course of the time period shown, with much of that increased derived from increases in government controlled stocks, reflecting a concerted effort by the U.S. government to increase supply security in the face of price increases seen in the mid-2000s.

Oft mentioned in other contexts, U.S. command of the commons provides substantial security for the United States and its allies, at a level that no other power possesses.[250] Supremacy in the commons is of course a boon for oil security. Command of the commons is a crucial aspect of U.S. oil security that provides overwhelming support underpinning the entire global oil security apparatus. This has primarily a military dimension and although the commons have traditionally been thought of as "naval mastery,"[251] more recently the concept has also included both air and space, traditionally captured by the air force in the United States. For the purposes of oil security, pre-eminent naval power is still of the utmost importance, maintaining command over the SLOCs that all oil tankers traverse. It is important to understand no other great power could remotely challenge this position over the course of the study and the security of the commons is of the utmost importance to the entire oil market. From U.S. nuclear attack submarines (SSNs), to multiple Nimitz-class nuclear-powered aircraft

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[250] Barry R. Posen, "Command of the Commons: The Military Foundation of U.S. Hegemony," *International Security* 28, no. 1 (2003).

[251] Paul Kennedy, *The Rise and Fall of British Naval Mastery*, (Amherst, NY: Humanity Books, 1983), 9.

carriers (with a new more advanced class on the way), to the Marine Corp VSTOL carriers, and the myriad multi-mission cruisers and destroyers for carrier protection and patrol have cemented the primacy of U.S. naval power over any potential adversaries.[252] And, the "command" aspect is based more on tacit supremacy, not complete domination. Command of the commons does not refer to its denial to certain states, or their militaries, but instead that the United States reaps far more military benefits from the commons, and can convincingly deny their use to other states, and that in any contest for the commons, the U.S. would prevail in its denial.[253]

Furthermore, regarding long-term protection from political events, war is something that must be confronted in the case of oil security. This is not considered enough in studies of this nature, much to the detriment of our understanding of energy security. This is inherently a process heavily reliant on military power, as we witnessed during the Second World War and during the security competition during the Cold War. If, for instance, political interruptions are large scale and prolonged, albeit a rare occurrence, the mitigating factors of the oil market would ultimately not be able to cope with the loss of supply. In a hot, kinetic, military conflict, oil tankers cannot easily traverse the commons in order to deliver any sort of crude supply to any country, putting the whole system in jeopardy with such blatant vulnerabilities. This also goes for the potential for war, where obviously military power, and in particular, a strong naval presence, is of core importance for energy security. This places the United States in a

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[252] Posen, "Command of the Commons: The Military Foundation of U.S. Hegemony," *International Security*, 11-12.

[253] Ibid., 8.

uniquely pre-eminent position with its large, advanced, and highly capable naval force that has been in command of the global commons for over six decades. The ability of the U.S. to field such a force is next to none, and is unlikely to be supplanted in the near to medium term. However, this power has its limits, in the sense that the power can typically only be utilized to its fullest after war has already broken out. This will be discussed further in chapter 5. Furthermore, the United States has been especially active militarily in order to protect against perceived threats to energy security, especially regarding the Saudi peninsula. Active engagement with the Saudis on the global supply of petroleum has been a mainstay since the 1940s, and the United States has acted as security guarantor for the region and the Gulf.[254] Much of this was tacit, but the eventual creation of the Rapid Deployment Joint Task Force (RDJTF), and later the progression to Central Command (CENTCOM), solidified the position of the U.S. against the former Soviet Union on the issue of Saudi oil, and while politically active in the region to counter the Soviets, never engaged in full military operations to counter communist influence or control over vital energy supplies. The U.S. did eventually move militarily to counter threats by Saddam Hussein, resulting in the First Gulf War. The Iraqi military presented a colossal risk to Saudi stability, security, and their crucial eastern oil fields that fuel much of the world. The importance of this military power, without true peer competition on open water, provides a decisive strategic advantage, and essentially underwrites the security of the global energy apparatus. Gholz and Press identify the

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[254] Gary Sick, "The United States in the Persian Gulf: From Twin Pillars to Dual Containment," in *The Middle East and the United States: History, Politics, and Ideologies, Fifth Edition*, eds. David W. Lesch and Mark L. Haas, (Boulder, CO: Westview Press, 2012), 309-325.

short-term ability of global energy markets to absorb a multitude of shocks, but these responses would not be available without the appropriate military force available to subdue threats.

Military power is essential in other areas as well. Perhaps the most notable lapse in the security of the commons came in the latter part of the study where frequent attacks by Somali pirates caused an international stir with the high frequency of their attacks, and the systematic ransoming of crews and cargos. This is notable, as it is near shipping lanes that transport, among other cargos, oil from the Persian Gulf to the U.S. This was essentially tolerated for some time, but after escalation, the U.S. was forced to increase response and work within a multilateral framework with other countries to halt the piracy. While this level of piracy was not enough to pose a significant threat to the oil supply security of the United States, there were a few incidents for concern, especially when in 2011 pirates hijacked a Very Large Crude Carrier (VLCC), carrying 2 million barrels of petroleum that was headed for the Gulf of Mexico.[255] This is approximately one-fifth of the daily import volume of crude to the U.S., which is not an entirely insignificant amount. If this had occurred more often, it would have attracted the attention of the navy sooner, but the major threat to oil simply did not materialize, and was mostly subdued after the multinational force began securing these shipping lanes.

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[255] Jonathan Saul and Renee Maltezou, "Somali pirates capture oil tanker bound for US: Higher oil prices ahead?" *Christian Science Monitor*, February 9, 2011, www.csmonitor.com/World/Latest-News-Wires/2011/0209/Somali-pirates-capture-oil-tanker-bound-for-US-Higher-oil-prices-ahead (accessed March 27, 2016).

Conclusion

After rising to a privileged position early in the 20^{th} century, the United States has maintained that predominance highly effectively, engaging all instruments of grand strategy in order to retain general and oil supply security. On the indicators available, the data show the United States to be in generally secure position regarding its general oil security. This is due to both active domestic and foreign programs to secure and enhance the availability of oil supplies. Overseas engagement per its grand strategy is particularly successful as evidenced by diversity in its supply, price stability, and domestic stocks. But, much of this security is derived from less quantifiable elements like the command of the commons and security underwritten by the U.S. military that makes market based security possible, viable, and resilient.

CHAPTER IV

THE OIL SECURITY APPROACH OF CHINA

The implications of various aspects of China's rise, from its expanding influence and military muscle to its growing demand for energy supplies, are being heatedly debated in the international community as well as within China. Correctly understanding China's achievements and its path toward greater development is thus crucial … For the next few decades, the Chinese nation will be preoccupied with securing a more comfortable and decent life for its people. Since … 1978, the Chinese leadership has concentrated on economic development. Through its achievements so far, China has blazed a new strategic path that suits its national conditions while conforming to the tides of history. This path toward modernization can be called "the development path to a peaceful rise."

Zheng Bijian[256]

Introduction

Throughout most of Chinese history, energy security was an afterthought. Home to many advancements and "firsts" in global history, China was a latecomer to the industrial revolution, and still heavily relied on human-based energy for domestic economic activity well through the 20th century, while other parts of the world were steadily moving towards more mechanization and technological bases for their societies. This is striking considering the relative global economic dominance of China until the mid-19th century, when a conflation of factors radically altered China's position and power. However, despite the great lag in energy interest and comparative accessibility,

[256] Zheng Bijian, "China's 'Peaceful Rise' to Great Power Status," *Foreign Affairs* 84, 5 (2005): 18-24.

China did start to make weak attempts at developing domestic sources of energy by the early 20th century, and only to have its oil fortunes undergo a major positive shift by the mid-20th century,[257] catapulting oil to a central component of Chinese economic and political power.[258] This centrality of oil is often overlooked in the case of China, with the process more directly explained in the following paragraphs.

The History of Chinese Oil Security[259]

The history of oil in China begins in much the same way as it began in other countries in the late 19th century, with small quantities of crude seepage that makes its way to surface level, saturating topsoil, or creating oil slicks atop river and lake water, which is in turn sighted and collected by locals with rudimentary tools, and little knowledge of what they possess. Eventually, foreign geologists, chemists, and entrepreneurs would realize the capability of this material as an energy source, and first marketed it as a fuel source for lamps. As mentioned in the previous chapter, Standard Oil made their initial profits not from oil for vehicles and industry, but from kerosene for

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[257] Tang Xu, Zhang Baosheng, Feng Lianyong, Marwan Masri, Afshin Honarvar, "Economic Impacts and Chalenges of China's Petroleum Industry: An Input-Output Analysis," *Energy* 36, no. 5 (2011), 2905-2911.

[258] Mikael Höök, Tang Xu, Pang Xiongqi, and Kjell Aleklett, "Development Journey and Outlook of Chinese Giant Oilfields," *Petroleum Exploration and Development* 37, no. 2 (2010), 237-239.

[259] Components of this section were used to inform the following chapter: Ryan C. Opsal and Remi B. Piet, "China and the Significance of Energy Security," in *Energy Security and Environmental Sustainability in the Western Hemisphere*, eds., Remi B. Piet, Bruce M. Bagley, Marcelo R.S. Zorovich (Lanham, MD: Lexington Books, 2017).

lamps and lighting. But, just before Rockefeller, many elite perspectives surrounding self-sufficiency and autarky were already being formed, which would fuel oil independence and the domestic Chinese energy industry. China's formative "Century of Humiliation," beginning with the first Opium War in 1839, settled with European "spheres of influence" in a severely weakened, carved up China under the auspices of the Qing Dynasty greatly contributed to the core Chinese narrative.[260]

It was these opened Chinese markets that would give Standard Oil a new market centered on Shanghai as an emerging consumer of kerosene in the 1860s.[261] The business was well positioned at the time in the Asian market, providing a significantly cheaper alternative to whale oil, which was much less difficult to produce in the quantities required for proliferation and diffusion of the product throughout the local population that could afford to purchase the new fuel. The Shanghai market was certainly opportune, as the most international and advanced urban center of the country, capable of purchasing large enough quantities of the combustible import. Exports of kerosene to Shanghai surged,[262] turning it into a significant market for Standard Oil, and created the first petroleum dependency for China in the emerging oil era.

Eventually, a new role for oil emerged around the turn of the century: as a reliable and durable fuel source for private industry, multitudes of automobiles, and even military equipment, all wielded in one form or another by countries and economies around the

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[260] John K. Fairbank and Merle Goldman, China: A New History, (Cambridge, MA: Belknap Press of Harvard University Press, 2006), 187-254.

[261] Irvine H. Anderson Jr., *The Standard-Vacuum Oil Company and United States East Asian Policy, 1933-1941*, (Princeton, NJ: Princeton University Press, 1975), 15-38.

[262] Ibid.

world. As this shift was underway, contending European powers, and then Japan would recognize its importance and begin searching for new petroleum sources. After World War One, the European powers were severely weakened in China, and heaped yet another insult on the country by handing over German colonial assets to Japan, which then began to exert more control over China, especially in Manchuria, China's industrial heartland and the area with the most energy reserves available. Indeed, this region would eventually become the largest petroleum producing region in the country, but it would not be under Japanese control. As the Western powers became further consumed with their own affairs in Europe, Japan steadily emerged as the dominant colonial power in China, and would eventually be forced to contend with organized combatants in the Chinese civil war between the Communist Party on one hand and the Guomindong on the other. During their time in control of key territorial assets, Japan was never very successful in its search for oil in China, uncovering only a few minor fields in the northwest of the country. This presented difficulties for Japan as a resource poor island country in dire need of energy resources, particularly oil, and would drive its strategy in the interwar years, pushing it deeper into China and Southeast Asia. The Dutch East Indies was the key area for the Japanese to control, along with all the oil supplies derived from discoveries made by Royal Dutch Shell. Japanese officials were well prepared for this endeavor, and the assumed reaction by Shell staff, which was to destroy the oil producing facilities in the region and evacuate before Japanese forces arrived. The oil company staff did just that, but Japanese engineers were proficient and incredibly effective, able to have the facility operational and producing oil in around two months.[263] This was, however, all for naught as Japanese power was eventually rolled back in the region as the war raged on, and the country was deprive of the vital resources needed to prosecute a 20th century war.

Domestically, in the years leading up to the Second World War, China provided a theater for civil war and many attempts at locating new sources of oil by both contending factions and Japanese colonial forces. While Japan required oil for utilization in the military and broader economy, the Communist forces and Guomindong did not necessarily need to use oil as a fuel in their own conflict, but to harness and sell as a valuable commodity.

In the 1930s, the Chinese Red Army was able to produce small quantities of oil at Yumen and Yanchang after the importation of necessary equipment and techniques, although the amounts were quite limited.[264] Afterwards, the Nationalist Guomindong forces were able to capture and use Red Army excavation equipment for themselves, albeit with less luck than the communist forces.[265] In fact, all forces operating in China had little success in the discovery of new fields, where the Nationalist forces even operated a joint venture with the Soviet Union, ending in failure during World War Two, with further attempts made in Taiwan by Western firms to discover new fields, which also did not yield any successes, and of course Japan's attempts at exploration and

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[263] Yergin, *The Prize: The Epic Quest for Oil, Money, and Power*, 358-359.

[264] Tatsu Kambara and Christopher Howe, *China and the Global Energy Crisis: Development and Prospects for China's Oil and Natural Gas*, (Cheltenham: Edward Elgar Publishing Limited), 8.

[265] Ibid.

refining which were largely failures.[266] Despite the best efforts of the Japanese, Guomindong, and Communist forces, none were able to make significant finds on the mainland, especially not enough to satisfy domestic or overseas demands for energy.

After the victory of the Communist Party in China in 1949, a period of consolidation ensued, and the emerging partnership between China and the Soviet Union became a central pillar of China's energy security, with Mao requesting from Stalin, in 1949, that the most important specialists be brought over as soon as possible with expertise in "railroads, electrical energy, steel production, mining, the oil industry, and the military."[267] The Soviets conferred capital equipment, knowledge, personnel, advisors, and technology to China in order to develop their oil industry infrastructure, even allowing Chinese students to study petroleum engineering in Moscow, and sending experts to China to teach and otherwise transmit knowledge beginning in 1952.[268] Despite this assistance, it was not enough to produce any significant finds in the country. Given these events, China was ultimately forced to depend on Soviet oil supplies for the vast majority of its consumption, with imports totaling around 14 million metric tons (mmt) through the 1950s.[269] And, despite the gradual souring of relations between the two countries, these high imports from the Soviet Union would continue since it was a

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[266] Ibid., 9-10.

[267] Dieter Heinzig, *The Soviet Union and Communist China, 1945-1950: The Arduous Road to the Alliance*, (Armonk, NY: M.E. Sharp Inc., 2004), 227-228.

[268] Xuetao Hu, Shuyong Hu, Fayang Jin, and Su Huang, *Physics of Petroleum Reservoirs*, (Berlin, DE: Springer-Verlag Berlin Heidelberg, 2017), 3-4.

[269] Tatsu Kambara and Christopher Howe, *China and the Global Energy Crisis: Development and Prospects for China's Oil and Natural Gas*, (Cheltenham: Edward Elgar Publishing Limited), 12.

mutually beneficial economic arrangement, and China simply lacked any alternative sources for energy.

The deterioration in relations between the Soviet Union and China culminated in Khrushchev's recall of all Soviet advisors in 1960,[270] a number that had ballooned to 18,000 after Eastern European countries expelled their own Soviet advisors in 1956.[271] This was an extremely vulnerable position for China, politically cut-off from its patron, but highly dependent on the Soviets for its oil needs. Unable to rely on the small, insignificant oil fields in the country, these Soviet imports coupled with poor relations, created a perilous situation for China, both politically and with regard to energy.

At the young age of ten, and after an arduous and determined effort by the government, the PRC's exploration efforts finally paid off as it made its first significant oil find in 1959 with the discovery of the colossal Daqing field in Heilongjiang Province. As a result of this find, China's oil security position would be significantly altered from that point forward, as it was large enough to catapult China not only to energy independence, but also to the point where it would become a major exporter.[272] This find not only had practical economic and security implications, but also substantial positive ideological consequences. With ample petroleum available for domestic use, these circumstances effortlessly fit with Maoist ideology calling for a more autarkic approach

[270] John K. Fairbank and Merle Goldman, China: A New History, (Cambridge: Belknap Press of Harvard University Press, 2006), 378-379.

[271] Hong Zhou, Jun Zhang, and Min Zhang, *Foreign Aid in China*, (Berlin, DE: Springer-Verlag Berlin Heidelberg, 2015), 92-98.

[272] Xu Tang, Baosheng Zhang, Mikael Höök, and Lianyong Feng, "Forecast of Oil Reserves and Production in Daqing Oilfield of China," *Energy* 35, no. 7 (2010), 3097-3102.

to the national economy.[273] Energy was extremely important for these reasons, and by 1963, China was largely energy independent, especially as the leadership was willing to break autarky in the area of petroleum refining and import any equipment required for successful operations,[274] and would be aided by two new fields that would come online later in the decade.[275]

The well-publicized and propagandized domestic energy industry was so successful for the Chinese government, it would go on to become a model industry. It was taunted as an idealistic component of the national economy,[276] as an example for workers in other industries to follow, and produced such famous people's heroes as "Iron Man Wang."[277] Viewed independently of other global oil fields, the domestic oil industry was quite successful, especially when compared to other Chinese industrial programs. It grew in importance as output rapidly increased through the 1960s,

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[273] Nai-Ruenn Chen and Walter Galenson, The Chinese Economy Under Maoism, (New Jersey: Aldine Transaction, A Division of Transaction Publishers, 2011) 143.

[274] Kenneth Lieberthal and Michel Oksenberg, *Policymaking in China: Leaders, Structures, and Processes*, (Princeton, NJ: Princeton University Press, 1988), 182-183.

[275] James Dorian, *Minerals, Energy, and Economic Development in China*, (Oxford: Oxford University Press, 1994), 25.

[276] Lieberthal and Oksenberg, *Policymaking in China: Leaders, Structures, and Processes*, 178-179.

[277] "China's 'Iron Man' an Undying Legend," *People's Daily Online*, September 17, 2009, http://english.people.com.cn/90001/90776/90882/6760061.html (accessed November 22, 2014).

generating around 20 percent growth year over year,[278] and maintained a high degree of supply reliability, facts that did not go unnoticed by the party's cadre members.

Interestingly, through the tumult of this period, from the catastrophic Great Leap Forward, which placed added political pressure on Mao and the CCP due to decreased living standards, to the events of the Cultural Revolution that forced Mao to deploy the military to regain control of the country, the oil industry was essentially left untouched, and even prospered. For instance, during the Cultural Revolution, Premier Zhou Enlai, second in the CCP hierarchy only to Mao, powerful political figure, diplomat, and ally to Deng Xiaoping, took personal responsibility for the safety of the industry,[279] and even stationed military units throughout the country to guard oil fields, equipment, infrastructure, and personnel.[280] The effort to safeguard this vital industry was quite effective; oil production hardly dropped, and even eventually grew as the revolution wore on.[281] Production data indicate China was producing 292,000 barrels per day (bpd) in 1966 at the beginning of the revolution, only to have that number increase 50 percent by 1969 to a production level of 437,000 bpd, and then increase further to 1,746,000 bpd in 1976, the year of Mao's death.[282] This amounts to a five-fold increase in oil production

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[278] Author calculation based on data from: China Economic and Industry Database, CEIC Data, https://www.ceicdata.com/en (accessed November 7, 2014).

[279] Lim Tai Wei, *Oil in China: From Self-reliance to Internationalization*, (Singapore: World Scientific Publishing, 2010), 145.

[280] Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World*, 224.

[281] James Dorian, *Minerals, Energy, and Economic Development in China*, (Oxford: Oxford University Press, 1994), 25.

[282] Data derived from BP Statistical Review Workbook 2014.

over the course of the Cultural Revolution, an event by which most other measures proved to be extremely detrimental to the economy, society, and general well-being of the population.

Oil was centrally prominent, and this importance only grew with time. So much so the industry wasn't vital only as a resource meant to supply domestic fuel requirements, or even simply to fuel its military power, but for broader economic reasons as well. As the economy lay in tatters, China desperately needed funding and capital equipment for development and growth, especially after being cut off from the Soviet Union. Specifically, large quantities of foreign exchange would be required to purchase the necessary equipment and supplies for necessary for the economy. Oil was one of the only products of value to the outside world that China could reliably export to for hard currency in order to purchase the necessary capital equipment. After the Sino-American thaw, negotiations were quickly under way to import more foreign equipment and technology from both Europe and the United States. In particular, China was keen to draw on American expertise in advanced energy technology, while comfortable relying on Japan and Western Europe for more standard energy related capital equipment.[283] This process was actually wide-ranging enough to ultimately culminate in the unheard of transfer of military technology from a NATO member to China in 1975, when F-4 Phantom engine schematics, associated personnel, and factory equipment to allow for

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[283] Kim Woodard, *The International Energy Relations of China*, (Stanford, CA: Stanford University Press, 1980), 90.

indigenous production was made available by the United Kingdom.[284] The U.S. role in arranging the transfer of F-4 engine technology was covert due to potential anti-communist backlash, but the U.S. was active in other areas, including energy. The first energy-related equipment contracts were signed in 1973 consisting mostly of coal mining materials, but more important was the purchase of advanced seismic-survey equipment consisting of a Raytheon 704 computer and the U.S.-based training required to operate the system.[285] Additionally, large sales of chemical plants and eventually, more advanced, American made, offshore seismic exploration technology was sold by France in 1976.[286]

After the death of Zhou Enlai and Mao Zedong, both in 1976, a power struggle ensued between the “Gang of Four,” which included Mao’s last wife, and Mao’s successor as chairman, who had risen to premier after Zhou Enlai’s death, Hua Guofeng. While deftly handling the Gang of Four, Hua was unable to successfully counter the rise of Deng Xiaoping, who was quickly regaining power after his latest purge. In what would be a ruinous error for Hua, he and his coalition would base his political power on Mao’s legacy and steady funding from the oil industry would make development possible,[287] and a return to growth.[288] Progression, however, would falter, and Hua was

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[284] James Mann, *About Face: A History of America’s Curious Relationship with China, from Nixon to Clinton*, (New York: Alfred A. Knopf, Inc., 1998), 74.

[285] Woodard, *The International Energy Relations of China*, 90.

[286] Ibid., 91.

[287] Lieberthal and Oksenberg, *Policymaking in China: Leaders, Structures, and Processes*, 60-62.

unable to fulfill his political promises, especially to the three key factions supporting his rise,[289] one of which was the petroleum industry itself represented by Li Xiannian and his "Oil Kingdom Faction," and oil income itself was restrained.[290] This oil-funded optimism, however, was based on little more than the assumption that China's spectacular production growth would simply continue, and result in another doubling of production output within a few years. An actual reservoir analysis was not completed on the key fields, and when it came time draw on these additional resources, the additional oil simply wasn't available to export, damaging China's ability to import supplies for development, stretching resources,[291] and Hua's political reputation suffered.[292] What had been a spectacular oil growth story, ended in 1978, contributing to the downfall of Hua.

Chinese leadership at this time was desperately seeking pragmatic solutions to jumpstart economic growth and development, fearful that if they did not, the CCP may risk the loss of political power and eventual dissolution. Many avenues for growth were

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[288] Susan T. Shirk, "Internationalization and China's Domestic Reforms," in Internationalization and Domestic Politics eds. Robert O. Keohane and Helen V. Milner (Cambridge, MA: Cambridge University Press, 1996) 193-195; Luke Patey, *The New Kings of Crude: China, India, and the Global Struggle for Oil in Sudan and South Sudan*, (New York, NY: Oxford University Press, 2014), 85-87.

[289] Robert Weatherley, *Mao's Forgotten successor: The Political Career of Hua Guofeng*, (New York, NY: Palgrave Macmillan, 2010), 153-154, 164-165.

[290] June T. Dreyer, *China's Political System: Modernization and Tradition, Ninth Edition*, (New York, NY: Routledge, 2016), 120-122.

[291] Joseph Fewsmith, *Dilemmas of Reform in China: Political Conflict and Economic Debate*, (Armonk, NY: M.E. Sharpe, 1994), 109.

[292] Barry Naughton, *Growing Out of the Plan: Chinese Economic Reform, 1978-1993*, (Cambridge, MA: Cambridge University Press), 72-74.

explored, including a return to the structure used during the first and second five year plans, when growth was more stable; however, Deng Xiaoping would advocate the more liberal approach to economic development.[293] This was done more as a political maneuver to position his liberal faction opposite Hua's more conservative faction. This allowed Deng to circumvent the powerful heavy industry elites,[294] at their moment of weakness when oil funding fell through (which was meant to pay for modernization efforts),[295] taking the unfunded "Four Modernizations" with it,[296] and had a resulting loss in political capacity.[297] Deng was able to seize the weakness of the entrenched interests, recruit more to his faction that would profit from a more liberal economic structure.[298] This conflation of factors, in addition to skilled political maneuvering by Deng Xiaoping,[299] resulted in the removal of Hua Guofeng and the ascension of Deng Xiaoping to party chairman.

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[293] Susan L. Shirk, The Political Logic of Economic Reform n China, (Berkeley: University of California Press, 1993), 21-22.

[294] Earlier referred to as the Oil Kingdom Faction, but also known as the Petroleum Faction which sometimes broadly used to include not just party members in the oil sector, but also heavy industry.

[295] Barry Naughton, *The Chinese Economy: Transitions and Growth*, (Cambridge, MA: The MIT Press, 2007), 78.

[296] Maurice Meisner, *Mao's China and After: A History of the People's Republic, Third Edition*, (New York, NY: The Free Press, 1999), 428-430.

[297] Susan L. Shirk, *The Political Logic of Economic Reform in China*, (Berkley, CA: University of California Press, 1993), 33.

[298] Ibid., 33-35.

[299] Alexander V. Pantsov and Steven I. Levine, *Deng Xiaoping: A Revolutionary Life*, (New York, NY: Oxford University Press, 2015), 345-358.

Through the 1980s, China would continue its drive to expand, modernize, and restructure the oil sector while attempting to assimilate as much new knowledge, techniques, and technology as possible. This traditional drive for oil sector technology and expertise stretches back to Stalin and continues well into the 21st century. As part of its modernization drive, the CCP began spinning off ministry assets into various corporate entities, based loosely on the image of companies in the U.S. and Europe. This drive towards privatization was meant to increase oil sector efficiency and capability, with an eye towards long-term, global growth. The three key state-owned enterprises (SOEs) that operate in the Chinese oil sector today are China National Petroleum Corporation (CNPC), China National Petrochemical Corporation (Sinopec), and China National Offshore Oil Company (CNOOC), all of which spun off from their respective government ministries, the Ministry of Petroleum Industry (MPI) and Ministry of Chemical Industry (MCI), in the 1980s.[300] These first few steps coincided with the initial phases of China's "Going Out" strategy, allowing newly formed companies to acquire the skills needed by importing knowledge through joint-ventures, which allowed these companies the capability to expand overseas during the following decade.[301]

Although Chinese national oil companies (NOCs) would begin their multi-decade expansion in the 1990s, China would also face its next oil crisis as it transitioned from net exporter to net importer of crude oil in 1993. Complicating China's oil concerns,

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[300] Lianyong Feng, Yan Hu, Charles Hall, and Jianliang Wang, *The Chinese Oil Industry: History and Future*, (New York, NY: Springer Publishing, 2013), 8.

[301] Nargiza Salidjanova, U.S.-China Economic and Security Review Commission, "Going Out: An Overview of China's Outward Foreign Direct Investment," USCC Staff Research Report, March 30, 2011, 4-5.

politically, this was an extremely difficult time as well. Still recovering from the domestic instability that culminated in the Tiananmen Square Crisis in 1989, the CCP was attempting to manage the collapse of the Soviet Union and communism, and the emergence of the United States as the sole superpower in the international system. Chinese political elites became especially concerned by U.S. military power during Operation Desert Storm in 1991,[302] recognizing the technological superiority of U.S. forces along with their ability to conduct and coordinate modern, multi-branch warfare. This was of course contrasted to the dismal state of the Chinese military, and how comparatively weak and dated it was compared to the U.S. military (and Japan),[303] and essentially spurred technological and doctrinal development from that point forward.[304] Soon after these events, politics would drive China to a direct confrontation with the United States, where China's extensive military exercises in response to President Lee's American visa issuance was met with two U.S. carrier battle groups of the coast of Taiwan. The 1995-1996 Taiwan Strait Crisis was simply another reminder to the political elites that the United States had no problem countering China militarily, and would need to view the predominance of American power as potentially disrupting to security.

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[302] David Scott, *China Stands Up: The PRC and the International System*, (New York, NY: Routledge, 2007), 86-87; Kevin J. Cooney and Yoichiro Sato, eds., *The Rise of China and International Security: America and Asia Respond*, (New York, NY: Routledge, 2009), 41-43.

[303] Russell Ong, *China's Security Interests in the Post-Cold War Era*, (London, U.K.: Curzon Press, 2002), 143-145.

[304] Melvin Gurtov and Byong-Moo Hwang, *China's Security: The New Roles of the Military*, (Boulder, CO: Lynne Rienner Publishers, 1998), 109-113.

Chinese Grand Strategy

Current Chinese grand strategy has been focused on adjusting to domestic economic realities and their connection to the external environment, and the continuing preponderance of American power in the face of an elusive multipolar environment. This constraint on Chinese strategic flexibility[305] is a key defining characteristic of the state's grand strategy in that it is constantly forced into a reactionary position vis-à-vis the United States and its respective grand strategy. As Avery Goldstein explains, this is a somewhat transitional strategy; one in which China is preparing for an anticipated international system of multi-polarity after the unipolar moment of the United States has passed, meaning certain aspects necessarily have an "expiration date."[306] Despite this possibility, a degree of continuity and strong patterns in Chinese grand strategy, when accounting for the core interests, threats, and objectives to the country do certainly exist. At its core, China is a vulnerable country, and views itself as such, especially when politically convenient.[307] Elite perspectives are drawn from the beginning of the first Opium War in 1839, when Western powers carved out their respective "spheres of influence" in China, imposing their own policies with impunity against a largely

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[305] Fettweis, "Free Riding or Restraint? Examining European Grand Strategy," *Comparative Strategy*, 317.

[306] Avery Goldstein, *Rising to the Challenge: China's Grand Strategy and International Security*, (Stanford, CA: Stanford University Press, 2005), 38-40.

[307] Christian A. Hess, "Keeping the Past Alive: The Use of History in China's Foreign Relations," in *Handbook of China's International Relations*, ed. Shaun Breslin, (New York, NY: Routledge, 2010), 47-54.

ineffective and impotent Qing dynasty.[308] This period, known to China as the "century of humiliation" is still fresh in the minds of policymakers, and forms a core belief within Chinese elite circles, that unless development progresses and military strength increases, another event such as this has the potential to occur.[309] It is, however, important to understand a core concern uniting all political elites within the CCP: the preservation of the monopoly of political power for the party.[310] This may hardly come as a surprise that those in power would wish to retain it. This is certainly true, regardless of the political system in question. However, it is important in the case of China, because the communist party has had a relatively short, tenuous, and turbulent existence. The elites are fearful and concerned that the party could feasibly lose power unless it is assiduously preserved and protected. Because of this threat, it is constantly on the minds of elites in the country, and carefully dictates their actions and policymaking. Internal dissent has been a constant in Chinese politics since the inception of the CCP in 1949. Born out of civil war, China has witnessed mass mobilization campaigns, revolutions, riots, famine, purges, party factionalization, and most recently the Tiananmen Square incident and frictions with Uigar and Tibetan ethnic groups. The party views its power as precarious, and therefore must do all it can to quell dissent and satisfy the population.

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[308] John K. Fairbank and Merle Goldman, *China: A New History*, (Cambridge, MA: Belknap Press of Harvard University Press, 2006), 187-254.

[309] Alison A. Kaufman, "The 'Century of Humiliation,' Then and Now: Chinese Perceptions of the International Order," *Pacific Focus* 25, no. 1, April 2010, 1-33

[310] M. Taylor Fravel, "China's Search for Military Power," *The Washington Quarterly* 31, no. 3 (2008): 127; Thomas J. Christensen, "China," 30-39 in Strategic Asia 2001-02: Power and Purpose, (National Bureau of Asian Research, 2001), 30-39; Minxin Pei, China's Trapped Transition: The Limits of Developmental Autocracy, (Cambridge, MA: Harvard University Press, 2006), 29-30.

The government places great value on stability and cohesion, and uses this as a legitimating factor to maintain internal security.[311] Today, this cohesiveness is built on satisfying the general public with continued economic growth and to a lesser part nationalism, used to reinforce policy at critical junctures.[312] This current situation emerged at the end of the Cold War when communism and Marxism were no longer viable avenues to maintain ideological allegiance. With one ideology broken, economic growth quickly assumed a role as the key point of legitimacy for the communist party. So long as growth continues, most of the population will continue to allow the CCP to remain in power. If acceptable growth does not continue, the party's monopoly on political power will come into serious jeopardy. This cannot be done without energy, and oil in particular. Most of China's activity overseas has been directed towards economic ends, and the grand strategy is largely centered on these core objectives.

China has had to alter its strategy and methods to secure its lands and polity drastically over the last two decades.[313] Several points have also emerged, giving a glimpse as to how China views and forms its grand strategy. As Robert Sutter points out, the "prevailing evidence shows that Chinese leaders focus on domestic stability and economic growth. Seeing these as the key elements in determining its ability to stay in

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311 Andrew Scobell, *China's Use of Military Force: Beyond the Great Wall and the Long March*, (Cambridge, U.K.: Cambridge University Press, 2003), 36-38.

312 André Laliberté and Marc Lanteigne, eds., *The Chinese Party-State in the 21st Century*, (New York, NY: Routledge, 2008), 8-13.

313 Marc Lanteigne, *Chinese Foreign Policy: An Introduction*, (New York, NY: Routledge, 2009), 79-83.

power, the Chinese Communist Party leadership views them as the top priority.[314] A good starting point are three general points expounded by Thomas Christensen: regime security, territorial integrity, and internationally recognized power, prestige, and respect.[315] The first has been covered here, but the second point is very important to consider in the Asian maritime environment. For starters, territorial integrity includes not only the hotly contested East and South China Seas, but also Taiwan. This is a major flashpoint in relations between the United States and China, and will continue to be so until the situation is resolved. There are also potential oil and gas deposits within the overlapping territorial claims in the surrounding maritime environment. Official estimates do not even exist, since the area is so politically contentious, that no company has been willing or able to explore these areas for oil and gas deposits. As such, a major part of this conflict is nationalism and territoriality, but energy does play a role.[316] Additionally, the maritime environment is home to myriad significant trade routes, whereby China receives nearly 80% of its overseas crude oil supplies. This is mainly through the Malacca Strait and then the South China Sea. It should also be noted, that if successful in its irredentist claims regarding Taiwan, China would then have stronger claims regarding their territoriality to some of these waters and trade routes. The third

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[314] Robert G. Sutter, *Chinese Foreign Relations: Power and Policy Since the Cold War*, (Lanham, MD: Rowman and Littlefield, 2012), 17.

[315] Thomas J. Christensen, "China," in *Strategic Asia 2001-2002: Power and Purpose*, eds. Richard J. Ellings and Aaron L. Friedberg, (Seattle, WA: National Bureau of Asian Research, 2001), 27-29.

[316] Martin Murphy, "Deepwater Oil Rigs as Strategic Weapons, Commentary," *Naval War College Review* 66, no. 2 (2013).

point by Christensen is difficult to gauge, and remains a lesser goal to be attained, so will not be discussed heavily.

Goldstein has a well-viewed volume on China's grand strategy and first points to China's desire to secure its vital interests, meaning its "territorial and political integrity," in his view the "negative purpose" of external security policy, but also to promote a "positive purpose" policy, that would provide for the state's ascension in the global hierarchy, allowing it shape the international system, instead of merely respond to events that occur.[317] As such, he maintains key continuities in Chinese strategy include coping with American primacy under anarchy, the joint maintenance of secured second strike nuclear capability and a modernized military undergoing its own revolution in military affairs RMA, and finally its geographical and historical imperatives that serve to constrain.[318]

It is also understood that China became nervous following the demonstration of U.S. military power during the First Gulf War, and then subsequently by the dispatch of that same military power, in the form of two carrier battle groups, to the Taiwan Strait in 1995-1996. These two events demonstrated the extreme lag of Chinese military hardware and doctrine behind Western military technology and methods, and that the United States would not hesitate to direct that power towards China, but also enticed the leadership to plan broadly for U.S. attempts to "contain" China, and devise ways to

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[317] Goldstein, *Rising to the Challenge: China's Grand Strategy and International Security*, 23-24.

[318] Ibid., 27-29.

counter this threat.[319] This spurred action on the part of the CCP, as the critical demonstration validated reforms that were currently underway on the part of the PLA, shifting from "people's war under modern conditions" to a focus on "local war," which entails such concepts as preparation for local wars over major wars, the implementation of advanced technologies in combat, the exclusion of nuclear warfare, highly trained professional military members, offensive doctrine, quick battles for quick resolutions, and a redefinition of offense and defense under multi-dimensional modern warfare.[320] These to events were extremely formative, and immediately informed their long-term global and regional strategies.

In a more recent volume by Andrew Nathan and Andrew Scobell, the authors are not shy about the security imperatives of a Chinese grand strategy, recognizing on the first page, that "Vulnerability to threats is the main driver of China's foreign policy. The world as seen from Beijing is a terrain of hazards, stretching from the streets outside the policymakers window to land borders and sea lanes thousands of miles to the north, east, south, and west beyond to the mines and oilfields of distant continents."[321] Insecurity drives their grand strategy. The authors contend their first objective is to restore and maintain territorial integrity, which includes domestic stability, suppression of outside support for separatist movements in Tibet, Xinjiang, and the Inner Mongolian

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[319] Sutter, *Chinese Foreign Relations: Power and Policy since the Cold War, Third Edition*, 29, 52.

[320] Nan Li, "The PLA's Evolving Warfighting Doctrine, Strategy, and Tactics, 1985-95: A Chinese Perspective," *The China Quarterly* 146 (1996): 444-445, 456-458.

[321] Andrew J. Nathan and Andrew Scobell, *China's Search for Security*, (New York, NY: Columbia University Press, 2013), 3.

Autonomous Region, control over Taiwan, and defense of maritime claims. The second objective is to prevent the domination of Asia by any other state while increasing influence throughout the region using military, economic, and diplomatic power. Third, China desires an international environment compatible to its continued economic growth, including access to energy. And fourth, China's growing clout should be translated into a greater ability to shape its global environment.[322]

Nathan and Scobell characterize these threats as part of "four concentric circles," the first being the territory China administers or claims, under threat from both inside and out, the second circle being China's complex relations with twenty immediately adjacent countries plus the United States, the third circle being the six nearby multistate regional systems,[323] and the fourth ring includes the rest of world which consists of Europe, the Middle East, Africa, and North and South America, which China has only really entered into since the 1990s, seeking energy, commodities, and markets.[324]

In terms of the specific regional strategy employed, M.Taylor Fravel expands on the territorial aspects of the Chinese approach. In a recent article, he lists the following as part of a coherent strategy for China: regime security, territorial integrity, national unification, maritime security, and regional stability.[325] There are three points to consider

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[322] Ibid., 32-36.

[323] They describe these systems as interconnected and include Northeast Asia, Oceania, continental Southeast Asia, South Asia, and Central Asia, totaling around forty-five different countries. The United States is present in all of these regions.

[324] Nathan and Scobell, *China's Search for Security*, 3-6.

[325] M. Taylor Fravel, "China's Search for Military Power," *The Washington Quarterly* 31, no. 3 (2008): 127-129.

here. First military engagement and defense along Chinese borders is incredibly important for basic strategic reasons but, if a conflict were to arise, this could potentially give Chinese forces operational capability along land-based energy routes. Most notably, this will include pipelines, and in some cases, trains and trucks that would bring in supplies. Second, maritime security is specifically brought up as increasingly important to the state. Fravel mentions a key point when he states:

> Chinese sources also reflect an increased sensitivity to military threats from the sea to China's wealthy coastal provinces, the need to exploit maritime resources for economic development and, as a trading nation, the economy's dependence on the sea lines of communication that could be disrupted in a conflict, especially one near China's coast. The NDU's study of military strategy, for example, notes the growing importance of the 'rights and interests' of our continental shelf and maritime exclusive economic zones, especially the threats facing strategic resources development and strategic passageways.[326]

Retention of maritime assets is incredibly important, as it is an important method for China to secure its economy. It's also the most realistic place where Chinese military power would find success, since it currently lacks meaningful power projection capabilities.

As part of the regional strategy, political stability also plays heavily into the economic and energy security of the state. In order to continue development over the past 30 years, China has also sought a stable environment where trade and business could thrive, and economic assets would not be put in jeopardy. It is for this reason, in the post-World War Two period and despite security concerns, China has welcomed a U.S. naval presence in the area, because it has restrained Japanese rearmament and secured

[326] Ibid., 129.

trade routes throughout Asia, all of which have benefited Chinese growth enormously.[327] It seems fitting that Chinese planners would wish this stable environment to persist, as the core objective of economic growth has not changed. Much of Chinese interests continue to be largely defensive[328] and regional.[329]

As for vital interests to the state, Michael Swaine points out that many of China's "core interests" have only been outlined relatively recently,[330] as they have attempted to adjust to their strategic environment and increasingly powerful role in the Asia-Pacific. Only in 2009 could one reference a truly official statement of core interests by State Councilor Dai Binguo, involved in the formulation of foreign policy for the PRC, when he stated at the end of the U.S.-China Strategic and Economic Dialogue that Chinese core interests are: preserving China's basic state system and national security; national sovereignty and territorial integrity; and, the continued stable development of China's economy and society.[331] It should be noted, that in this list, the reference to territorial integrity does include national unification with Taiwan.

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327 Thomas J. Christensen, "Chinese Realpolitik: Reading Beijing's Worldview," *Foreign Affairs* 75, no. 5 (1996): 40-45.

328 Andrew Scobell, *China's Use of Military Force Beyond the Great Wall and the Long March*, (Cambridge, U.K.: Cambridge University Press, 2003), 15-39. Especially 36-38.

329 Lawrence Freedman, "China as a Global Strategic Actor," in *Does China Matter? A Reassessment: Essays in Memory of Gerald Segal*, ed. Barry Buzan and Rosemary Foot, (New York, NY: Routledge, 2004), 21-36.

330 Michael D. Swaine, "China's Assertive Behavior—Part 1: On 'Core Interests,'" *China Leadership Monitor* 34 (2011): 2-4.

331 Ibid., 4.

There are also those that feel Chinese grand strategy, when operationalized, is simply not meeting its long-term objectives, and that major issues began to arise in the late-2000s. Importantly, Edward Luttwak believes China's actions will trigger the oft-mentioned coalition to move against it, but preceding overt actions such as these, will be the increased geo-economic response. This type of responses means actions by external power to slow China's economic growth by restricting trade, investment, and technology transfers, but most importantly by the denial of raw materials. High levels of economic growth coupled with rapid increases in military spending on capabilities will arouse "adversarial reactions" in according to the logic of strategy. This breeds reactions ranging from caution to coalition building. For instance, the United States has already moved to revive alliances with Japan and the Philippines, moves that have been reciprocated. Myanmar is open to the West and Vietnam is moving closer to the Washington orbit.[332]

Luttwak is also not kind to Chinese strategic texts (i.e., *The Art of War*), which he cautions drives Chinese strategic thinking, but ultimately amount to intra-cultural inter-state relations during the brief "Warring States" period and contains logic not always readily applicable to modern, intercultural, interstate relations.[333] This reliance on old strategy based on narrow norms has caused counterproductive missteps in foreign policy, compounding problems. For instance, he mentions one of the calculations by the government is their propensity to provoke crises in order to force negotiations and

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[332] Edward N. Luttwak, *The Rise of China vs. the Logic of Strategy*, (Cambridge, MA: The Belknap Press of Harvard University Press, 2012), 237-238.

[333] Ibid., 72-88.

resolve disputes on their terms, as is the case with the current clash over the South China Sea. However, in modern interstate relations this only "raises the perceived value" to all states making settlement and concessions far less likely, and stoking public and elite opinion against the state.[334]

Furthermore, Luttwak points out his belief that the grand strategy of "Peaceful Rise" was quite successful, and did not trigger any reactions or create adversaries by its actions, but that China largely abandoned this approach in 2009, creating new problems for itself, a contrast to the restraint, engagement, and reassurance of the past.[335] And, other states besides the United States have taken note of this shifting approach. For instance, India is beginning to shed some of its ambiguity towards the Indian Ocean in response to Chinese actions.[336] Luttwak is also quick to point to escalation control as another approach by China in order to control its security environment, a point expounded by others.[337]

Echoing some of the other authors, Bates Gill recognizes the strategic shifts taking place in China's engagement, and sees a Chinese leadership that is determined to maintain a stable regional and international environment so it may focus on internal development, the concerted use of diplomacy to enhance economic growth and regional

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[334] Ibid., 78-82.

[335] Avery Goldstein, "The Diplomatic Face of China's Grand Strategy: A Rising Power's Emerging Choice," *The China* Quarterly 168 (2001).

[336] Jason J. Blazevic, "Defensive Realism in the Indian Ocean: Oil, Sea Lanes, and the Security Dilemma," *China Security* 5, no. 3 (2009): 64-67.

[337] Alison A. Kaufman and Daniel M. Hartnett, "Managing Conflict: Examining Recent PLA Writings on Escalation Control," *Report by CNA China Studies, CNA Analysis and Solutions*, (February 2016).

persuasion, and to "counter, co-opt, or circumvent" U.S. influence in the Asia-Pacific region while not appearing overly confrontational.[338]

Countering U.S. power, especially on its periphery, is a running theme. For instance, in Defense White Papers, there are both direct and indirect mentions of the United States, lending credence to consideration as its chief adversary. Although not always directly stated as the United States, it is difficult to determine another power the Defense White Paper would be referring to when it states, "some powers have worked out strategies for outer space, cyber space and the polar regions, developed means for prompt global strikes, accelerated development of missile defense systems, enhanced cyber operation capabilities to occupy new strategic commanding heights."[339] In fact, the White Papers seem to go to some length to vaguely suggest the U.S. as the primary adversary without actually saying so. This is usually done by suggesting a needed response to capabilities that are only available to the United States military, like missile defense, or weapons platforms that are utilized by the United States more than other states, such as aircraft carriers.

However, as Andrew Scobell warns in the final paragraph of his 2003 text on the subject, that even though Chinese strategic aims may be defensive in nature, and certainly perceived to be defensive by party planners, they have been led to the rationalization that

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338 Bates Gill, *Rising Star: China's New Security Diplomacy*, (Washington, D.C.: Brookings Institution Press, 2007), 10.

339 Information Office of the State Council of the People's Republic of China, *2010 Defense White Paper*, March 31, 2011.

any action on their part is defensive, even in cases that are blatantly threatening to external actors.[340]

In testimony on China's grand strategy, Bonnie Glaser cites three core security objectives[341] for China in Asia as exerting control over its near seas,[342] defending and advancing Chinese sovereignty claims to include the East and South China seas and Taiwan, and regional economic integration.[343] Although she doesn't mention this in her testimony directly, it is clear this encompasses the full elements of grand strategy, including not just security, but the economic and political aspects as well. Rather problematic from a perspective of grand strategy, Bonnie Glaser finds China's long-term security objectives elusive, while the past and near term are relatively straightforward.

Jian Yang brings to the fore the Chinese concept of "comprehensive national power" (CNP) as the foundation for Chinese grand strategy. Within this context, it is understood once again that internal security is problematic for Beijing, and economic development is widely understood to be broadly beneficial for all aspects of national

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340 Scobell, *China's Use of Military Force Beyond the Great Wall and the Long March*, 198.

341 Bonnie S. Glaser, "China's Grand Strategy in Asia," (Statement before the U.S.-China Economic and Security Review Commission, Washington, D.C., March 13, 2014).

342 Specifically, Dr. Glaser refers to "enhancing the PLA's capacity to conduct regional military operations, including what China refers to as counter intervention operations," which "refers to a chain of capabilities and missions aimed at preventing foreign, especially U.S., military forces from intervening in a conflict in China's near seas, which include the East China Sea, South China Sea, and Yellow Sea."

343 Dr. Glaser notes "fostering greater economic dependence on China and promoting regional economic integration are integral to Beijing's strategy of persuading its neighbors of the benefits of China's rise and dissuading them from challenging Chinese interests," and that this strategy was followed previously to relative success.

power and grand strategy. Planners seem to have taken from the Soviet experience, the main fault, which was the stagnated economy that could not maintain military power, or internal security sufficiently.[344] CNP is broad, and consists of various inputs depending on the writer, but can be roughly understood as: basic power (population, resources, nation unity); economic power (industrial power, agricultural power, scientific and technological power, financial power, and commercial power); national defense power (strategic resources, technology, military strength, nuclear power); and diplomatic power (foreign policy, attitude toward international affairs, foreign aid, etc.).[345] At an expansive level, this leads to a grand strategy with three main components: national security strategy, national development strategy, and national reunification strategy.[346] The author deems Taiwanese unification to be not quite at the same level as the other two, but important enough to be in a category of its own. Reflecting the importance of the economic aspect, the author gives more weight to these aspects, and broader development to include technological, social, and cultural development strategies, along with both internal and external economic development and diplomatic and national defense strategies.[347]

Although not an explicit piece on China's grand strategy, David Shambaugh's recent work on China's global presence notes some key aspects of the grand strategic

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[344] Jian Yang, *The Pacific Islands in China's Grand Strategy: Small States, Big Games*, (New York, NY: Palgrave Macmillan, 2011), 47-49.

[345] Ibid., 47-48.

[346] Ibid., 48.

[347] Ibid., 49.

approach. In his section on security requirements, there is a direct mention of China's "rising dependence on imported oil and other natural resources" which is "fundamentally reshaping China's energy security, away from autarky and relative independence toward rapidly accelerating dependence."[348] This ultimately informs security strategy, territorial claims, and naval developments. Another point that warrants mention is the Chinese conception of security, which is something internal as much as external, with the complete recognition that internal security allows greater coherence against external threats. Several other scholars have mentioned the importance of internal security and the maintenance of the CCP as the sole political organ in China, and Shambaugh concurs with this understanding. China conceives of security very broadly, including the internal dimension, but there is a great level of focus and concern on internal aspects, given the Chinese government spent more on internal security in 2012, than on external security at $111 billion to $107 billion, respectively.[349]

Others take a more direct view of China's intentions with malign intent. Masako Ikegami is explicit about the negative aspects of China's rapid growth and extremely critical of "peaceful rise," claiming China is preparing for a new Cold War, referring to "U.S.-China co-management," intent on replacing the Soviet Union in a global role. Ikegami does believe the current approach to be a blatant shield, disguising more malign

[348] David Shambaugh, *China Goes Global: The Partial Power*, (New York, NY: Oxford University Press, 2013), 269.

[349] Ibid., 47; Dr. Shambaugh goes on to demonstrate the actual amount spent on internal security is potentially close to $250 billion.

intentions, since the facts simply do not back China's claims for several reasons.[350] The "counter-facts" to these claims reside in four key areas: China's rapid military build-up, China's emerging global power projection over natural resources, the aid-for-oil and oil-for-arms deals in Africa, and China's expanding soft power.[351] This view is notable for its explicit focus on energy resources, and its direct inclusion to overall grand strategy. This approach also reconciles resource needs through involvement in Africa, Latin America, and Central Asia, all areas where an expanding Chinese presence is meant to secure resources for the state.

And, finally, much of this amounts to what is, broadly speaking, a defensive grand strategy constrained by American unipolarity as China attempts to close the wide gap in comprehensive national power.[352] This is a result of U.S. power and in line with past Chinese practice adopting accommodationist grand strategies during periods of weakness and more offensive grand strategies during times of relative strength.[353] Further, China is counterbalancing U.S. power by "self-strengthening" through economic growth and military modernization, and through proactive diplomacy in its external environment to maintain stability.[354]

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[350] Masako Ikegami, "China's Grand Strategy of 'Peaceful Rise' A Prelude to a New Cold War?" in *Rise of China: Beijing's Strategies and Implications for the Asia Pacific*, ed. Hsiao, Hsin-Huang Michael, and Cheng-Yi Lin, (New York, NY: Routledge, 2009), 21-54.

[351] Ibid.

[352] Yuan-kang Wang, *Harmony and War: Confucian Culture and Chinese Power Politics*, (New York, NY: Columbia University Press, 2011), 192.

[353] Ibid., 192.

[354] Ibid., 196.

Overall, China's grand strategy is dual-purpose: the provision of diplomatic space and stability to allow for economic growth in order to support its expanding security obligations. Much of this drawn from the experience of the Soviets, and their own mishandling of the economy that ultimately could not support the level of military spending required to maintain competitiveness with the United States. China has prosecuted the peaceful rise strategy, to be supplanted by the peaceful development strategy for much of the study period, and despite missteps, has seen much success without triggering too many adversarial reactions.[355]

An Assessment of Chinese Energy Security

China is inherently insecure when it comes to its energy supplies, and just as with economic statecraft within a grand strategic context,[356] energy figures heavily as a key component of grand strategy. Energy security is of the utmost importance to the CCP. Without energy, there is no economic growth. Without economic growth, the party's existence is imperiled and likely to falter. It is not mere energy security to China, but political and party security for the political elites. Energy must be secure, and available to the population at acceptable cost or growth will grind to a halt, taking the party with it. Without energy, there is no gas to put in the tanks of the cars of the emerging middle

[355] Although China does seem to have become more combative in recent years on the issue of the South China Sea.

[356] William J. Norris, Economic Statecraft with Chinese Characteristics: The Use of Commercial Actors in China's Grand Strategy, Doctoral Dissertation Massachusetts Institute of Technology, November 12, 2010.

class, or energy to power heating and cooling systems, or fuels for cooking, or running industrial machinery. Energy is vital to the country, and therefore represents a core interest of the CCP in managing its grand strategy.[357]

Despite all that has been done on the part of the CCP, one simple flaw still exists in their multi-decade attempt to secure overseas sources of energy: their naval power is undeniably weak compared to that of the United States, leaving trade routes highly susceptible to naval interdiction. However, despite this weakness, China has made great strides to reduce vulnerabilities in its energy supply chain, and has in many ways taken on approaches typically used by Western powers, including the United States. This integration has greatly enhanced Chinese security and efficiency, but there are also limits. China cannot fully rely on a system built by its chief potential adversaries. In this vein, China relies on the market where possible,[358] but only as much as it has to, and attempts to find other ways to mitigate weaknesses in the supply chain. For instance, the reliance on equity oil[359] for some of its supplies is viewed as problematic by some analysts, and arouses suspicions of China "locking up resources" so others are unable to access

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[357] Michal Meidan, Philip Andrews-Speed, and Xin Ma, "Shaping China's Energy Policy: Actors and Processes," in *China's Search for Energy Security: Domestic Sources and International Implications*, Suisheng Zhao ed. (New York, NY: Routledge, 2013), 48-50.

[358] Maximilian Mayer and Jost Wübbeke, "Understanding China's International Energy Strategy," *The Chinese Journal of International Politics* 6 (2013): 273-298.

[359] Wojtek M. Wolfe and Brock F. Tessman (2012): China's Global Equity Oil Investments: Economic and Geopolitical Influences, *Journal of Strategic Studies* 35, no. 2 (2012): 175-196.

them.[360] Others contend this simply isn't the reality of these supplies and that most end up going to the open market anyway. So, do these supplies uniquely contribute to oil security? Some have contended these actions don't even matter since China has maintained a relatively accommodative posture towards its Asian neighbors and the United States,[361] and the market itself stands to benefit. These topics will be confronted in a later section, but it is important to understand the various approaches and perspectives on these approaches to securing a state's supply of energy.

Availability

Domestic Production:

For the last 30 years, China has been attempting to mitigate the negative effects of production declines, as the state has had to shift from producer to consumer. Despite these steep declines, with the adoption of modern extractive technologies and advanced production techniques, China has been able to steadily increase production over the course of the study. Regarding Table 4.1 below, as Chinese firms have acquired skills and equipment, production has increased reversing the declines that began in the 1970s. Production since 1992 has increased almost every year, and will most likely begin to

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[360] David E. Sanger, "China's Oil Needs Are High on U.S. Agenda," *New York Times*, April 19, 2006, http://www.nytimes.com/2006/04/19/world/asia/19china.html?ex=&_r=0 (accessed May 14, 2016).

[361] Hongyi Harry Lai, "China's Global Oil Diplomacy: Is It a Global Security Threat?" *Third World Quarterly* 28, no. 3 (2007): 519-537.

accelerate as Chinese firms unlock tight oil deposits domestically. The data also demonstrate a 47% increase in production from 1992 to 2013, suggesting gradual, and consistent, growth absent large aberrations, reflecting a methodical approach to increases in production capacity.

Table 4.1: Annual Domestic Oil Production (Mbbls/d)

Year	Production	Year	Production
1992	2,845	2003	3,406
1993	2,892	2004	3,486
1994	2,934	2005	3,642
1995	2,993	2006	3,711
1996	3,175	2007	3,742
1997	3,216	2008	3,814
1998	3,217	2009	3,805
1999	3,218	2010	4,077
2000	3,257	2011	4,074
2001	3,310	2012	4,155
2002	3,351	2013	4,180

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil Production, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Refining capacity has seen high growth as well. A large state such as China cannot properly secure its sources of energy without the ability to domestically process and refine large amounts of crude for use throughout the military and broader economy. The data in Table 4.2 reflects China's concerns with refining capacity, which has grown over fourfold from the period 1992 to 2013. This has been consistent growth in capacity as well, with a steady doubling over both halves of the study period. Beyond raw numbers, the types of crude to be processed have expanded, and the efficiency gains and economies of scale have accelerated as China has moved to consolidate the sector especially with regards to shutting down the litany of independent, "teapot" refiners localized in Shandong Province.[362] Many of the new refineries are even designed to accept varying types of crude oil, allowing China to absorb and process ever greater varieties of petroleum.[363] This refining flexibility allows for the import of a greater number of blends and crude types going forward.

Table 4.2: Country-level Refining Capacity (Mbbls/d)

Year	Daily Amount	Year	Daily Amount
1992	3,044	2003	6,295
1993	3,334	2004	6,603
1994	3,567	2005	7,165
1995	4,014	2006	7,865
1996	4,226	2007	8,399
1997	4,559	2008	8,722
1998	4,592	2009	9,479
1999	5,401	2010	10,302
2000	5,407	2011	10,834
2001	5,643	2012	11,933
2002	5,933	2013	12,598

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil: Refinery Capacities, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Energy Infrastructure:

Information on China's domestic pipeline network is incomplete, but it seems to be growing at a steady pace. As of 2012, China has around 20,000 kilometers of crude oil pipelines crisscrossing its terrain, and the majority of domestically produced crude is

[362] U.S. Energy Information Administration, China: International Energy Data and Analysis, May 14,2015, https://www.eia.gov/beta/international/analysis_includes/countries_long/China/china.pdf (accessed November 20, 2015), 13.

[363] Ibid., 12.

transported through this network.[364] Much of this has been designed as a way to properly disperse oil throughout the country from China's own fields in the northeast and northwest, to more economically active regions, including the coast.

More directly related to import security is the number and capacity of China's transnational pipelines responsible for importing crude from nearby states. The two main pipelines for oil imports come from Russia and Kazakhstan. As Russia has expanded its exports east, through the East Siberian Oil Pipeline (ESPO), a Russia-China spur was built south off the main line, which goes south 597 miles into China. The spur was operational in 2011, and carries approximately 300,000 b/d. The Kazakhstan-China oil pipeline traverses about 1,384 miles of difficult terrain and was opened in 2006, carrying 240,000 b/d, with an expansion to 400,000 b/d currently underway.[365] Central Asia strongly figures into China's energy diversification strategy, with CNPC sourcing one-quarter of its overseas production in Kazakhstan. Its also notable to mention, CNPC is the only foreign company operating in the energy sector in Turkmenistan, where China receives around 44% of its natural gas imports.[366] This line is notable for its technical

[364] International Energy Agency, "China," http://www.iea.org/publications/freepublications/publication/china_2012.pdf (accessed May 22, 2016): 8.

[365] Erica S. Downs, "Looking West: China and Central Asia," Testimony before the U.S.-China Economic and Security Review Commission, March 18, 2015, http://www.uscc.gov/sites/default/files/Downs%20Testimony_031815.pdf (accessed May 15, 2016).

[366] Erica S. Downs, "Mission Mostly Accomplished: China's Energy Trade and Investment Along the Silk Road Economic Belt," *China Brief, The Jamestown Foundation* 15, no. 6 (2015).

difficulties: the length and extreme cold can present certain problems.[367] Length can become a problem due to gravity. These pipelines need force in order to push the oil through the line and eventually out the other end, and several thousands of miles complicates these efforts and increases the number of pumping stations and maintenance required to keep he lines functioning.[368] Inclement weather presents its own problems. Incredibly low temperatures through the areas that the line traverses, can cause the oil to simply sludge, and stop. This means additional costs are incurred in order to overcome this technical obstacle. However, increased costs simply do not trump the importance of diversification from Central Asia.

Perhaps most interesting, however, is the opening of the clearly strategic Myanmar-China oil pipeline. Myanmar doesn't have oil, but it has deep-water ports capable of offloading oil from the Middle East and any other sources requiring seaborne trade through the Malacca Strait. This 479-mile pipeline is purely meant as an alternate route through the straits, which feeds petroleum directly to facilities in Yunnan Province, and reflects the increasing strategic importance of not only the route, but also Middle

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[367] James Fishelson, "From the Silk Road to Chevron: The Geopolitics of Oil Pipelines in Central Asia," The School of Russian and Asian Studies, 2007, http://www.sras.org/geopolitics_of_oil_pipelines_in_central_asia (accessed June 23, 2016)

[368] Andrew Inkpen and Michael H. Moffett, *The Global Oil and Gas Industry*, (Tulsa, OK: PenWell Publishing, 2011), 398-403.

East oil. This pipeline is capable of transporting approximately 440,000 b/d from Myanmar's coastal areas to China.[369]

Current Extractable Reserves:

This is a weak point for China, and was one of the main contributing factors resulting in their "going out" strategy. Chinese oil reserves are significant, and rank at number thirteen in the world,[370] but they simply do not have enough to power the development and economic growth of 1.3 billion people. Furthermore, domestic reserve growth is weak, and the industry has essentially stagnated over the past two decades. This reinforces the desire for the Chinese NOCs to develop their own shale oil and gas technology imported from abroad, as this will be the main avenue for them to get out of this trend.

As a result of China's "going out" strategy, and its push for overseas reserves, Chinese NOCs have attempted to boost recoverable reserves, under their de facto control, since inception of the strategy. In the 1990s, this was an incredibly important component of China's energy security strategy, and represents one of the major shifts of the strategy away from economic realism to a more liberal approach, much like the Western states. Loans for oil, infrastructure for oil, and equity oil agreements have all been used to boost

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[369] Adam Rose and Aung Hla Tun, "Oil pipeline through Myanmar to China expected to open in January," *Reuters*, January 20, 2015, http://www.reuters.com/article/petrochina-myanmar-oil-idUSL3N0U22PP20150120 (June 23, 2016).

[370] Energy Information Agency, "Crude Oil Proved Reserves 2014," International Energy Statistics, www.eia.gov (accessed June 22, 2016).

China's reserves of oil under its control. However, in pursuing this approach, it has completely disregarded political risk factors, especially as China has pursued these particular deals in places like Sudan and S. Sudan, where oil exports are now essentially halted due to domestic politics. China, having invested a great deal in Sudan, is now unable to reap payment on those investments because of the politically contentious climate. But this approach has also remade entire economies and has had only some success in retrospect,[371] where certain countries and regions are more pliable to Chinese interests. For instance, a falling out over contract details in 2006 had Angola re-auctioning offshore blocs to other energy companies, hindering development and supply out of that country.[372]

As displayed in Table 4.3, Chinese reserves, while not nearly sufficient, have been steadily growing as China's NOCs are able to adapt and bring on new skills and technology from abroad. It remains to be seen whether or not China will be able to unlock shale deposits throughout the country, which will remain challenging not only because of technical reasons, but those of geography.

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[371] Ana C. Alves, "Chinese Economic Statecraft: A Comparative Study of China's Oil-backed Loans in Angola and Brazil," *Journal of Current Chinese Affairs* 42, no. 1 (2013): 99-130.

[372] Ibid., 110.

Table 4.3: China Proved Reserves of Crude Oil (Bbbls)

Year	Proved Reserves	Year	Proved Reserves
1992	15.2	2003	15.5
1993	16.4	2004	15.5
1994	16.3	2005	15.6
1995	16.4	2006	15.6
1996	16.4	2007	15.5
1997	17	2008	15.6
1998	17.4	2009	15.9
1999	15.1	2010	17.3
2000	15.2	2011	17.8
2001	15.4	2012	18.1
2002	15.5	2013	18.1

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil: Proved Reserves History, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.
BP Includes gas condensate and natural gas liquids (NGLs).

Table 4.4 shows China's reserves concerns in stark detail, where despite year-over-year growth in reserves, the years available at current consumption has gone from over 5 years, to less than 2. This is a significant drop and only underscores China's overseas energy requirements, due to both consumption and the lack of domestically controlled reserves. With current availability, China has very little supply chain flexibility from domestic sources.

Table 4.4: Reserves-to-Consumption

Year	Annual Consumption (MMbbls)	Years of Supply	Year	Annual Consumption (MMbbls)	Years of Supply
1992	2,902	5.24	2003	6,040	2.57
1993	3,221	5.09	2004	7,053	2.2
1994	3,301	4.94	2005	7,230	2.16
1995	3,593	4.56	2006	7,805	2
1996	3,916	4.19	2007	8,184	1.9
1997	4,313	3.94	2008	8,287	1.89
1998	4,401	3.95	2009	8,640	1.84
1999	4,646	3.25	2010	7,000	2.47
2000	4,967	3.06	2011	9,678	1.84
2001	5,102	3.02	2012	10,230	1.77
2002	5,529	2.8	2013	10,713	1.69

Source: BP Statistical Review of Energy 2014, Statistical Workbook, Oil: Consumption, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.
Author converted daily consumption figures to annual, and then calculated years of supply by dividing reserves by the annualized consumption figures, for each year
BP, consumption data combined with Hong Kong SAR, added then rounded.

Capital Investment and Capital Efficiency:

The energy industry runs on high levels of capital investment. Oil exploration, extraction, transportation, and distribution are all highly capital-intensive processes. Chinese NOCs have never been too concerned about capital since they branched off from their respective ministries, as they have consistently had some type of government support in the form of subsidies or loans. Additionally, off-book assistance to the companies exist as many loans are made on the companies' behalf by the China Development Bank (CDB) and the Export-Import Bank (Exim) with their notorious oil-for-loan and oil-for-infrastructure loans. This has been a boon for business, granting access to many deposits that would have otherwise been out of reach. However, contrary to popular belief, these companies do not completely run off the government. They are stable profit-seeking enterprises that are becoming more adroit at seeking out business opportunities and navigating the market. While it would be hard to believe Beijing would allow any of these companies to go bankrupt and dissolve, and constitutes implicit guarantees by the state, the government does not have a direct hand in day to day business operations,[373] nor frequent direct involvement in the international operations of the firms.[374]

Chinese companies, and by extension, Beijing, have the tendency to pay up and over the proper valuation of an asset if they believe their long-term security interests can be served. This was especially the case in the 1990s and early 2000s. For instance, the costly purchase of PetroKazakhstan[375] is one of the deals industry professionals point to when making their case that Chinese firms simply pay high in order to hoard assets; however, the true benefit to Beijing was not simply the company and oil access, but its ability to open a whole new land corridor for oil supplies, greatly enhancing its energy security. Individual IOCs, such as Exxon or Chevron, do not have to worry about energy security for the United States. Their sole purpose is business and profit. The Chinese NOCs however, are concerned with profit and energy security. Perhaps a deal like the PetroKazakhstan deal is less about overpaying to gain material assets, and more about

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[373] Erica S. Downs, "Business Interest Groups in Chinese Politics: The Case of the Oil Companies," in *China's Changing Political Landscape: Prospects for Democracy*, ed. Cheng Li, (Washington D.C.: Brookings Institution Press, 2008), 121-127.

[374] Linda Jakobson and Dean Knox, "New Foreign Policy Actors in China," *Stockholm International Peace Research Institute (SIPRI) Policy Paper* 26 (2010): 24-28.

[375] Christopher Pala, "China Pays Dearly for Kazakhstan Oil," *The New York Times*, March 17, 2006, http://www.nytimes.com/2006/03/17/business/worldbusiness/17kazakh.html?_r=1& (accessed June 25, 2016).

gaining material assets and an entire new avenue for oil supplies well into the future. This is clearly beneficial to Chinese energy security, increasing diversity of supply, and adding an overland route that is less susceptible to attack.

We also have a much better picture of whether or not China has been a serial over-payer for oil assets beginning in the mid-2000s, when Chinese purchases increased, and more analysts started to take notice. A recent study demonstrates that from the period 2005-2013, Chinese companies did not typically overpay in their M&A transactions overall, although would overpay when entering new sectors and sub-sectors, and were generally more capital efficient than other NOCs but still less capital efficient than the Western IOCs.[376]

Finding enough detailed information on specific oil related deals over the 1993-2012 period has been difficult to come by, however, there are ways to glean certain information regarding the Chinese mindset for strategic commodities. First, the Chinese government is very price conscious. The companies may have overpaid in the past, but there are many cases in the past decade where China has simply bided its time, and made major acquisitions when the market was advantageous. For instance, during the financial crisis in 2008-2009, Chinese companies took the opportunity to go on a buying binge of assets around the globe. They were, of course, able to buy at bargain prices, snapping up assets that have paid off since. During major price drops in oil, and other commodities for that matter, Chinese firms always heavily increase their buying. In 2008, China

[376] Anatole Pang, "Chinese Overseas Oil and Gas M&A Strategy: Assessing the Financial and Strategic Performance of Foreign Upstream Acquisitions by the Chinese National Oil Companies, 2005-2013," (Master's Thesis, Tsinghua University, Beijing, 2014), 39-54.

drastically stepped up acquisitions for its first phase strategic petroleum reserve, simply because prices had crashed after the major run-up.

The recent deal that China made with Russia to be supplied with natural gas was a deal that took over 10 years to negotiate.[377] China was responsible for how drawn out this bargaining was, simply pushing for a better deal, and waiting. Only when Russia was in major trouble over Ukraine, steeped in sanctions and a fiscal mess, did China finally accept a deal from a severely economically weakened and constrained Russia. This reduced bargaining power meant Russia was not in the position to push for higher prices with the only other major export source for Siberian gas.

Table 4.5: Return on Average Capital Employed (ROACE)

Year	China National Petroleum Corp (PTR)	China Petrochemical Corp (SNP)	China National Offshore Oil Corp (CEO)
2005	0.25	0.13	0.32
2006	0.23	0.15	0.3
2007	0.2	0.14	0.24
2008	0.14	0.09	0.28
2009	0.11	0.14	0.16
2010	0.14	0.15	0.25
2011	0.13	0.14	0.26
2012	0.11	0.11	0.2
2013	0.11	0.11	0.14
Average for All Years	0.16	0.13	0.24

Source: Author's calculations based on data from company reports, Bloomberg Terminal company data, Morningstar, www.morningstar.com and NASDAQ, www.nasdaq.com. Company reports available at Exxon Mobil, http://corporate.exxonmobil.com/en/ ; Chevron, https://www.chevron.com ; Conoco Philips, http://www.conocophillips.com/Pages/default.aspx.
Note: Some financial data related to Chinese companies may be inaccurate.

377 James Paton and Aibing Guo, "Russia, China Add to $400 Billion Gas Deal With Accord," *Bloomberg*, November 9, 2014, http://www.bloomberg.com/news/articles/2014-11-10/russia-china-add-to-400-billion-gas-deal-with-accord (accessed June 25, 2016).

Table 4.5 demonstrates some relatively respectable returns on average capital employed for the three main NOCs in China. The most transparent, and international of the three, CNOOC, with the symbol "CEO" on international exchanges, has the highest return at 24% return on capital, on par with levels seen in Western IOCs. It should also be noted, while efficiency might not be as high as IOCs, Chinese companies can still have higher ROACE levels due to other factors, such as below market petroleum purchases negotiated by the government as with Venezuela.

Affordability

Pricing and Volatility:

China employs price controls in the domestic economy in order to cushion its population against any major rises in the price of petroleum. This is another reason for the desire of the NOCs to go outward, and sell their oil in new and different markets: they can't always make money at home. While it is a captive market for the companies, they are not free to price their final products based on market supply and demand, and adjust their prices accordingly. If prices are too high internationally, and these firms then refine and sell their products to the domestic market, they have the capacity to incur heavy financial losses. However, after petroleum is procured internationally, they are always able to sell that at market rates overseas, making a profitable transaction whereas it would have been unprofitable domestically. The government cushions the population and businesses from severe prices swings, forcing the brunt of these adjustments on the energy industry itself.

Because China operates heavily in both the international markets, and using bilateral deals directly with several foreign governments, much of their transaction history is clouded. However, at this point, it does not seem to put the NOCs at significant disadvantage, as they are able to price some of their petroleum from distressed countries at lower rates than going international rates.

Table 4.6: Annual Price of Dubai Crude (Medium, Fatah, 32 API, USD), USD per Barrel, and Volatility (Annual Standard Deviations)

Year	Price	Volatility	Year	Price	Volatility
1992	17.14	1.23	2003	26.73	1.79
1993	14.91	1.28	2004	33.46	3.06
1994	14.83	1.34	2005	49.2	5.9
1995	16.13	0.83	2006	61.43	4.46
1996	18.54	1.98	2007	68.37	10.41
1997	18.1	1.21	2008	93.78	27.29
1998	12.09	0.84	2009	61.76	12.29
1999	17.08	4.54	2010	78.06	4.81
2000	26.09	2.78	2011	106.03	5.54
2001	22.71	2.74	2012	108.92	7.26
2002	23.73	2.55	2013	105.43	3.25

Source: Quandl, Dubai Crude Oil Price (ODA/POILDUB_USD), https://www.quandl.com/data/ODA/POILWTI_USD, sourced from Open Data for Africa, African Development Bank Group IMF Primary Commodity Prices August 2015, http://opendataforafrica.org/efkgejg/imf-primary-commodity-prices-august-2015, and International Monetary Fund, IMF Primary Commodity Prices, http://www.imf.org/external/np/res/commod/index.aspx , author took the simple average of the end-of-month price for each year to calculate annual price. Author also calculated the standard deviations for each year.

The data in Table 4.6 demonstrate relatively higher levels of volatility in Dubai crude, but still somewhat stable over the course of the study. The average price over the first half, 1992 to 2002, was approximately $18.30 with a standard deviation of $4.04.

This results in a 22% price variation off the average. The second half witnessed higher prices and the much higher volatility, with the average price at $72.12 and a standard deviation of $27.69. However, using monthly prices for the index, the standard deviation rises to 25% and 41% respectively. The average price for all years is $45.20 with a standard deviation of 34.23 using monthly figures, resulting in a 76% variation. Here, as with the WTI price, 2008 is an aberration, when the culmination of new demand pressures acting on the price of oil reached their breaking point, resulting in the spectacular run up and subsequent crash in prices. 2008 for Dubai, as with WTI, is the most volatile during the study.

Reliability

Diversified sources:

This is one of the most critical areas for a large state to be secure, and over the course of the study, the level of diversification of Chinese oil supplies has gone from dismal to the same level as the United States while maintaining similar import requirements. The interesting point demonstrated by the data, is that China in a way seems to be following the energy footsteps of the United States almost in lockstep. Not only has diversification increased, but also it now has the same level of overreliance on Middle East oil, particularly Saudi Arabia, that the United States had for much of the latter half of the 20^{th} century, and especially in the mid-2000s.

Table 4.7: Total Number of States Exporting to China by Year

Year	Number of States	Year	Number of States
1992	21	2003	44
1993	24	2004	44
1994	25	2005	39
1995	29	2006	44
1996	20	2007	46
1997	32	2008	42
1998	30	2009	43
1999	31	2010	51
2000	32	2011	46
2001	32	2012	48
2002	31	2013	45

Source: United Nations Comtrade Database, United Nations, Trade Data Extraction Interface, HS Commodity Code 2709, Petroleum Oils, Oils From Bituminous Minerals, Crude, http://comtrade.un.org.

As can be see in Table 4.7 above, China has moved to rapidly expand the number of suppliers of oil. From a low of 21 in 1992, all the way to a maximum of 51 in 2010, China now sources from all over the world. With import sources more than doubled by 2013, China has both needed to source additional oil to meet domestic demand from all over the world and has needed to diversify for security purposes.

Table 4.8: Annual Herfindahl-Hirschman Index (HHI) Score

Year	HHI Score	Year	HHI Score
1992	2,588	2003	891
1993	1,601	2004	847
1994	2,401	2005	915
1995	1,739	2006	951
1996	1,866	2007	904
1997	1,358	2008	1,043
1998	1,117	2009	996
1999	785	2010	915
2000	979	2011	912
2001	940	2012	944
2002	910	2013	943

Source: Author's own calculations using UN Comtrade Data (United Nations Comtrade Database, United Nations, Trade Data Extraction Interface, HS Commodity Code 2709, Petroleum Oils, Oils From Bituminous Minerals, Crude, http://comtrade.un.org) and above HHI equation derived from multiple sources, including the U.S. Department of Justice (https://www.justice.gov/atr/horizontal-merger-guidelines-08192010#5c), but for a more detailed look, reference Stephen A. Rhoades, The Herfindahl-Hirschman Index, Federal Reserve Bulletin, Volume 79, Number 3, March 1993, pp 188-189.

The HHI scores displayed in Table 4.8 also express an interesting point relating to the timing of Chinese supplier expansion. It is possible that China may have opportunistically taken advantage of the oil price drops resulting from the Asian financial crisis in 1998, in order to begin to buy from a more diversified array of suppliers that would have been in dire need of new export outlets in the midst of economic downturn, especially in Asia. This absolutely fits with the Chinese pattern of taking advantage of economic malaise elsewhere in the world to advance their interests, especially in strategic sectors. Just as during the more recent economic downturn in 2008, China went on a buying binge in the energy sector, buying all sorts of assets on the cheap, striking advantageous bargains with desperate sellers. It would appear, that China might have taken the same action during the regional crisis in order to expand suppliers, probably garnering a cost advantage of some sort on equity and loan-for-oil deals. The timing is stark on the HHI index above, where from 1997 to 1999, the reduction in the HHI score craters at 785 from 1358, a 42% drop over the two-year period. This compared to the raw data on the number of suppliers indicates that China took the opportunity to significantly expand new supplier relationships in order to gain cost advantages. This was a surprising piece of data, but falls completely in line with Chinese actions in the sector.

The other interesting, and surprising point demonstrated by the HHI index, is how quickly China went from importing from undiversified sources, to a highly diversified import base. As mentioned earlier, the specific point where this happened was over the 1998-1999 period, where China attained a score of 785 for 1999. After 1999, China's score breached the 1000 level only once in 2008. This level of diversity is quite remarkable for its rapidity and maintenance at a level in the 900s for about three-quarters of the study period. It is reasonable to assume that the Chinese government recognized this as a critical area for its long-term energy security goals, and made concerted efforts to quickly expand its supplier base, coordinated at the highest levels of government.

Short and long-term protection from political interruptions:

China spent much of the study period learning to manage political interruptions along its supply chain, typically in the form of management teams at the various state owned companies gaining experience and the capacity to understand and mitigate diverse types of political risk.[378] This type of risk mitigation covers many political disruptions, but not all, and certainly not the potential circumstances that come with "containment" or open warfare. These other risks must also be accounted for.

China relies on the global oil market for economic expediency and efficiency, but constantly makes bilateral energy deals directly with governments and generates a great deal of oil through equity deals in several politically risky countries. In particular, the government-to-government deals conducted by China are far more frequent than the United States and members of the OECD. Politics and U.S. dominance, particularly military dominance, of global oil markets will always force China to look for other alternatives to the current market, even if it means less efficiency, prioritizing a more secure supply chain, over lower prices. Further, it is position of this research, that in particular China's government led oil-for-loan and oil-for-infrastructure deals, and equity contracts are all examples of paths for China to side step the current oil market in favor of a greater degree of supply chain control. This control and stability may be illusory,[379] particularly in times of stress and political upheaval, but it does provide another avenue of supplies to Beijing, with more control than the global oil market itself. Many analysts believe that this does supply additional security, particularly Chinese hawks, and many others feel that this step does not provide any additional security at all. The truth is somewhere in-between. It may or may not be cheaper depending on the particular deal

[378] Susana Moreira, "Learning from Failure: China's Overseas Oil Investments," *Journal of Current Chinese Affairs* 42, no. 1 (2013): 131-165.

[379] Philip Andrews-Speed and Roland Dannreuther, *China, Oil and Global Politics*, (New York, NY: Routledge, 2011), 88.

made, doesn't reduce oil price volatility, and would not necessarily provide ready access in the case of a crisis, dependent on severity.[380] Most Chinese equity oil is exported to global markets, but one cannot discount the fact that these approaches result in more control over supplies. In light of the proposed model above, it makes more sense to think about this from Beijing's perspective in a gradual standoff with the West. Under normal conditions, the market works best, but all must states must prepare for the worst. Going from this point to open warfare is stretch as well. If Western powers continue to follow their current path, pressure may be ratcheted up first in the form of sanctions and other forms of economic warfare. China feels the need to prepare for this, and a higher level of supply chain control will result in sanctions immune supplies to China. If China sources oil from Venezuela or Sudan using Chinese owned equipment and workers, hosted by countries on less than friendly terms with Western powers, and is brought back to the mainland by Chinese companies using Chinese flagged vessels, there is very little susceptibility to oil sanctions with that approach. At many times, this approach has even paid off, with Beijing striking deals with desperate governments ready to supply oil at bargain prices for a bailout, whatever it may be. This has happened time and again, not only with troubled African governments, but with Russia and Venezuela as well.[381]

As with the United States, China's strategic petroleum reserve has risen in importance, although it is difficult to quantify since Beijing does not release reputable

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[380] Erica S. Downs, "The Chinese Energy Security Debate," *The China Quarterly* 177 (2004): 35-36.

[381] Iacob Koch-Weser, *Chinese Energy Engagement with Latin America: A Review of Recent Findings*, Report by Inter-American Dialogue, January 2015, 11.

figures and considers such information a state secret, although promises have been made recently[382] to begin releasing figures on oil stocks. The available information is shown below in Table 4.9, and initial estimates were for the reserves to total 500 million bbls by 2020, but that figure has now potentially been raised to 600 million bbls,[383] and is roughly the same 90-day consumption average for OECD/IEA countries.[384] The government has pursued this task in a series of three phases that began in mid-2000, with each phase bringing multiple storage facilities online. Table 8 demonstrates capacity estimates for the SPR. The distinction between capacity and actual stored crude is important and further complicates China's SPR. While capacity has been growing greatly, we also know that official estimates are lower than the capacity available, putting SPR total stocks at around 190 million barrels.[385] In 2013, total SPR capacity was at around 253 million bbls after construction was completed on phase 1 facilities and partial completion of phase 2 facilities.

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[382] Lucy Hornby, "China Releases First Formal Estimate of Strategic Oil Reserves," *Financial Times*, November 20, 2014, http://www.ft.com/intl/cms/s/0/09c47d8e-7084-11e4-8113-00144feabdc0.html#axzz48HlAYZbA (accessed June 25, 2016).

[383] Abheek Bhattacharya, "China's Petroleum Reserve Builds Shaky Floor for Oil," *Wall Street Journal*, http://www.wsj.com/articles/chinas-petroleum-reserve-builds-shaky-floor-for-oil-heard-on-the-street-1409755068 (June 25, 2016).

[384] Chen Aizhu and Florence Tan, "China Ramps Up Crude Buying, Reserves Purchases Far Ahead of Schedule," *Reuters*, November, 26, 2014, http://www.reuters.com/article/us-china-oil-stockpiles-idUSKCN0JA0SN20141127 (June 24, 2016).

[385] Adam Rose and Chen Aizhu, "UPDATE 1-China's Strategic Oil Reserves Double to 190 mln bbl - Stats Bureau," *Reuters*, December 11, 2015, http://www.reuters.com/article/china-oil-reserves-idUSL3N1402YL20151211 (February 20, 2016).

Table 4.9: Government-Controlled Petroleum Stocks (SPR), Industry-Controlled Petroleum Stocks, and Total Petroleum Stocks (MMbbls/yr)

Year	Government-Controlled	Industry-Controlled	Total Stocks
2003	0	N/A	N/A
2004	0	N/A	N/A
2005	0	N/A	N/A
2006	30	N/A	N/A
2007	30	N/A	N/A
2008	30	N/A	N/A
2009	91	N/A	N/A
2010	91	N/A	N/A
2011	129	220	349
2012	209	N/A	N/A
2013	253	257	510

Notes: Government-Controlled stocks refer to storage capacity.
Source: Various, company reports, news reports,
Michal Meidan, Amrita Sen, and Robert Cambell, China: the 'new normal,' Oxford Energy Comment, Oxford Institute for Energy Studies, University of Oxford, February 2015, pp 9-10
Song Yen Ling, China's end-October commercial crude, oil product stocks fall on month, Platts Oil Service, November, 25, 2014, http://www.platts.com/latest-news/oil/singapore/chinas-end-october-commercial-crude-oil-product-27868887
Christopher J Neely, China's Strategic Petroleum Reserve: A Drop in the Bucket, Economic Synopses, Federal Reserve Bank of St. Louis, 2007, no. 2
Mandip Singh, China's Strategic Petroleum Reserves: A Reality Check, IDSA Issue Brief, Institute for Defense Studies and Analysis, May 21, 2012, http://www.idsa.in/system/files/IB_ChinasStrategicPetroleumReserves_MandipSingh_210512.pdf.

Even hazier is information regarding industry stocks. If information on the SPR is sparse, industry stocks are even sparser. To make matters worse, since the NOCs run SPR facilities for the government, much of the information available on petroleum stocks might have duplicate data. This means there is no clear distinction between government and industry-controlled stocks, complicating data quality issues.[386] However, there are

[386] Hornby, "China Releases First Formal Estimate of Strategic Oil Reserves," *Financial Times* (accessed May 5, 2016).

estimates that industry controlled stocks are around 257 million bbls, but this is again, an estimate.[387]

We should also take the time to distinguish, in the case of China, between storage capacity and actual petroleum stocks. We know that commercial storage capacity in China has actually been high for quite some time, but it simply has not been filled. Many new private players rushed into the sector in the 1990s, contributing to the large growth.[388] This is most likely through a lack of incentives as Chinese NOCs have attempted to become more competitive over time, they did not deem it necessary to keep large stocks of petroleum since this is typically unprofitable. By some estimates, commercial storage is around 1.6 billion barrels.[389] But, it is still difficult to know how much of that capacity is actually filled.

As stated previously in the section on the United States, the ultimate guarantor of long-term oil security is sufficient military power in order to secure overseas routes back to the homeland. This is inordinately difficult to achieve with a weak navy, which China has been making great strides to correct. Albeit far off, China's naval developments are clearly on a path to develop a full blue water naval force capable of meeting threats along supply routes, and in China's near abroad as a compliment to forces in China. A less

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[387] Platts, "China's End-October Commercial Crude, Oil Product Stocks Fall on Month," November 25, 2014, http://www.platts.com/latest-news/oil/singapore/chinas-end-october-commercial-crude-oil-product-27868887 (accessed May 7, 2016).

[388] Mandip Singh, "China's Strategic Petroleum Reserves: A Reality Check," *Institute for Defense Studies and Analysis Issue Brief*, May 21, 2012, http://www.idsa.in/system/files/IB_ChinasStrategicPetroleumReserves_MandipSingh_210512.pdf (accessed May 8, 2016): 5.

[389] Ibid., 7.

talked about attempt by the Chinese to secure energy routes is the so called "string of pearls," which refers to the contracting of port usage along Beijing's Indian Ocean supply routes, extending to near the Persian Gulf and Africa's east coast. This can be thought of as not only a strategic placement of bases along critical supply routes, but also as a way to mitigate current and future naval weakness, until the PLAN has the opportunity and ability to "catch-up" with more modern naval powers. While these plans have not amounted to anything as yet, the potential of China laying the groundwork for future military deployments along its supply routes could be a critical development.

As mentioned, Chinese flagged tankers are a component of this response as well. The Chinese tanker fleet has been growing rapidly, and is capable of carrying significant amounts of petroleum. According to Platts, in 2014, Chinese vessels transported approximately 50-60% of China's oil imports, and this number is set to increase with the rapid build up in the fleet.[390] It is interesting to note, many large energy importers do rely on large tanker fleets flagged in their own territory. Japan, one of the clear vanguards of modern energy security, receives approximately 90% of its crude oil via Japanese flagged tankers. This measure is also nearly impossible for U.S. tankers given that companies based there do not typically flag their vessels in the home country, a common practice in

[390] James Bourne, "Petrodollars: China Builds Up its Oil Tanker Fleet," *Platts Oilgram News*, August 18, 2014, blogs.platts.com/2014/08/18/china-oil-tankers/ (accessed May 8, 2016).

the shipping industry.[391] The ability to control the transport requirements of crude imports is compelling.

It should be noted, that during wartime conditions, the targeting of tankers has been problematic, but this may be less so today. The intelligence capabilities of the United Sates are within reason to be able to properly identify, and isolate or destroy tankers bound for China. But, not even all tankers bound for China would need to be destroyed, before these attacks begin to have a deterrent effect on any crews slated to sail for the APAC region. Interdiction and if needed, destruction, is possible, and if only occurs with limited success, would still provide the needed outcome.

Supply interdiction is also challenged in that this approach would make oil more costly to everyone in the world.[392] This is most likely unfounded due to a black market pricing mentality within individual economies. Just because some products cost more on the black market within a country does not mean they cost more outside. It's not a matter of supply and demand, but one simply of access. It would raise the cost of imports to China, but would not raise the cost to other parts of the world – in fact, it would most likely lower them given large swathes of Chinese oil would be left undelivered and in need of buyers.

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[391] Institute of Shipping Economics and Logistics, "Shipping Statistics and Market Review," *World Tanker Fleet* 56, no. 3 (2012): 4; John Rogers, ed., *Review of Maritime Transport 2014*, (Geneva: UNCTAD, 2014), 27-45.

[392] Michael May, "Energy and Security in East Asia," Report on America's Alliances with Japan and Korea in a Changing Northeast Asia, Asia-Pacific Research Center at Stanford University, (1998) 25.

This is hugely problematic for Chinese supply and the integral nature of sea power has not gone unnoticed in China with respect to grand strategy.[393] The waterways and maritime routes responsible large volumes of the oil trade are so important they have received considerable attention by top political elites. This area is a key vulnerability for China, referred to by many as the "Malacca Dilemma"[394] after Hu Jintao's first public mention of the strategic issues concerning the Strait in 2003.[395] China has worked assiduously to mitigate and correct vulnerabilities attributed to the dilemma, including worries of supply interdiction, the strengthening of U.S. alliances in the region, and the encirclement by potentially hostile powers at the behest of the United States, first through non-military measures[396] followed principally by enhancing naval power in the region[397] and re-orienting focus to Asia's SLOCs.[398] One of the greater leaps forward for China has been the purchase of a Soviet era aircraft carrier from Ukraine. The carrier ambition has been with China since the 1920s, and feasibility, technical capacity, or funding never

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393 Zhang Wei, translated by Shazeda Ahmed, "A General Review of the History of China's Sea-Power Theory Development," *Naval War College Review* 68, no. 4 (2015): 87-88.

394 Lanteigne, *Chinese Foreign Policy: An Introduction*, 86; Chen Shaofeng, "China's Self-Extrication from the 'Malacca Dilemma' and Implications," *International Journal of China Studies* 1, no. 1, (2010): 2.

395 Ji, "Dealing with the Malacca Dilemma: China's Effort to Protect its Energy Supply," *Strategic Analysis*, 470-473, 476-484.

396 Chen Shaofeng, "China's Self-Extrication from the 'Malacca Dilemma' and Implications," *International Journal of China Studies* 1, no. 1, (2010): 9-12.

397 Ibid., 13-14.

398 Ji, "Dealing with the Malacca Dilemma: China's Effort to Protect its Energy Supply," *Strategic Analysis*, 476-484.

culminated to launch a program, until the recent economic boom, when China's resources matched ambitions and the late Admiral Liu Huaqing, to whom some refer as China's Alfred Thayer Mahan and father of China's modern navy, spearheaded efforts to acquire a carrier and begin indigenous production of a carrier fleet.[399]

In a very practical sense, China's PLAN has embarked on a concerted effort to stall and strangle U.S. sea power in the region through development of anti-access and area denial (A2/AD) capabilities mid-way through the research period. China continues to develop these methods as a means to counter a technologically superior military force through degradation, first strikes, and periphery control, operationalized by use of submarines, ballistic and cruise missiles, mines, land-based air strikes, air defense, electronic warfare, cyber warfare, counter-space, and joint operations.[400] China also looks abroad for this security as well. Access to deep water ports along the Indian Ocean maritime routes will strengthen Chinese naval power in the future, especially in the context of the "String of Pearls" projections across the Indian Ocean, which is also not just about hardened military sites, but perhaps more about maintaining its benign status while making use of dual-use civilian-military facilities highly dependent on bilateral relationships.[401] All of this will need to be balanced by the difficulties in the South China

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[399] Andrew S. Erickson, Abraham M. Denmark, and Gabriel Collins, "Beijing's 'Starter Carrier' and Future Steps: Alternatives and Implications," *Naval War College Review* 65, no. 1 (2012): 16-24.

[400] U.S.-China Economic and Security Review Commission, *2011 Report to Congress*, Washington, D.C.: U.S. Government Printing Office, 2011), 182-193.

[401] Robert D. Kaplan, *Monsoon: The Indian Ocean and the Future of American Power*, (New York, NY: Random House Publishing, 2010), 10-11.

Sea, which present their own security hurdles, if only by the provocation of conflict with neighboring states.[402]

A fascinating aspect of China's maritime approach is that it simply may not be new, or original. The previous adversary of the United States, the Soviet Union, may very well have provided a naval template for a technologically superior adversary with overwhelming naval power brought to bear close to the maritime periphery.[403] Like the Soviets, China faces an intractable opportunity cost with respect to its naval power. The distribution of military funding will have to continue to be siphoned away from the PLA's ground forces, which are also responsible for funding internal security.[404] However, as China grows, and requires more resources to be dedicated to naval advancement and expansion, it will come at a time when internal security will still be challenging and China may well be encountering more external resistance. This will place great strain on the military budget, and represents an intractable, enduring choice that China has wrestled with for centuries, and all continental based powers must confront.[405] This inherent tension exists through the study period as China has focused

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[402] Michael G. Gallagher, "China's Illusory Threat to the South China Sea," *International Security* 19, no. 1 (1994).

[403] Robert S. Ross, "China's Naval Nationalism: Sources, Prospects, and the U.S. Response," *International Security* 34, no. 2 (2009): 50; John B. Hattendorf, *The Evolution of the U.S. Navy's Maritime Strategy, 1977-1986*, (Newport, RI: Naval War College Press), 124-127, 148-149.

[404] Ross, "China's Naval Nationalism: Sources, Prospects, and the U.S. Response," *International Security*, 58.

[405] Ibid., 53-54.

on its submarine and missile based area-denial strategy in its maritime environment, increasing costs and frustrating efforts by any future hostile powers in the region.[406]

Concluding Remarks on China's Energy Security Approach

As mentioned in the opening paragraph of the previous section, the most salient concern of China's political elites is the interdiction of seaborne crude under containment or hostile conditions. The NOCs and China have the same security concerns whether or not the companies ship supplies directly back to China from where they are sourced, or simply buy supplies on the market at the lowest price. Therefore, it makes sense for China to operate in the market as much as possible, and reap the benefits of the lowest possible prices for its oil supplies. However, if needed, China can re-direct overseas sources of petroleum back to the homeland without any concern over economics.

They have the facilities overseas, the oil assets, and a growing tanker fleet available to move supplies directly back to the country in extreme scenarios. This level of control over the entire supply chain provides an extra layer of energy security to China, especially with assets retrieved from abroad. A conflict with the United States or other countries may compromise the security from this approach; however, more importantly, in the potential lead up to a conflict, where embargoes may be put in place, China will have the ability to continue to receive overseas supply of oil due to this control over the entire supply chain. Other energy companies and tankers may be subject to, and

[406] Ibid., 58-59.

willing to comply with, embargoes or restrictions put in place during the lead up to any conflict, but Chinese companies with Chinese flagged vessels would almost certainly disregard any orders to discontinue supplying the country, and would continue shipments. This essentially makes certain suppliers risky, yet more resistant to sanctions pressures in the event they may be applied in the future by the United States and other Western powers, should any conflicts arise.

This would also force the hand of those implementing the embargo, recognizing that any seizure or destruction of Chinese assets or vessels would be an unacceptable escalation, potentially leading to an all out conflict.[407] Therefore, these overseas sources are not necessarily meant to provide security in the sense that supplies will be able to circumvent the U.S. Navy across the world's trade routes, but to instead provide breathing room during any highly hostile points in the relationship between China and its competitors that may ensue. This breathing room, or "buffer," can be very valuable, and lessens the leverage the United States would have over China in any conflict outside of open warfare. This essentially shifts the burden of a hot war onto China's competitors, putting them in a very unenviable position.

This point of view has strong historical precedent, involving the fateful events that brought Japan into open warfare with the United States in 1941. Cutting off energy supplies to a state, has very real consequences, and will force that state into open conflict if they have no other supplies to rely on. President Roosevelt knew this point well. Time

[407] Alison A. Kaufman and Daniel M. Hartnett, "Managing Conflict: Examining Recent PLA Writings on Escalation Control," *Report by CNA China Studies, CNA Analysis and Solutions*, (February 2016).

and again, Roosevelt told his staff that oil shipments needed to continue to Japan. He knew any cutoff of oil to Japan would back them into a corner, leaving only open conflict. The eventual cutoff of oil supplies was implemented as a Japanese asset freeze in the U.S., where U.S. dollar denominated assets required by the Japanese to purchase oil supplies, were made unavailable. This put the Japanese government in a tight spot. They did not own any significant oil producing assets, as much of their attempts in Manchuria did not turn up much. They received around 80% of their oil consumed from the United States, regarding the halt in shipments as vital. Ultimately, they were forced to seize oil-producing assets owned by Royal Dutch Shell, in the Dutch East Indies. There, they had Japanese forces in control of oil producing assets, and Japanese flagged tankers and vessels, transporting the oil back to the homeland, regardless of economics. But, the situation would not have been possible unless Japan were able to conduct these operations themselves. This highly analogous to a Chinese "lesson learned" whereby control over the entire supply chain is vital to energy security.

Chinese energy security approaches have been storied and unique for a great power, absorbing swings back and forth along the producer-consumer scale, forcing drastic re-thinks of energy security throughout the 20th century. But its core strategic goals have remained the same, especially since the inception of the CCP in 1949 as the monopolizing governing body of China. The flow of energy, in particular oil, must continue unhindered for military and economic purposes, and this imperative will not change anytime soon.

CHAPTER V

THE CLASH OF GRAND STRATEGY

Some in the United States see a Chinese grand strategy to preempt the United States and the West when it comes to new oil and gas supplies, and some strategists in Beijing fear that the United States may someday try to interdict China's foreign energy supplies.

Daniel Yergin[408]

Introduction

The main focus of this chapter deals with the results of the principal components analysis and the derived Oil Security Ratings (OSR), along with the individual indicators, as well as a comparative analysis between both the United States and China. As a key component of the final analysis, it is important to note the unique PCA weighting process used in this study, which differentiates it from other weighted scores, and even other PCA-based studies. A key element of this research is the temporal component, whereby I am gathering data over a 22-year period, not just over the course of a single year, allowing a quantification of the long-term approaches to oil security. As argued earlier, this allows greater depth and robustness of the importance of the variables included in the analysis, and allows this study to capture that temporal factor. This study did not weight the individual variables based on a single year as with the previous studies, but instead applied the weights derived from the entire 22-year dataset for all 30 countries in each

[408] Yergin, "Ensuring Energy Security," *Foreign Affairs*, 77.

year. For instance, in Gupta's study from 2008, a single year was used to calculate the scores for the European Union 27-country bloc, yielding 27 data points for seven variables, yielding only 189 data points. By adding the temporal dimension, new variables, and calculating for 22 years, this research generated 660 data points for each of the ten variables (dimensions of oil security), resulting in 6,600 total data points used to generate the principal component analysis and final scores. The aim was not to understand just the importance of different dimensions of energy security in each individual year, but to understand the relative importance of each variable over the long-term, since grand strategy and oil security are inherently long-term, forward looking, temporal issues that must be confronted by assessing enduring security.

Analysis

The data utilized for this project yielded considerable insights into understanding relative levels of oil security for China and the United States, among many other countries, and to understand why some countries are more successful, or less successful, at achieving supply security. This represents a great stride in understanding the long-term dynamics influencing oil supply security among many countries, and results in an effective policy oriented measure capable of identifying weaknesses and deficiencies in security planning.

First, the correlation matrix and eigenvalues can be found in Table 5.1:

Table 5.1: Correlation Matrix and Eigenvalues

Correlation Matrix

Indicator	Intensity	PtoR	CtoR	TPEC	MIT	Depend.	HHI	ItoGDP	Power	Price
Intensity	1.0000	-0.1660	-0.1843	-0.6031	-0.0633	0.2457	0.0465	0.1902	-0.2303	0.1620
PtoR	-0.1660	1.0000	0.9241	0.5527	-0.0455	-0.1572	0.2254	-0.0339	0.2681	-0.2675
CtoR	-0.1843	0.9241	1.0000	0.5848	-0.1080	-0.0895	0.1428	-0.0241	0.2497	-0.2644
TPEC	-0.6031	0.5527	0.5848	1.0000	0.2928	-0.4382	0.0711	-0.2173	0.1613	-0.3505
MIT	-0.0633	-0.0455	-0.1080	0.2928	1.0000	-0.3588	0.0898	0.1273	0.1800	0.1309
Depend.	0.2457	-0.1572	-0.0895	-0.4382	-0.3588	1.0000	-0.1865	0.4761	0.1108	0.1938
HHI	0.0465	0.2254	0.1428	0.0711	0.0898	-0.1865	1.0000	0.0026	0.3674	0.0027
ItoGDP	0.1902	-0.0339	-0.0241	-0.2173	0.1273	0.4761	0.0026	1.0000	0.0903	0.3038
Power	-0.2303	0.2681	0.2497	0.1613	0.1800	0.1108	0.3674	0.0903	1.0000	0.0532
Price	0.1620	-0.2675	-0.2644	-0.3505	0.1309	0.1938	0.0027	0.3038	0.0532	1.0000

Eigenvalues

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Standard Deviation	1.7527	1.3066	1.2181	1.0431	0.9667	0.8265	0.7346	0.5220	0.3966	0.2497
Proportion of Variance	0.3072	0.1707	0.1484	0.1088	0.0935	0.0683	0.0540	0.0272	0.0157	0.0062
Cumulative Proportion	0.3072	0.4779	0.6263	0.7351	0.8285	0.8968	0.9508	0.9780	0.9938	1.0000

The derived weightings for the study are drawn from the eignenvectors in Table 5.2:

Table 5.2: Eigenvectors

Eigenvectors

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Intensity	0.3117	0.1811	-0.1105	0.4754	-0.5312	0.1269	-0.3760	0.0857	-0.4215	-0.0836
PtoR	-0.4545	0.3198	-0.1910	0.0609	-0.2567	-0.1567	-0.0881	-0.0950	0.3809	-0.6314
CtoR	-0.4472	0.3263	-0.2512	-0.0224	-0.2301	-0.1765	-0.1005	0.0072	0.0329	0.7312
TPEC	-0.4948	-0.1164	0.0820	-0.2788	-0.0741	0.0236	0.1392	0.4053	-0.6525	-0.2042
MIT	-0.0901	-0.1143	0.6584	-0.1728	-0.3956	0.2789	-0.2667	0.2529	0.3679	0.1039
Depend.	0.2815	0.4727	-0.2587	-0.2575	0.2363	0.1892	-0.0839	0.6607	0.1650	-0.0409
HHI	-0.1528	0.2391	0.3269	0.6704	0.1531	0.0415	0.5087	0.2674	0.0693	0.0550
ItoGDP	0.1828	0.4977	0.1566	-0.3551	-0.2871	0.2828	0.4793	-0.3917	-0.1502	-0.0130
Power	-0.1909	0.3995	0.3473	0.0409	0.5205	0.1403	-0.5043	-0.2875	-0.2303	-0.0330
Price	0.2662	0.2094	0.3594	-0.1369	-0.0660	-0.8442	-0.0204	0.1061	-0.0858	-0.0360

Then, by only using principal components with a variance above 1, that leaves the weightings to be derived from the first four principal components, resulting in the shares listed below in Table 5.3.

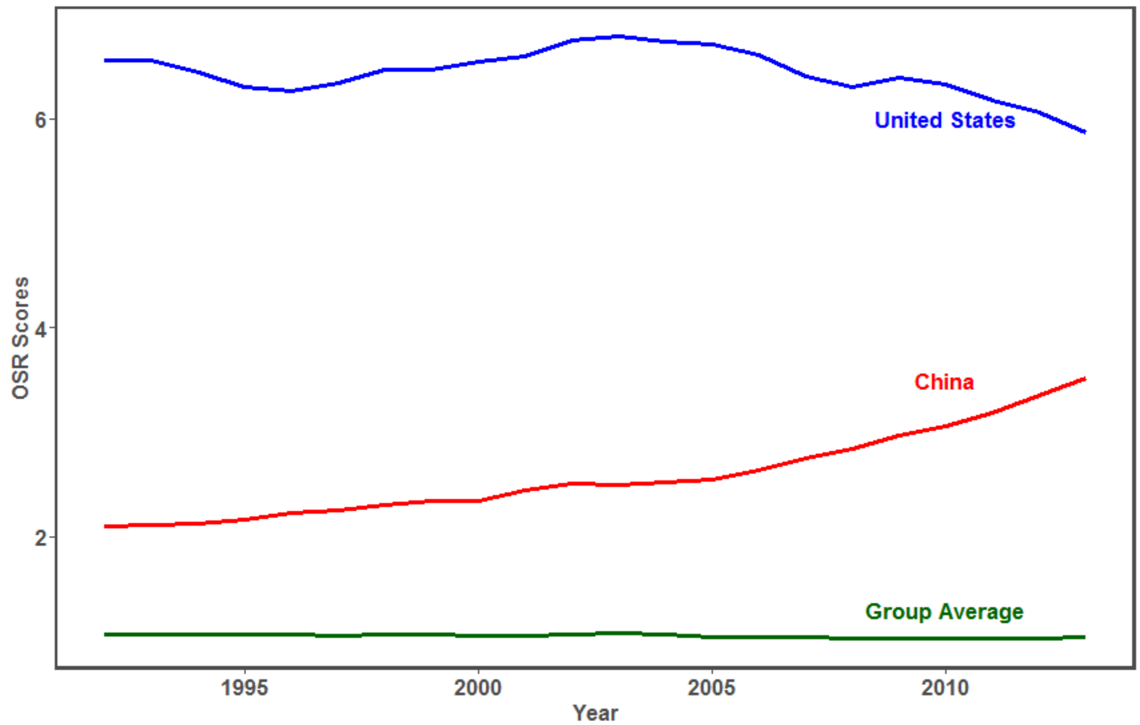
Table 5.3: Indicator Derived Weights

Indicators	Weights	Percentage
Herfindahl-Hirschman Index (HHI)	0.1591928	15.92%
MIT Economic Complexity Index (ECI)	0.1211287	12.11%
Import Dependence	0.1089781	10.90%
Imports to Gross Domestic Product	0.1079193	10.79%
Consumption-to-Reserves	0.0925175	9.25%
Eenrgy Intensity	0.0920566	9.21%
Production-to-Reserves	0.0872637	8.73%
Oil of TPEC	0.0857032	8.57%
National Power	0.0795933	7.96%
Price Volatility	0.0656468	6.56%

As demonstrated in Table 5.3 above, the Herfindahl-Hirschman Index was determined through the principal component analysis to account for the largest amount of variance in the dataset, assigning it the greatest weight at 15.92 percent. This does not come as a surprise, given crude oil import diversity is routinely touted as one of the most import aspects of oil security, and it would make sense higher levels of diversity would pay off over the long-run. It would seem these long-term results have already corroborated a key component of oil security. Interestingly, the MIT ECI variable accounted for the second greatest amount of variance in the data set, signifying a high level of importance of a strong knowledge base underlying an economy, which can then be translated in to gains in the energy sector. It also does not come as much surprise that the variable with the lowest weight at 6.56 percent is Price Volatility, owing to the greater degree similarity in pricing volatility among the countries involved in the study due to these participants drawing from a "global oil market." This will eliminate greater degrees of volatility between various countries, even though there still will be some differences.

Found below, Figure 5.1 is perhaps the most important graph in the study, encapsulating the entirety of this process. Using this quantitative process, and the creation of a robust scoring mechanism, it is possible to surmise two key insights from the data. First, the United States is the most oil secure country in the study, by a wide margin. The United States has also maintained a steady level of oil security throughout the study period, owing to many key elements that will be discussed later in the chapter. As a matter of fact, the United States scores in the "6" range throughout nearly the entire 22-year period analyzed, only witnessing a drop through the 6 level in the final year of the study, 2013. Whether this is an aberration or a trend, remains to be seen; however, the decline almost certainly has to do with the relative increase of China, which is the other key takeaway from the final scores. This other insight is that China ranks as the second most oil secure country in the study since 1996 after Japan's precipitous drop, and has been rising in supply security dramatically. This increase in security represents the most impressive in the study and backs one of the research hypotheses. As evidenced by the main graph comparing the OSR scores between the United States and China, the massive gap in scores that existed in 1992 has narrowed considerably and appears this trend will continue. The average score over the 22-year period for the United States is 6.44, China is 2.58, and score for all thirty countries included in the dataset is 1.05. The average for all countries was remarkably steady throughout the study period, vacillating only slightly between 1.07 and 1.02, indicating an overall downward trend for the entire group, with a 4 percent decline.

Figure 5.1: Oil Security Ratings of China and the United States



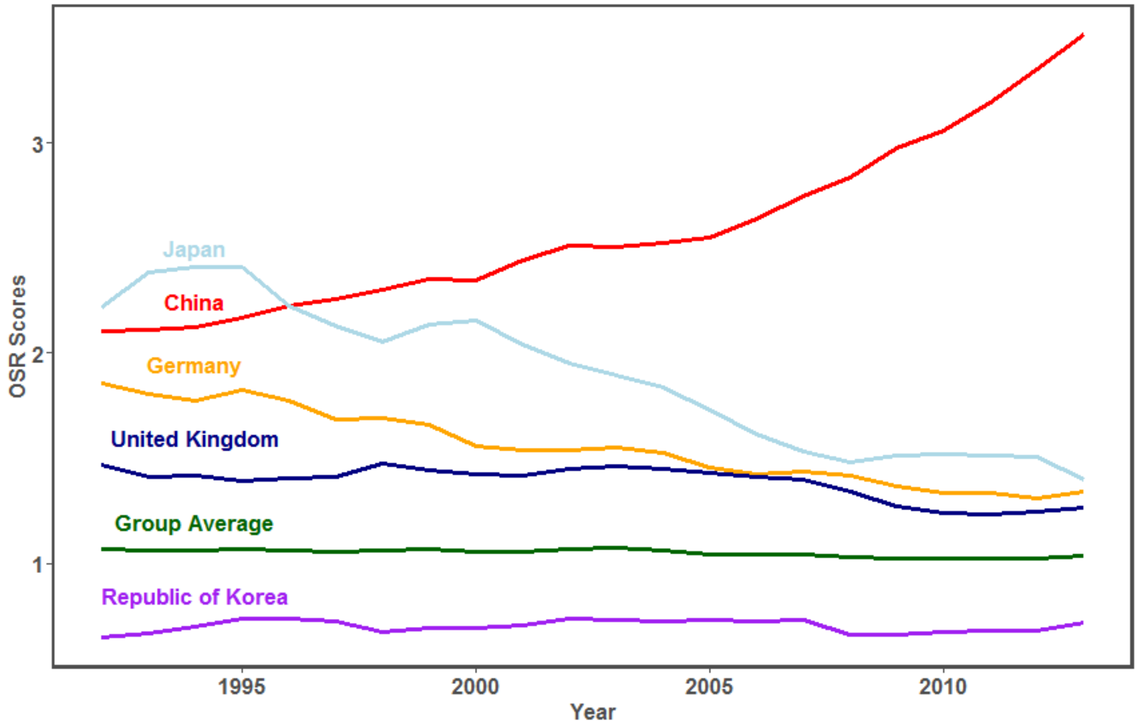
Source: Multiple. Key inputs provided in appendix.

Second, a striking feature alluded to above is the steep increase in China's oil security mirrored to the decrease witnessed by the United States over the last decade. Throughout the entire period, China's oil security has been on a steady, upward trajectory, beginning with a score of 2.11 in 1992, and ending with a score of 3.51 in 2013, resulting in a stunning increase of 67 percent. No other country comes close to mirroring these rapid advances in oil security. The average year-over-year gain for China throughout the entire study is 2.48 percent, well ahead of the second highest average belonging to Ireland with 1.64 percent. The United States, while starting with, and maintaining, a superior level of oil security, actually saw a year-over-year drop throughout the study period, with a -.51 percent decrease.

China's year-over-year advances also accelerate beginning in 2005, where the average jumps to 3.76 percent ending in 2013. The United States, over the same period, actually witnesses acceleration in year-over-year declines to 1.52 percent beginning in 2005, and this number rises further to 2.46 percent when beginning in 2011. The decreases are clearly accelerating, and these last few years account for the overall decrease in oil security for the United States throughout the entire study period. As a matter of fact, the year-over-year rate for the United States is essentially flat from 1992 through 2006, only dipping into the negatives overall beginning in 2007.

Another fascinating aspect of the OSR results is demonstrated when viewing Figure 5.2, which displays the comparison of China’s final scores to those of other countries included in the study. One must quickly come to the conclusion that oil security is of incredible importance to the Chinese government, owing to the steady, concerted, long-term increase in oil security compared to these other countries. Policy is purposefully orientated in order to create sustainable gains on this scale, placing China's oil security on a trajectory unparalleled by any other. They are adapting, changing, and copying best practices developed by the United States over many decades. The following graph demonstrates this, by removing the United States, and allowing for a closer look at other selected countries, this starkly demonstrates China’s path as separate from the others.

Figure 5.2: Oil Security Ratings (China and select countries)



Source: Multiple. Key inputs and full data for all countries provided in appendix.

Gross Domestic Product per Unit of Energy Used

This is a measure of energy intensity in the economy. The higher the dollar amount, the more energy efficient the overall economy is, meaning per unit of energy used, the country will ideally be able to create more wealth from that single unit as opposed to less wealth. As Table 5.4 shows, both the United States and China do not score particularly well on this measure compared to other countries. For instance, averaged out through the entire 22-year period, China ranks last out all countries in the study, coming in at number 30. The United States does not do much better, ranked at 24. However, both did improve efficiency over the study period, and since the data is inflation adjusted at constant 2011 U.S. dollars at purchasing power parity, these were real efficiency gains. Both also steadily increased over the study period, with only slight changes in the year-over-year growth rate. Efficiency in the United States rose by a healthy 51 percent, while China more than doubled efficiency for a 116 percent gain over 22 years. Much of this gain in China, however, is the result of the country continuing to shed inefficient manufacturing and industrial businesses throughout the economy. During the Maoist era and well into the 1980s and 1990s, China's industrial base was wildly inefficient and incredibly energy intensive, so it makes sense that as it advances, it is able to lose some of these legacy programs, boosting efficiency considerably. This does not, however, do much compared to the other countries in the study, resulting in the rank at 30, with only $4.09 of GDP produced for each unit of energy consumed. The United States produced $6.05 of GDP per unit of energy consumed, while Malta gained the top spot with $12.42, Italy the second spot, with $12.16, and Ireland in the third spot with $12.00. Interestingly, Japan, largely considered highly energy efficient, only ranks at 16 out the countries considered. Compared to other advanced industrial economies, both the United States and China have much room for improvement.

Table 5.4: GDP per Unit of Energy Used (U.S. and China, USD)

Year	China	United States	Year	China	United States
1992	2.45	4.86	2003	4.23	6.06
1993	2.64	4.91	2004	4.05	6.17
1994	2.85	5.01	2005	4.17	6.34
1995	2.94	5.08	2006	4.30	6.57
1996	3.15	5.16	2007	4.66	6.58
1997	3.44	5.34	2008	5.00	6.73
1998	3.69	5.53	2009	5.06	6.88
1999	3.89	5.64	2010	5.11	6.89
2000	4.00	5.71	2011	5.15	7.08
2001	4.24	5.87	2012	5.30	7.41
2002	4.38	5.91	2013	5.30	7.36

Source: World Bank, World Development Indicators, GDP per unit of energy use (constant 2011 PPP per kg of oil equivalent), 2016, http://data.worldbank.org.

Production to Reserves

The production to reserves ratio is an oil security measure used to understand the amount of time a country could produce oil at current levels of production, for each year, given the amount of proved reserves available within the territory of that country. Basically, this adopts the view that the most secure oil supplies a country could possibly draw on, are those supplies which are wholly domestic in nature. Shown in Table 5.5, on this measure, China comes out ahead of the United States. This is simply due to the lower levels of production in China. On the other hand, the United States is a massive importer of crude oil, that also refines a large portion of that crude, and then re-exports the products to other markets. China actually takes the number four ranking at .06, behind Bulgaria at .02, Romania at .04, and India at .05, respectively. The United States ranks at 15, with a score of .13. Several countries received a score of 1, due to a complete absence of reserves or production, or the absence of both reserves and production. This indicates the lowest score possible, and nine countries in the study attained this count. Interestingly, the majority of these nine countries are small, economically advanced countries like Belgium and the Republic of Korea. Another interesting point about this data, is the curious stability witnessed in the scores for the United States, where it vacillates only slightly in the .12 to .14 range for all 22 years. Meanwhile, China has similar levels of stability, but there is an over all trend to the data, showing an increase in the score, where China has actually had a hefty reduction in the level of domestic reserves available, beginning in 2003. Even still, China's scores only waver between .04 and .09, where the peak is in 2009 and drops down to .07 in 2013.

Table 5.5: Production to Reserves (U.S. and China)

Year	China	United States	Year	China	United States
1992	0.04327	0.12665	2003	0.06846	0.11839
1993	0.04395	0.12915	2004	0.07005	0.12118
1994	0.04470	0.13066	2005	0.07265	0.11851
1995	0.04547	0.13338	2006	0.07413	0.11611
1996	0.04762	0.13341	2007	0.08588	0.12227
1997	0.04867	0.13476	2008	0.08749	0.12114
1998	0.04864	0.12823	2009	0.08780	0.14476
1999	0.04859	0.13228	2010	0.07421	0.14112
2000	0.04941	0.12777	2011	0.07412	0.13121
2001	0.05019	0.12500	2012	0.07499	0.12683
2002	0.05163	0.12310	2013	0.06566	0.12300

Source: Calculated by author using data derived from Energy Information Administration, International Energy Statistics, Crude Oil Proved Reserves (Bbbls) and Production of Crude Oil, NGPL, and Other Liquids (Mbbl/d), 2016, https://www.eia.gov.

Consumption to Reserves

The consumption to reserves ratio is a measure not unlike the previous production to reserves ratio, where the goal is to understand the how long a country could survive off its current stock of domestic crude oil reserves given current levels of consumption for each year. The production versus consumption distinction is crucial, given the importance of both aspects of a state to both produce requisite amounts of crude oil and to ultimately be able to meet that demand in the form of consumption. As with the previous measure, a lower score is better, indicating less consumption compared the amount of domestic proved reserves available. With this measure, in Table 5.6, China exhibits a better score for each of the 22 years considered, but the clear trend for China is negative, with a quadrupling of the score over this period from .04 in 1992 to .16 in 2013. This is due to the combined factors of greatly increased crude oil consumption in China and reduced crude reserves available beginning in 2003. China's massive increases in consumption could not have happened at a worse time for this measure, given the declines in reserves coinciding at the same time, and most likely due to these consumption increases. The United States, on the other hand, started in 1992 with a relatively high score of .24, only to rise to a peak of .338 in 2007. However, the trend for the United States since then has down, reaching .21 in 2013, below even the beginning score in 1992. This represents a very positive contribution to oil security, and the 2013 score is on trend to reach parity with China in a few years. Among the other countries surveyed, both China and the United States rank relatively well. The worst score goes to Japan where the lack of meaningful crude reserve levels and extremely high consumption levels catapult it into an extremely unfavorable position with this ratio.

Table 5.6: Consumption to Reserves (U.S. and China)

Year	China	United States	Year	China	United States
1992	0.04048	0.23980	2003	0.11156	0.30438
1993	0.04501	0.25195	2004	0.12875	0.32749
1994	0.04807	0.26780	2005	0.13591	0.33608
1995	0.05115	0.27408	2006	0.14527	0.32803
1996	0.05490	0.28379	2007	0.17064	0.33832
1997	0.05956	0.29139	2008	0.17559	0.31197
1998	0.06244	0.28906	2009	0.18409	0.33334
1999	0.06636	0.31849	2010	0.16032	0.31372
2000	0.07293	0.31038	2011	0.17047	0.27370
2001	0.07479	0.30496	2012	0.18250	0.23312
2002	0.07849	0.30250	2013	0.16129	0.20719

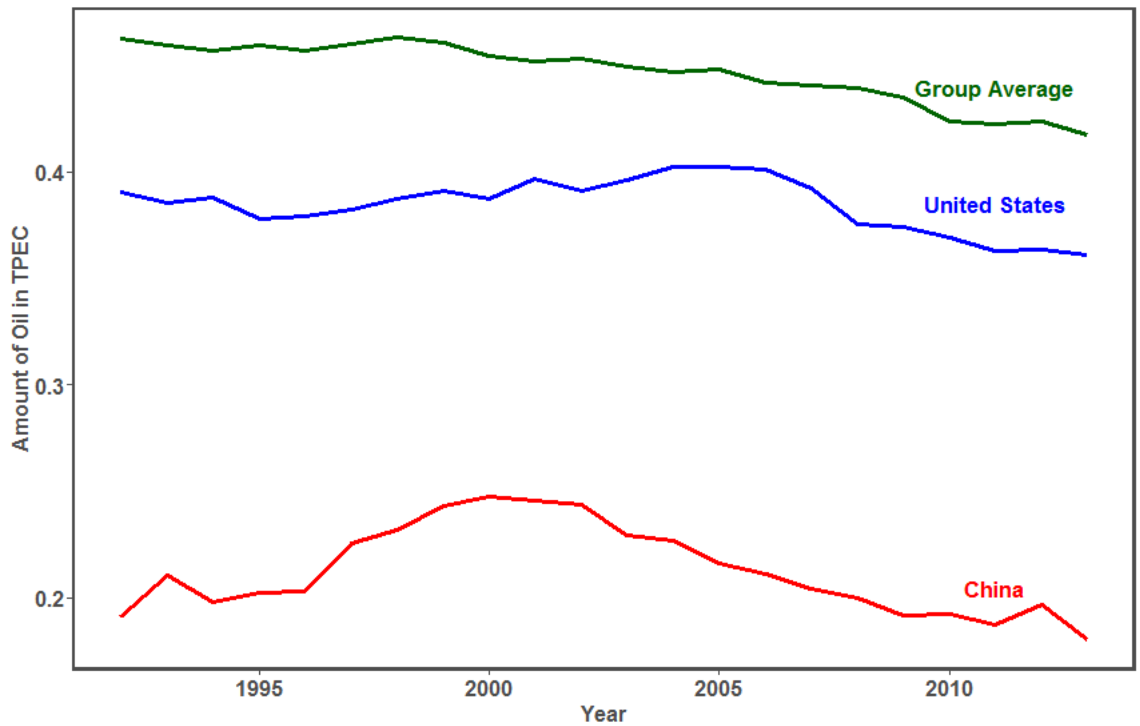
Source: Calculated by author using data derived from Energy Information Administration, International Energy Statistics, Crude Oil Proved Reserves (Bbbls) and Total Petroleum Consumption (Mbbl/d), 2016, https://www.eia.gov.

Oil as a Component of Total Primary Energy Consumption

For this study, Total Primary Energy Consumption was used instead of the oft used Total Primary Energy Production. This was done since the determination of oil security using a metric like this should reflect consumption since that is the ultimate end goal of any imports or production. The oil production share of the total amount of primary energy produced doesn't tell much with the consumption indicator, which is covered by another measure. Oil as a component of consumption, however, allows you to glean information as to the ultimate requirements of the state and the mix among oil, natural gas, coal, renewables, and nuclear energy. Production demonstrates what is produced, but much of that may be exported depending on the country in question. Consumption tells the overall energy requirements and diversification along primary energy components in the economy. This metric once again takes the lower score to more advantageous, but this is in a sense, not completely accurate. The true point of gauging primary energy consumption should be to demonstrate some level of diversity. Since the figure represents the percentage of the consumption mix that is attributable to crude oil it is simply assumed that most states typically have higher levels of oil consumption compared to other forms of primary energy, and that this overreliance can contribute to oil security deficiencies. As shown in Figure 5.3, China performs quite well, maintaining lower levels of oil in the domestic economy compared to other energy sources. Even though China has grown rapidly, the highest level oil reaches as a share of consumption is 25.8 percent in 2000. After that, it declines to 20 percent in 2007 and finally to 18 percent in 2013. These are very low levels when the 22-year averages are examined for all countries in the study, with China attaining the number two rank behind only Slovakia with an average of 20 percent. It is interesting to note the largely lower levels of oil consumption in the ex-Soviet bloc of countries included in the study, plus China which mirrored many of the industrialization and development approaches of the

Soviet Union. As a legacy of this era, Slovakia, China, Poland, Czech Republic, Bulgaria, Romania, and Hungary all occupy the ranks one through seven, in that order. Meanwhile, the United States ranks at number 14 with an average level of 38 percent, and witnessed less variability than China over the period, but did report a steady decline beginning in 2008. In 1992 the amount of oil in the mix was 39 percent, with a peak of 40 percent in 2005, and ultimately ended with 36 percent in 2013. The level essentially plateaued from 1992 through 2007, before the earlier mentioned drop.

Figure 5.3: Oil Consumption as a Component of TPEC



Source: Calculated by author using data derived from Energy Information Administration, International Energy Statistics, Total Primary Energy Consumption (quadrillion Btu) and Total Petroleum Consumption (quadrillion Btu), 2016, https://www.eia.gov.

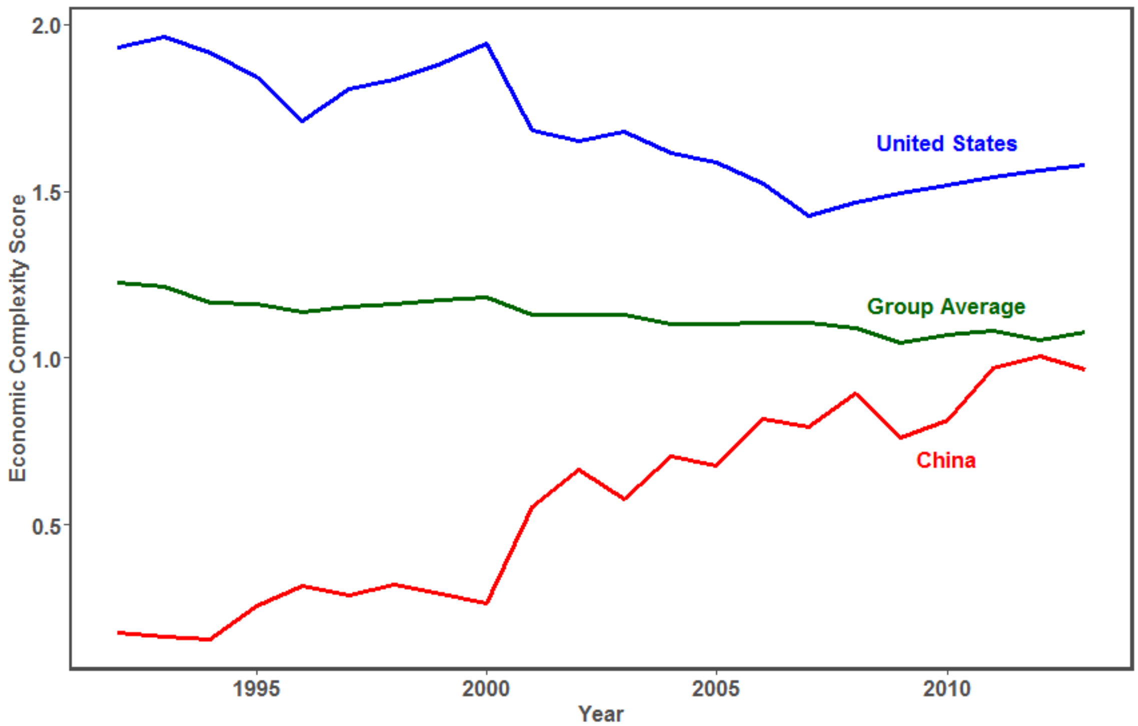
Massachusetts Institute of Technology Economic Complexity Ratings

The MIT Economic Complexity Rating is one of the most fascinating indicators utilized in the study, and it proved to be a dynamic component to the overall OSR scores. Again, this is meant to be a proxy indicator for economic advancement, the knowledge economy, and to a certain degree, entrepreneurship. A measure of this type was sorely needed when one considers something as stunningly impressive as the reserve and production gains resulting from the tight oil revolution occurring in the United States. This materialized only because of domestic technological development in the United States, and resulted in a massive impact not only to the supply of oil available for domestic development, but also through the resulting collapse and upending of oil markets.

For this indicator, presented in Figure 5.4, the overall average score for the United States turned out quite well, recording a score of 1.69 and coming in at rank 7 for the study. China came down in the rankings at 23 with an average score of .56. There is, however, a trend towards convergence between both countries, where China has greatly increased its complexity over the study period, and the United States has actually had an overall reduction in complexity. As a matter of fact, in 1992, China's score was .18 and the United States' score was 1.93, resulting in a difference of 1.75. By 2013, that gap narrowed considerably with China scoring .96 and the United States scoring 1.58, with a difference of .62. China's complexity gains since 1992 have been quick and massive, with gains accelerating in 2001, resulting in an increase of over 400 percent over the course of the study. And, in 2001, China's economic complexity actually doubled year-over-year, from .26 in 2000 to .55 in 2001. This coincides with the rapid growth in

China's economy and its attempts to shed basic manufacturing for higher value added industries requiring the dense knowledge based networks this measure is used to quantify. Over the study period, the score for the United States decreased by 18 percent from 1.93 in 1992 to 1.58 in 2013.

Figure 5.4: Economic Complexity Scores (U.S. and China)

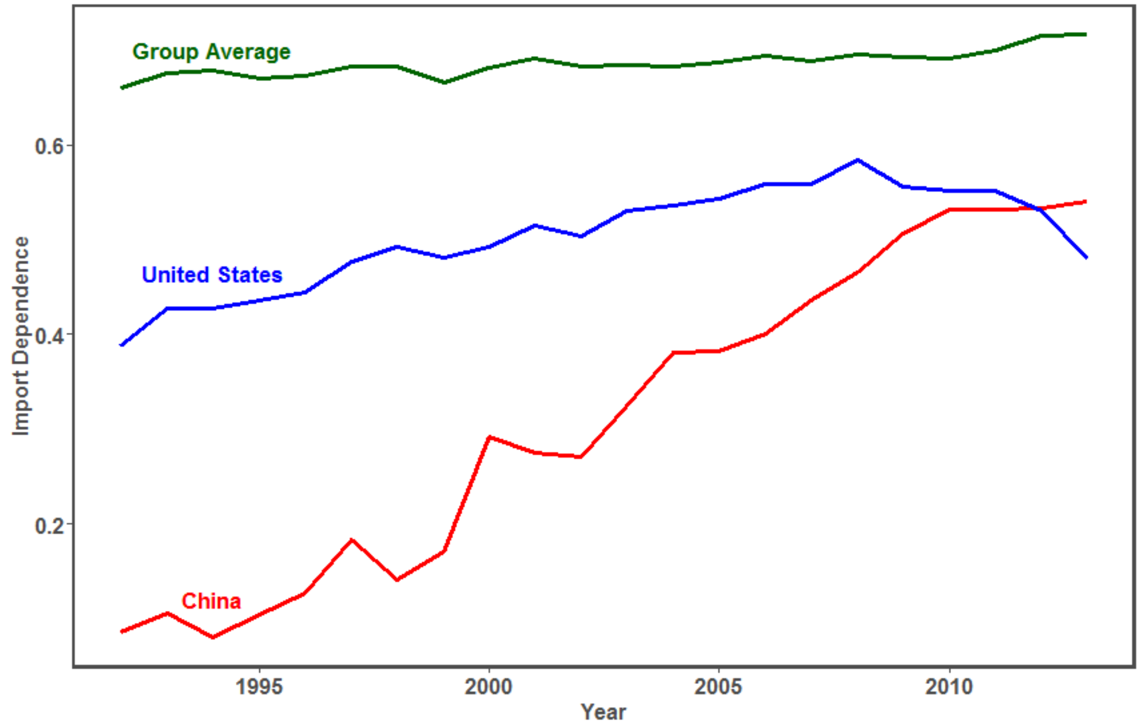


Source: AJG Simoes, CA Hidalgo, The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development, Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence, 2011.

Import Dependence

Import dependence is a simple ratio that has been used heavily by the International Energy Agency as a quick measure for understanding oil import vulnerability. This indicator demonstrates the percentage of crude oil imports to a state as a component of overall petroleum consumption. It measures the ability of the state to supply its own energy needs as opposed to importing to meet those requirements. The higher the level of imports to consumption, the greater the degree of vulnerability a state will witness, along with potential supply issues. Once again, for this particular indicator, a lower score is better since importing a lower percentage of the economy wide consumption base should lead to less exposure to oil supply security challenges. For much of the study, China had much lower levels of import dependence than the United States, owing to its lower consumption levels in the 1990s and comparatively large resource base. The starting point for this study was determined by capturing China's transition from oil exporter to importer, which means in the 1990s, China still had enough domestic resources to cover most requirements, but rapid economic growth quickly evaporated this advantage, can be observed in Figure 5.5. As can be seen in the graph, there is a huge gap in 1992 between both states, but it is completely gone by 2012, and by 2013 China has a higher level of import dependence, especially as the United States begins to realize production gains from domestic tight oil resources, causing a sharp drop. For much of this period, the United States has a steady increase, which is halted in 2008 before finally decreasing. China on the other hand rapidly increases from .09 in 1992, to .54 in 2013, meaning fully 54 percent of China's crude oil consumption must be met by imports. The United States starts in 1992 at .39, peaks at a high of .58 in 2008, and ends with a .48 in 2013. The averages for all countries adds to our understanding when we see the relative levels of import dependence for both China and the United States are quite good, with each ranking 5 and 9, respectively. China's average over the period was .31 and the average of the United States was .5.

Figure 5.5: Comparison of Oil Import Dependence

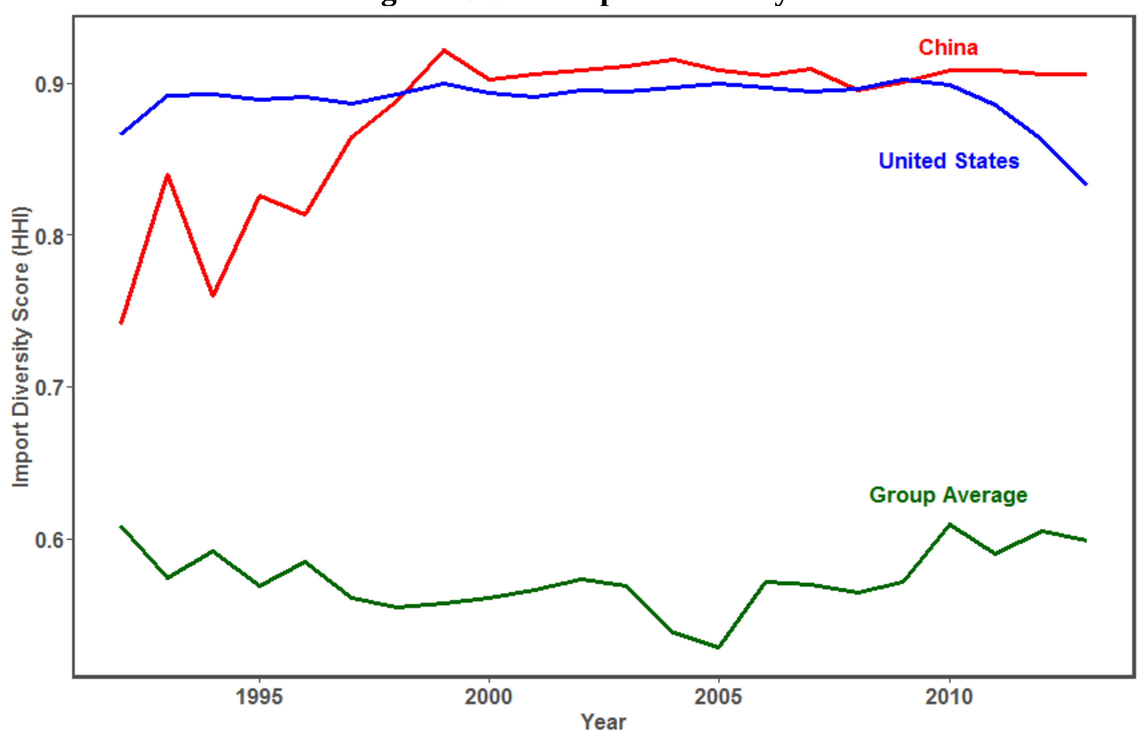


Source: Calculated by author using data derived from EIA databases, and included in appendix.

Herfindahl-Hirschman Index

This is another extremely useful indicator, even outside of more complex models. The ability to diversify import sources increases oil supply security immensely, allowing for potentially several sources to falter, while the others pick up the slack, resulting in only a minor supply interruption. Diversity in oil import sources is an extremely valuable tool for oil security. As indicated in Figure 5.6, over the entire 22-year period, the United States ranks as the second most diverse oil importer, following Spain in the number one spot. Spain's average rating was a .90, where the United States received a rating of .89. China ranked at number 4, with a rating of .88. However, digging into the data a little deeper, and referencing the graph, we see an interesting story between both countries as they strive for diverse oil sources. First, China moves rapidly to increase the diversity of its oil imports, achieving rough parity with the United States by 1998, and exceeding that level of diversity in 1999. This represents a rapid increase from .74 in 1992, to .89 in 1998, and .92 in 1999, realizing a 24 percent gain in import diversity from 1992 to 1999. At this point, both states' scores plateau, hovering around the .9 mark, before the United States begins to drop after its peak in 2009 at .90. The United States ultimately ends up with a .83 in 2013. This drop is most likely the result of the shifting global oil markets centering on the changes occurring in the United States as a result of the domestic gains from tight oil production. As this domestic production grows, smaller and more ancillary oil exporters to the United States will necessarily drop off and are forced to move their product elsewhere. Losing supply in this way will certainly negatively impact import diversity.

Figure 5.6: Oil Import Diversity



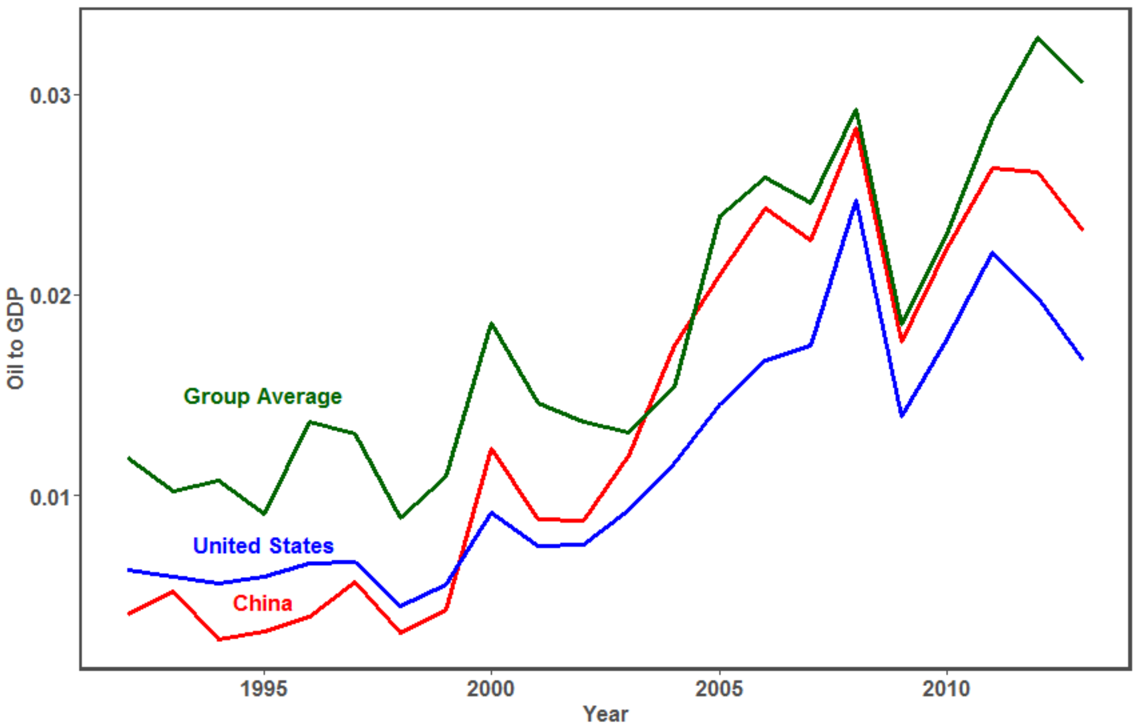
Source: Calculated by author with data from the UN Comtrade database: United Nations, UN Comtrade Database, 2016, http://comtrade.un.org/.

Imports to GDP

This is an indicator used to understand the actual dollar amount as a percent of GDP that is spent on crude oil imports economy-wide. This is a clever measure to understand the actual impact of price fluctuations on the broader economy, and to measure the depth of oil costs on an economy. The more money spent as a percentage of GDP, the greater any potential supply disruptions will result in higher levels of economic damage. Spending less as a percent of GDP is advantageous in the case of any unforeseen shocks. On this metric, the trend throughout all countries included is to ultimately spend more on oil over time given price increases in the latter half of the 22-year period in the study. Even if some countries had halted increases in the actual, physical supply of oil imports, the dollar value of those imports would still rise in response to the price increases witnessed during this time. In Figure 5.7, the data reflects this in all participants, and smaller, less oil reliant states take higher level spots with this indicator as Luxembourg and Malta take the top two rankings. However, the United States still ranks at 9 with an average of .0116 (1.2%) and China at a rank of 12 with an average of .0138 (1.4%). The Republic of Korea takes the last spot, with oil accounting for a hefty .0457 (4.6%) of GDP. Looking at the graph we see striking similarities between the United States and China, with both lines plotted quite close to one another. Both seem to be very heavily reflective of the greater oil market and it is impressive that China has been able to grow its economy sufficiently fast in order to accommodate the massive increases in crude oil imports over the period, which was no small feat.

Actually, the dollar value of Chinese imports swiftly rose from $1.7 billion in 1992 to $220 billion in 2013. However, China's increases in this category were more marked than with the United States. China went from .004 (.4%) of GDP in 1992 all the way to .0232 (2.3%) of GDP in 2013. China actually surpasses the United States on this measure by the year 2000, and maintains the higher level throughout the study period. The United States starts at .0063 (.6%) of GDP in 1992 and ends with .0167 (1.7%) in 2013, maintaining a healthy separation.

Figure 5.7: Comparison of Oil Import Value as a Percent of GDP

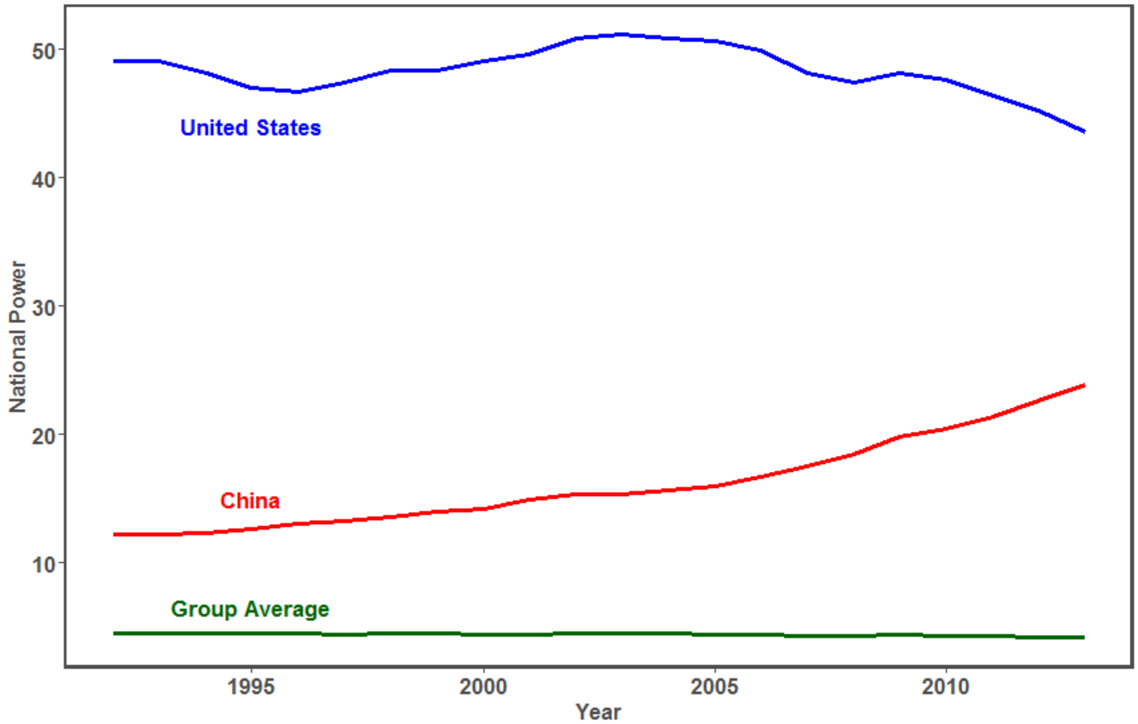


Source: Calculations by author with data from multiple sources, including UN Comtrade and the MIT Observatory for Economic Complexity.

National Power

The power measure comparison is a crucial component to any oil security mix, and is a key way the United States maintains such a high OSR score. There is no shortage of power measures available, as discussed previously, but since this is not a study on power, it was much easier to choose a stable, safe measure of national power that could ably provide the variable in the model for this study, and it certainly provides some interesting results. Looking at Figure 5.8, it is easy to spot some narrowing of the values between the United States and China; but even in 2013, the United States still scores nearly double what China scores. In addition, the United States' overall average power score over the study period dwarfs any other states listed with a 72.47. The second highest went to China, with a score of 24.2, and this is followed by Japan, with 16.48, and India with 13.79. But, again, the real interest of this measure is the rapid power advances made by China, the slight decline by the United States in the last few years of the study, and the overall narrowing of the gap between the two. China actually increases its power in this measure by 96 percent over the entire 22-year period, which represents a staggering level of growth, while the United States actually declines on this measure by 11 percent over the whole period. Much of the decline comes quite late in the study, and only falls through the 70 level in 2011. However, the narrowing of this measure between both states is stark.

Figure 5.8: National Power (U.S. and China)

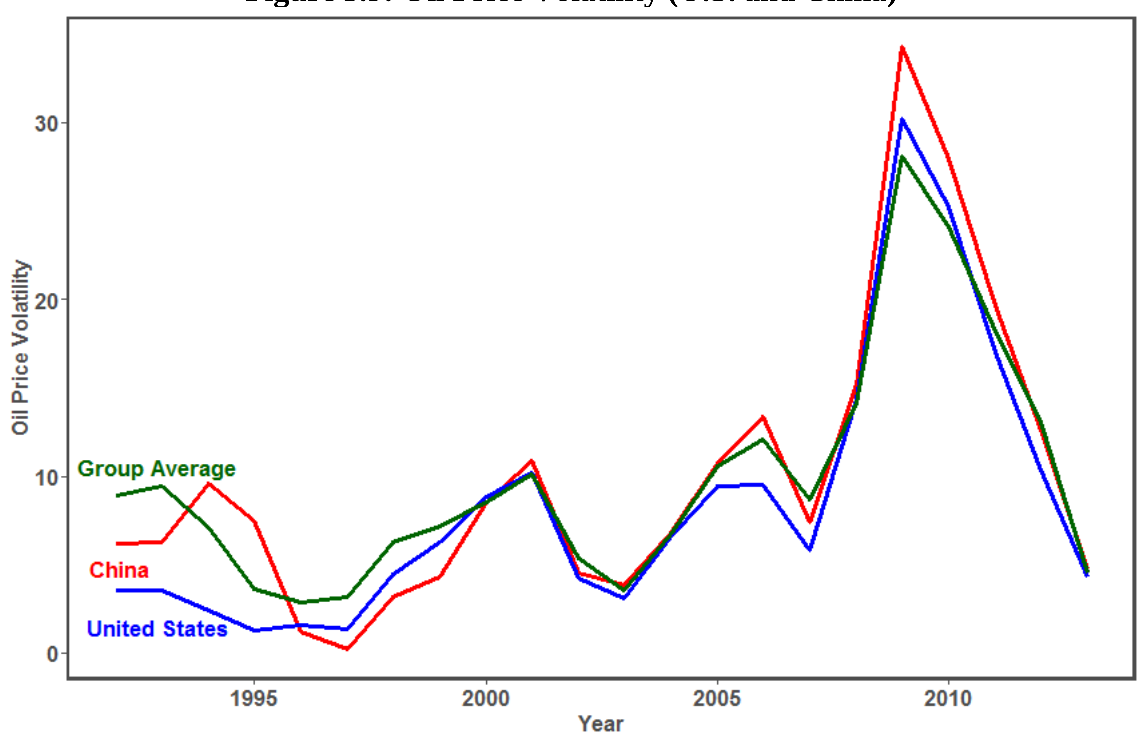


Source: Calculations made by author with data from multiple sources including World Bank World Development Indicators and the Stockholm International Peace Research Institute. See appendix for additional information.

Oil Price Volatility

This is ultimately a unique approach to measuring oil price volatility. Instead of looking at the pricing of the dominant crude blends being imported to both countries, which in this case would have been the West Texas Intermediate and Dubai blends, this study utilized trade data that ultimately revealed the average annual price per barrel of crude imported for each individual country in the study. After the average annual price per barrel was calculated, a simple measure averaging the change in the current year with the change in the previous two years is applied, which gives the volatility figure. This is a unique approach in that it allows to look at pricing on an individual country level instead of a less precise measure looking at the volatility of specific blends. As for the results, shown in Figure 5.9, this is another measure where small states with barely any imports receive the highest scores; however, the United States comes in at the number 4 spot for the average level of volatility over the 22-year period, at a level of 8.34, following Luxembourg, Malta, and Cyprus. China comes in 18th out of the group with a 9.94 level. Looking at the graph, however, volatility levels are fairly close between the United States and China. Oil is a global market, so this should be expected to a certain degree, barring other issues involving pricing. For instance, this study showed Bulgaria and Romania to be the subject of extremely high volatility in the early 1990s, quite unlike anything experienced by any other country involved in the study. In the graph for the United States and China, it is quite interesting to also note the large spike in volatility beginning in 2008 when pricing became much more erratic.

Figure 5.9: Oil Price Volatility (U.S. and China)

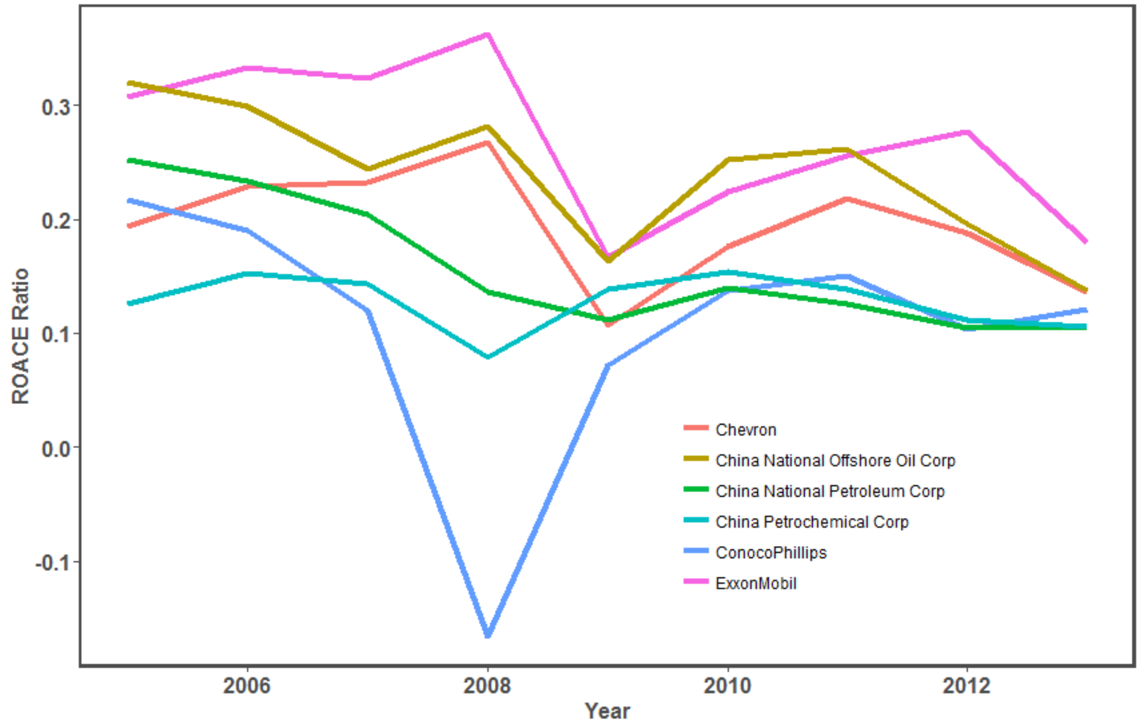


Source: Calculations made by author using data from UN Comtrade.

Data Not Included In the OSR

Even with other sources of data outside the OSR model above, there is a trend toward convergence. Take data and calculations presented in earlier chapters of capital efficiency from the largest three oil companies in both the United States and China. We see both parity and convergence. Figure 5.10 shows the period 2005-2013, where the average return on average capital employed (ROACE) for Exxon Mobil was 27 percent, while the second highest out of the group was actually China National Offshore Oil Company (CNOOC) at 24 percent. Conoco Phillips actually did the worst out of the group at 10 percent. Through much of this period, ROACE movements were relatively similar between the American and Chinese energy companies, indicating the same market forces were at work on both, with a comparable impact. In 2013, Exxon Mobil, Chevron, and Conoco Phillips returned 18 percent, 14 percent, and 12 percent, respectively, whereas China National Petroleum Corporation, Sinopec, and CNOOC returned 11 percent, 11 percent, and 14 percent, respectively. While there is a gap, it's not as large as one might think. CNOOC had the same return as Chevron, and continued to outperform Conoco Phillips.

Figure 5.10: Return on Average Capital Employed (ROACE) for Select U.S. and Chinese Energy Companies



Source: Calculations made by author from multiple data sources including Bloomberg Terminal and Morningstar.
Note: Some financial data related to Chinese companies may be inaccurate.

Furthermore, despite the constant chorus of Chinese tendencies to "overpay" for assets,[409] recent research on Chinese M&A data would seem to confirm this hypothesis.[410] Despite the assumption that most Chinese NOCs tend to overpay for their acquisitions,[411] it would seem this is not necessarily the case, especially when compared to other Asian energy companies, and other NOCs around the world. For instance, when

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[409] Andrews-Speed and Dannreuther, *China, Oil and Global Politics*, 80-81.

[410] Pang, "Chinese Overseas Oil and Gas M&A Strategy: Assessing the Financial and Strategic Performance of Foreign Upstream Acquisitions by the Chinese National Oil Companies, 2005-2013," 39-54.

[411] Ibid., 2-4.

looking at the average pricing in the North American shale sector per barrel from 2005-2013, Chinese firms have generally been on par with their competitors active in the same area,[412] along with acquisitions made in Canadian Oil Sands.[413] While the Chinese NOCs are still behind the Western majors on most financial and efficiency metrics, there are caveats for recent years. The large IOCs have been buying into sectors at a time when they were technologically unproven, and garnering lower prices as a result, and certain firms, like CNOOC, have been able to close the gap on efficiency considerably.[414] In general, acquisition costs have been in line with other, non-Western competitors.

Additionally, some of the overpaying done by Chinese firms in the past might be part of the risk analysis conducted beforehand, in order to overcome some of the domestic political costs in the target country. This is because the domestic populations and governments in many countries where China makes acquisitions, like the United States, may be hostile to the sale of energy assets to a strategic competitor. In order for a domestic firm to overcome the adverse political consequences, Chinese firms might need to pay an increased premium for the purchase.

Individual costs per barrel are also on par with China's Asian neighbors, reflecting the general "Asia premium" for crude, typically the Dubai blend,[415] and even has similar costs to several European countries, as shown in Figure 5.11. While costs per

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[412] Ibid., 62.

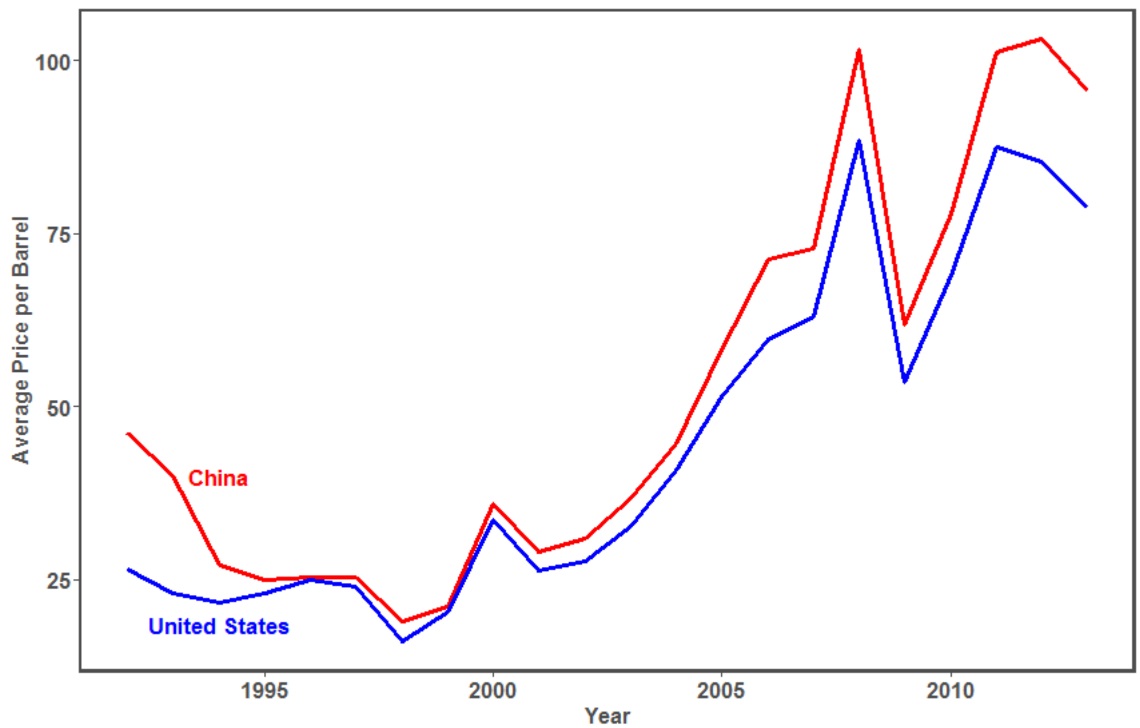
[413] Ibid., 57.

[414] Ibid., 51.

[415] Bassam Fattouh, "An Anatomy of the Crude Oil Pricing System," *The Oxford Institute for Energy Studies*, WPM 40 (2011): 61.

barrel imported to China typically have a significant premium over the cost per barrel in the United States, it is stable and once again, only reflecting region-wide premiums that exist between the major WTI, Brent, and Dubai-Oman blends of crude. Apart from that, per barrel costs imported to China are typically lower than both the Republic of Korea and Japan, and lower than larger European countries like Germany and France. It is also interesting to note the slowly rising prices per barrel for European economies paired with the increasing costs of Brent crude over time due slowing reserve growth and increased extraction costs.

Figure 5.11: Average Price per Barrel (inflation adjusted, 2010 dollars)



Source: Calculations made by author with data from UN Comtrade.

Direct per-barrel costs between the United States and China provide a stark contrast and clear advantage to the U.S. as shown in Table 5.7 below. Reflecting the

Asia premium, China's cost per barrel is considerably higher than the United States. In fact, the United States consistently has some of the lowest costs per barrel in the entire 30 country study, and costs in the United Kingdom tend follow closely to U.S. costs; although, there is a noticeable change in U.K. and European pricing towards the upside as North Sea crude costs began to rise in the mid-2000s, translating into higher Brent pricing for the continent. U.K. per barrel costs were actually cheaper than the United States until 2005, when the two countries switched price levels, and the U.S. retained its lower comparative costs.

Table 5.7: Comparative Costs for U.S. and Chinese Crude Oil Imports

Year	China ($)	US ($)	US-China (%)	Dubai Crude ($)	China-Dubai (%)
1992	20.54	17.10	-16.74	17.14	19.83
1993	20.35	15.27	-24.97	14.91	36.50
1994	17.11	14.80	-13.49	14.83	15.36
1995	18.48	16.14	-12.66	16.13	14.61
1996	20.30	17.96	-11.53	18.54	9.49
1997	20.82	17.73	-14.87	18.10	15.03
1998	15.48	11.98	-22.63	12.09	28.07
1999	17.07	15.60	-8.62	17.08	-0.01
2000	29.07	26.56	-8.62	26.09	11.45
2001	23.61	21.45	-9.15	22.71	3.95
2002	25.06	22.77	-9.15	23.73	5.58
2003	30.01	27.55	-8.20	26.73	12.27
2004	37.94	35.28	-7.00	33.46	13.40
2005	50.31	46.12	-8.34	49.20	2.25
2006	62.64	55.25	-11.80	61.43	1.97
2007	67.03	59.98	-10.52	68.37	-1.96
2008	99.03	87.39	-11.75	93.78	5.61
2009	59.91	52.66	-12.10	61.76	-2.99
2010	77.98	68.96	-11.56	78.06	-0.10
2011	106.72	90.25	-15.43	106.03	0.65
2012	111.60	89.91	-19.43	108.92	2.46
2013	106.18	84.33	-20.58	105.43	0.72

Source: Calculations made by author with data from UN Comtrade.
Notes: All prices are nominal costs countrywide, per barrel.
"US-China" and "China-Dubai" categories demonstrate the percent difference anchored in the first listed.

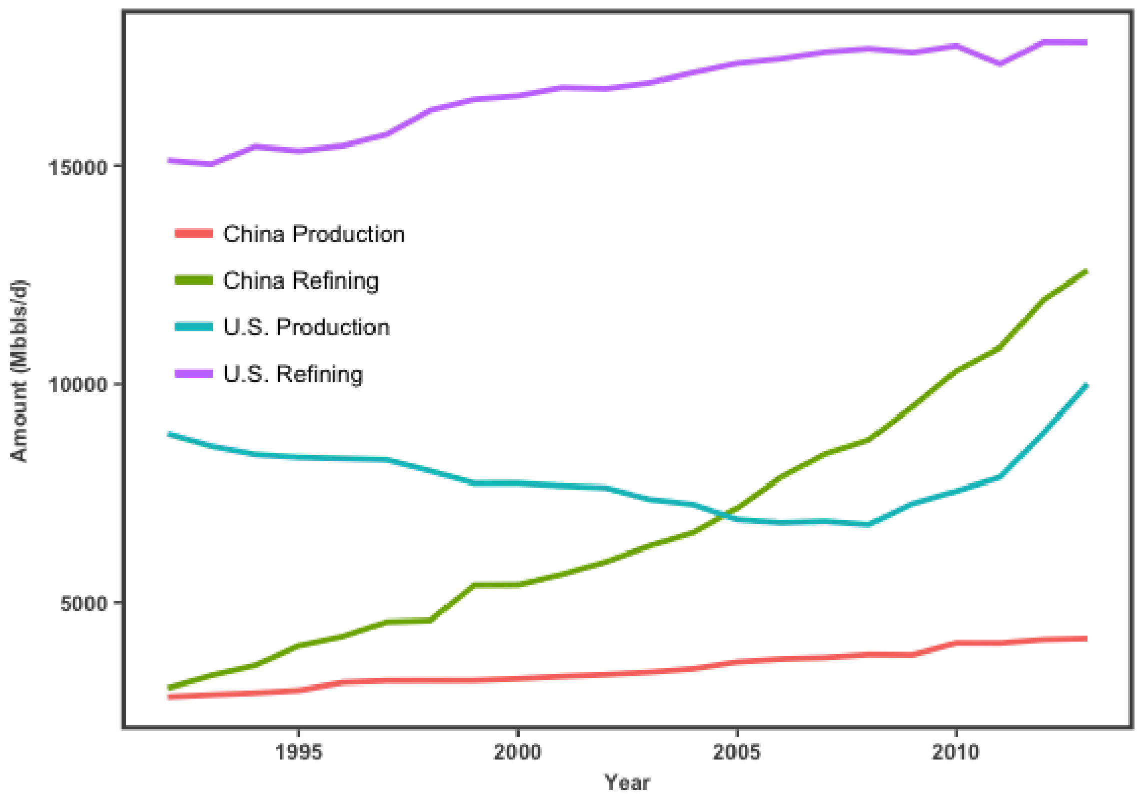
The cost differences between the United States and China were quite volatile in the first half of this study, while stabilizing in the second half, retaining a two-digit percentile difference in that half. When China began importing smaller amounts of crude in the beginning of the study period, its initial costs were much higher than the United States, and only sees a drop coinciding with the Asian financial crisis in 1998 when economic activity and oil prices were regionally depressed. But, after that period, China was able to close the gap in costs with the United States, only to see it rise and stabilize in the 2000s.

We can also see from the Chinese price differential to the cost for Dubai blend crude that per-barrel costs have not been noticeably different from the listed costs for the region, coming from the Persian Gulf. Here, again, as with the differentials to U.S. pricing, the higher costs are front loaded in the first half of the study period, showing Chinese costs per barrel on average 14.53 percent higher than the Dubai blend. Then, in the second half, these costs coalesce much closer to Dubai blend pricing, averaging only 3 percent higher for that period.

So even on a per barrel basis, the level of exorbitant pricing thought to exist with Chinese crude purchases doesn't seem to hold up that well. Per barrel pricing is well above those found in the United States, but relatively close to European costs and generally in line with the Asian premium on crude found with Asia-based buyers.

Finally, although data on individual production and refining levels for both countries have been presented in previous chapters, it is worthwhile to view a direct comparison between the two. In Figure 5.12 the comparative levels show China especially has gained a great deal of capacity. Most notable is Chinese refining capacity which has quadrupled over the course of the study, allowing China a high degree of crude sourcing flexibility. The United States, already the global leader in refining capacity, had modest increases as well, in addition to fluctuating production levels. These fluctuations are due to lowering overall production in the U.S. before massive increases witnessed as a result of the tight oil and gas revolution, resulting in a spike that allowed production to surpass levels seen over the entire 20-year period. Chinese domestic production, on the other hand, increased but only merely doubled from an already low level. Overall gains were modest. However, the importance of refining level increases should not go unnoticed.

Figure 5.12: National Production and Refining Levels (U.S. and China)



Source: Data sourced from Energy Information Administration, International Energy Statistics, Production (Mbbls/d) and Refining (Mbbls/d), 2016, https://www.eia.gov.

Section Summary

After reviewing the final data generated from the analysis, as well as the individual components, it is clear a single word could be used to summarize the relationship between China and the United States: convergence. And, in nearly every case, it is China that is "catching up" to the United States, adapting its approaches, and in doing so following many of the same paths to oil supply security. Much of this is a concerted effort on the part of the Chinese government; however, it is curious to note that certain components are simply the product of the environment and the size of the consumer reacting to that environment, meaning massive oil consumers are forced to pursue supply security in a certain way if they want to secure energy at those relatively outsized levels. For example, the power measure certainly represents a deliberate act on the part of the government to increase its economic and military power, while increased levels of import dependence appear to be something that larger, rapidly growing oil consumers simply need to accommodate, especially when dealing with limited domestic supplies. However, the trend toward coalescence is clear. Earlier in Chapter Two, when the political climate model was introduced with the three key "oil security" scenarios, being a state operating in a politically neutral environment, a politically contentious climate, or open conflict climate, it should be noted these environments, perceived or misperceived, and future-oriented, have a direct impact on conflict or even cooperation between the United States and China. However, since both states seem destined for the politically contentious zone of the model, it is reasonable to assume the convergence noted above will result in a more confrontation relationship between the United States and China. Since it is the grand strategies of these states, with the elevated element of energy security in their calculations, this pursuit of security has led to convergence and the arrival at similar approaches to secure supplies of oil. Further evidence will follow in the proceeding sections.

Clashes of Grand Strategy

China has made a concerted effort to minimize its oil security vulnerabilities, but what does this lead to in terms of clashes in grand strategy between the United States and China? China has reduced the oil security gap with the United States; however, it is far from parity. It still has much to accomplish to sustain similar levels of oil security as its large consuming competitor.

Most worrisome are the areas of extreme vulnerability for China, which mainly involves areas outside its capacity to militarily secure them: namely, the sea lines of communication running from the Middle East, through the Indian Ocean, into various straits, and finally, transit through the South China Sea. This is a path fraught with numerous security challenges and areas where vessels must traverse waters full of current or potential adversaries. If China is to don its veil of security in full, this severe weakness must be mitigated and eventually rectified. And, this weakness, from the Chinese perspective, can only be resolved via political means and military preparedness. Commercial trade can be altered and adjusted, especially in the case of highly fungible goods. But, the oil trade cannot be so easily adjusted, especially since the entire global oil market apparatus is built on institutions and networks created and guarded by the United States and its allies. This complements quite well with the holistic approach by the Chinese to grand strategy in the pursuit of comprehensive national power. Only with comprehensive power, can the great power be sufficiently secure. Energy is, of course, part of that comprehensive power.

One of the core issues to grapple with is whether the existing market-based apparatus, constructed for the efficient and lowest cost distribution of petroleum, is the best way to attain energy security for China. Outside the market, China has made strides and overtures, strengthening bilateral relationships, establishing equity contracts, and cementing political partnerships. Whether this even provides security beyond the market-based mechanism may be a moot point itself: Chinese policymakers believe it does. As other authors have pointed out, it might not even be about whether or not directing oil supplies based on political relationships is advantageous, but whether policymakers actually think it is and act on these beliefs. In an important piece of scholarship Levi determines that there is in fact a relationship, regardless of outcome.[416] Foreign policy elites' perceptions of the threat environment, along with proper recourse, have mattered greatly.

Even the perception that China is more energy secure than it actually is may lead to increases in conflict potential with the United States. At various levels of grand strategy, weaker states tend to overestimate their capabilities, and underestimate the capabilities of their competitors. In addition, despite the superior material capabilities of

[416] Clayton and Levi, "The Surprising Sources of Oil's Influence," *Survival*, 107-122.

the United States it would be difficult to deter Chinese aggression with anything involving territory or nationalism, given that they tie directly to state security and energy security.[417] This course of events is particularly worrisome, given that any threats to Chinese state security, vis-à-vis its energy security, will have a particularly strong reaction due to these conjoining threats of overestimation of successful outcome, nationalism, and territoriality. These competing issues have been joined with oil security.

Important to note, as mentioned earlier, while sanctions, embargoes, or containment directed toward China do not necessitate outright war, there exists the potential for devastating long-term consequences to the Chinese state in terms of the economy and satisfaction of the general population. Any complications in this intermediate area between war and peace can generate a moral threat to the legitimacy of the CCP, questioning the internal monopoly of power. The monopoly on political power may also be a direct derivative of the Chinese experience before the fall of the Qing Dynasty, when before the forced opening by Western powers, there existed an already weakening state, plagued with internal disorder, rebellion, and revolt, that left the state in a far more vulnerable position to hostile outside powers. Swaine and Tellis touch on this point by their frequent inclusion of the primacy of internal order in their calculations of Chinese grand strategy.[418] Many of the strategists referenced refer to domestic order as a

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[417] Thomas J. Christensen, *The China Challenge: Shaping the Choices of a Rising Power*, (New York, NY: W. W. Norton and Company Inc., 2015), 99-115.

[418] Michael D. Swaine and Ashley J. Tellis, *Interpreting China's Grand Strategy: Past, Present, and Future*, (Santa Monica, CA: RAND, 2000), 16-19; Robert D. Blackwill and Ashley J. Tellis, "Council Special Report No. 72: Revising U.S. Grand Strategy Toward China," Council on Foreign Relations, (April 2015).

preeminent concern, along the hierarchy of other concerns central to the CCP. The precariousness of the Chinese government has grown progressively, albeit gradually, worse. Although information is now scarce on the level of social unrest within Chinese borders, by the mid-2000s, there were already over 80,000 such protests throughout the country, with more than 100,000 possible later in the decade.[419] However, conceptualized the way Swaine and Tellis do, there is a high level of interdependence between the internal and external threat environment,[420] such that they are completely dependent on one another.[421] Furthermore, in the interaction between the internal and external environment, there are three key issue areas required, the second being the "level and origin (external or internal) of resources available to the state," bringing strategic energy issues to bear in the internal and external threat environment.[422]

China's Maritime Environment

More so than the Cold War between the United States and Soviet Union, the burgeoning Sino-American competition will not be with conventional land based hardware, but instead will take place in the maritime environment. This shift in the

[419] Kevin O'Brien and Rachel Stern, "Introduction: Studying Contention in Contemporary China," in *Popular Protests in China*, ed. Kevin O'Brien, (Cambridge, MA: Harvard University Press, 2008).

[420] Reminiscent of nei luan wai huan (internal strife, external threat).

[421] Swaine and Tellis, *Interpreting China's Grand Strategy: Past, Present, and Future*, 17.

[422] Ibid., 18.

strategic theater of conflict, for both states, places greater emphasis on strategic naval assets and materials, increasing contention in the maritime environment and greatly increasing its importance.

The recent uptick in territoriality exhibited on the part of the Chinese in the South China Sea is an outgrowth of its attempts to secure its maritime environment, thereby contributing to the security of its SLOCs, increasing oil security. China has had a strategy in place to frustrate forward deployed military units and to utilize asymmetric warfare since the 1990s, with the ability to carry out the various components of that strategy more effectively over time as material resources have increased and doctrine has adapted.[423]

As China grows stronger, and feels more secure in multiple areas of state security, including oil security, that sense of confidence will lead to bolder actions. We have already seen this in the escalation of conflict with China since 2011, especially in the South China Sea,[424] and advances to Chinese naval power are notable. It is important to take note that China has surprised analysts, strategists, forecasters, and scholars by advancing military capabilities, economic relationships, and overseas political interests beyond what thought possible for over two decades.[425] And in some areas, there is actual, or near, technological parity with the United States. As a matter of fact, as

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[423] Thomas J. Christensen, "Posing Problems Without Catching Up: China's Rise and Challenges for U.S. Security Policy," *International Security* 25, no. 4 (2001).

[424] Most recent reports indicate China is further militarizing its presence in the South China Sea by installing military hardware on its network of artificial islands.

[425] Amy Chang, "Indigenous Weapons Development in China's Military Modernization," U.S.-China Economic and Security Review Commission Staff Research Report, (2012): 38-41.

Thomas Christensen notes, China may have a certain degree of technological parity with the United States in the area of anti-ship ballistic missiles (ASBM),[426] where China has had the CSS-5 Mod 5 (DF-21D) medium range ballistic missile (MRBM) system, then an ASBM, deployed for several years, which is meant to put vessels at risk, particularly aircraft carriers, within a 1,500 km range.[427] This has the strong potential to frustrate U.S. efforts to control the maritime environment close to Chinese shores and increases the difficulty to counter Chinese maneuvers in the case of a conflict over Taiwan. Additionally, China's naval and air forces that cover China's littoral and near maritime environments extending east and south, have grown rapidly, qualitatively and quantitatively.[428]

However, a state cannot provide SLOC defense without a robust naval presence capable of extended deployments, backed by a potent logistics framework. It is also understood that the orientation of China's naval assets, in particular its newest and most advanced hardware, is disproportionately deployed to the South China Sea areas indicating a prioritization of not countering the threat posed by Japan, or the coercion of Taiwan, but instead indicates the support of sovereignty claims in the maritime

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[426] Christensen, *The China Challenge: Shaping the Choices of a Rising Power*, 102-103.

[427] Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2016," (2016): 61. Reports indicate a new version of the DF-21D is operational and ready to be deployed, the DF-26, which has a potential range out to 4,000 km, with the ability to target medium-sized vessels.

[428] Andrew S. Erickson, "China's Modernization of Its Naval and Air Power Capabilities," in *Strategic Asia 2012-13: China's Military Challenge*, Ashley J. Tellis and Travis Tanner eds., (Seattle, WA: National Bureau of Asian Research, 2012), 61-125.

environment and the security of the oil based SLOCs to Chinese ports.[429] A key part of this strategy during China's naval transition phase is the deployment of advanced submarines capable of bridging the gap between a navy attuned to coastal defense and one that is blue water capable in addition to closing naval capability gaps with a qualitatively superior adversary.[430]

You Ji expands on this idea of submarines as an effective platform while the PLAN hardware and doctrinal transition is underway, when the submarine growth is referred to as a "contingency capability" able to fill the "transitional vacuum," and conceiving of submarine use not necessarily as protective, but as a deterrent capable of low-cost threats and attacks on other state's shipping in the region.[431] China has been orienting its fleet toward SLOC operations, especially in the acquisition of nuclear powered attack submarines of which research, development, and deployment has taken precedent.[432]

China is rapidly developing these underwater assets. China has been developing submarines and deploying them to the Indian Ocean, along with the relevant support vessels and materials, which builds a credible deterrent threat, something Chinese military leaders have openly acknowledged as a security gap that needs to be filled as

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[429] James C. Bussert and Bruce A. Elleman, *People's Liberation Army Navy: Combat Systems Technology 1949-2010*, (Annapolis, MD: Naval Institute Press, 2011), 185.

[430] Gurpreet S. Khurana, "China's 'String of Pearls' in the Indian Ocean and Its Security Implications," *Strategic Analysis* 32, no. 1 (2008): 2-4.

[431] Ji, "Dealing with the Malacca Dilemma: China's Effort to Protect its Energy Supply," *Strategic Analysis*, 481.

[432] Ibid., 482.

quickly as possible, in an attempt to mitigate this weakness of the "lane" of China's "one point, one lane" strategic disadvantages.[433] For example, the indigenously built Yuan-class attack submarine, unveiled in 2004,[434] represents one of many steps in this direction, amid a larger effort to expand the submarine force both qualitatively and quantitatively, where the underwater force has actually seen the most growth out of advanced naval and air assets indigenously built or acquired abroad.[435]

The PLAN's submarines are gaining familiarity with two key locations as well: the Western Pacific for obvious strategic reasons and then multiple class submarine deployments to the Indian Ocean.[436] China's forward deployed submarine force has begun to familiarize themselves with the Indian Ocean transit corridor first. And, over the past few years, this has expanded to intelligence gathering missions, exercises involving surface combatants, and the rotations of all four submarine classes available in the Chinese inventory.[437] It is also projected, that by 2020, the Chinese navy will field

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433 Khurana, "China's 'String of Pearls' in the Indian Ocean and Its Security Implications," *Strategic Analysis* 32, 9. This is an important reference to energy "shunt" routes and mentions a quote from PLA General Qian Guoliang where he states the "threat perception is centered on the danger of one point [and] one lane," where the "one point" is Taiwan and the "one lane" is the route through the Indian Ocean.

434 Chang, "Indigenous Weapons Development in China's Military Modernization," U.S.-China Economic and Security Review Commission Staff Research Report, 8.

435 Ibid., 10.

436 Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2016," (2016): 69.

437 U.S.-China Economic and Security Review Commission, "2016 Report to Congress of the U.S.-China Economic and Security Review Commission, One Hundred Fourteenth Congress Second Session," (Washington, D.C.: U.S. Government Publishing Office, 2016), 263.

the third largest fleet of nuclear-powered attack submarines in the world, behind the United States and Russia.[438] More recently, by 2015 the number of nuclear powered attack submarines in the Chinese inventory had grown to five, which is a substantial accomplishment,[439] of which both Han and Yuan class vessels have made recent, lengthy deployments to the Indian Ocean.[440]

It should, however, be pointed out that these naval forces also create a new crisis point if any type of embargo is placed on China and enforced militarily on China's maritime periphery. With the submarine force as the only potential effective means for countering oil embargo operations, the PLAN would face crucial decisions early on regarding optimal deployment of naval assets. For instance, submarine deployment from home bases in the South China Sea is predicated on rather predictable and narrow passageways susceptible to focused monitoring and easier interception by enemy military assets.[441] The submarine force would need to remain in China's immediate maritime environment in order to remain relatively safe; however, if this were the case, the force would lose it coercive power and anti-access and area denial capabilities in the outer island chains or the Indian Ocean, defeating the purpose of the existence of the force as a security gap while the PLAN force adapts and modernizes. These are crucial decisions to be made early in any crisis.

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[438] Ibid., 266.

[439] Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2016," (2016): 108.

[440] Ibid., 22.

[441] Avery Goldstein, "First Things First: The Pressing Danger of Crisis Instability in U.S.-China Relations," *International Security* 37, no. 4 (2013): 56-57, 69-73.

Embargos, Containment, and Sanctions

Access denial by the United States is a primary concern among Chinese defense planners.[442] Chinese political elites have been concerned over the potential of a blockade of their maritime environment since the early 1990s, around the time China shifted from net exporter to net importer of petroleum.[443] China's oil security is broadly speaking centralized on the Middle East, and the SLOCs leading through the Indian Ocean and the South China Sea, and the oil pipelines coming in through Central Asia and Russia, where in all areas, China views itself, even now, as a subject of containment pressures by the United States and its direct or indirect allies.[444]

Once again, due to these pressures, referencing the market as a reliable source of oil security is not plausible. Nor is merely referring to the need for a predominance of naval power in order to militarily secure the sea lines of communication in the case of war. This is important, but it does not deliver the entire story. These both leave out the transitional aspects between peaceful competition and war, which potentially involves increasing political tensions, sanctions, and containment. Why should China not expect and prepare for containment of its power on the part of a Western alliance? This is exactly the sort of long-term, protracted relationship that took place when the last great

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[442] Ji, "Dealing with the Malacca Dilemma: China's Effort to Protect its Energy Supply," *Strategic Analysis*, 472-473.

[443] Jacqueline Newmyer, "Chinese Energy Security and the Chinese Regime," in *Energy Security and Global Politics: The Militarization of Resource Management*, Daniel Moran and James A. Russell eds., (New York, NY: Routledge, 2009), 203.

[444] Pak K. Lee, China's Quest for Oil Security: Oil (Wars) in the Pipeline?" *The Pacific Review* 18, no. 2 (2005): 281-289.

power attempted to challenge the United States during the 20th century. The Soviet Union could not rely on the "Western" market; nor would China be able to.

The problem with many market based analyses for oil security is that they do not account for anything outside these normal market-operating conditions. The argument overwhelmingly centers on the fact that petro-nationalism is self-defeating due to the fungibility of oil and the reliability of global oil markets.[445] But, this is simply not an accurate representation of how states would pursue oil security in a politically belligerent climate. Under sanctions, containment, intense competition, or open warfare, pre-existing, politically resilient and militarily secure energy supply lines do matter. In addition, containment, or in its lesser form, sanctions, typically occur for much longer duration than open warfare. The Cold War, and the concomitant containment and security competition, lasted for the better part of forty years. Warsaw pact allies did not rely on the global oil market because it was insecure and a Western designed system, but instead relied on the Soviet Union for such supplies. For instance, many scholars reject the security effects of bilateral, long-term supply contracts and equity oil, since most of this oil is generated from efficient, open-market operations and China sells this same oil to the open market instead of sending equity oil directly back to home ports, thereby eliminating these political approaches as viable energy security strategies.[446] This is patently false if one considers containment or sanctions as an intermediary, and quite

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[445] James M. Griffin, "Petro-Nationalism: The Futile Search for Oil Security," *The Energy Journal* 36, no. 1 (2015); Gholz and Press, "Protecting 'The Prize': Oil and the U.S. National Interest," *Security Studies*, 457-463.

[446] Andrews-Speed and Dannreuther, *China, Oil and Global Politics*, 82.

feasible step towards open war. If China has established itself as a major political ally, and more importantly, reliable mass importer of oil, a state is more likely to maintain its relationship with Beijing at the cost of political relationships with other countries, like the United States.

Even before the Cold War, the idea of oil security was well known and codified, from Churchill's famous quotes on oil insecurity and diversification, to the concept of oil as a core strategic commodity worth fighting over, and "red line" well established in international politics as demonstrated by one of the few actions taken by the defunct League of Nation's actions against Italy in response to the Abyssinia Crisis in 1935,[447] or Hitler's concern when the Soviets cut-off supplies to downstream operations in Germany.[448]

The energy markets themselves were put to the test during World War Two when all involved attempted to fall back on politically and militarily secure energy sources both in the lead up to war, and during. The great powers didn't put their faith in a "market" but instead supplies they could control for themselves and their allies at any cost. While oil access wasn't as important at that time to the general population, and consequentially economic growth, during both World War One and World War Two oil was primarily a military issue, as this was the only sector that was fully utilizing oil as an energy source,

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447 Cristiano A. Ristuccia, "1935 Sanctions in Italy: Would Coal and Crude Oil Have Made a Difference?" Discussion Papers in Economic and Social History, Oxford University, March, 1997, http://www.nuffield.ox.ac.uk/economics/history/paper14/14paper.pdf (accessed August 4, 2016).

448 Yergin, *The Prize: The Epic Question for Oil, Money, and Power*, 332.

albeit a vital one. The impact of oil deprivation on the general population in many cases would have been negligible, but in some ways was even harsher since any cut-off was more directly an attempt by foreign powers to directly strangle the military of a country.[449] This may not be the case today, but constrained supply can still impact military operations, and certainly affects the broader economy, which is vital to all states, and especially to Chinese Communist Party legitimacy.

In the lead up to World War Two, Germany had access to the global oil market, but decided to begin to synthesize oil domestically in order to have its own secure source of supplies. Germany knew that it would not be able to depend on the market as competition increased between the major European powers. Actions were taken to mitigate this weakness of the reliance on the market.

A deciding factor for Japan's attack on Pearl Harbor had to do with secure oil sources: the market based approach failed as it had become necessarily politicized and militarized and had to expend efforts to secure supplies elsewhere. This shift was underway even before the U.S.' oil embargo on Japan.[450]

Even other vital commodities would take part in this pattern. Aside from oil, there have been many other strategic resources inducing vulnerability in a state. Take for

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[449] Daniel Moran, "The Battlefield and the Marketplace: Two Cautionary Tales," in *Energy Security and Global Politics: The Militarization of Resource Management*, Daniel Moran and James A. Russell eds., (New York, NY: Routledge, 2009), 30-31.

[450] The oil import cut-off was actually the result of Japan's inability to access frozen, dollar denominated assets in the United States, which were needed in order to make petroleum purchases. The actual inability of Japan to import oil from the United States was opposite President Roosevelt's wishes, who stated consistently that he did not wish to cut-off Japan's oil supply.

instance imported foodstuffs to Germany during World War One. The Industrial Revolution dramatically lowered the cost of overseas transport via steam-powered vessels, allowing the capacity to import cost competitive food to continental Europe. This created a strategic vulnerability for Germany as Britain embargoed Germany of its desperately needed supplies, contributing significantly to the war effort.[451]

Reasons for Interdiction

Something bold, like an embargo or blockade is attractive since it is relatively low risk to the U.S. and allied forces that would be engaged in operations. Vessels can be kept at a relatively harmless range, and vital supplies can be denied. And, it's not only the actual interdiction of oil transport vessels, or the actual implementation of any embargo, but instead just the mere threat of the world's most powerful naval force moving on any oil transport infrastructure. This could potentially be crippling.

The United States has a long tradition of interdicting naval vessels, and even more so, has honed these skills in the Persian Gulf since the early 1990s.[452] Furthermore, in 1993, the U.S. Navy even intercepted and boarded the Chinese flagged container ship *Yinhe*, which was potentially carrying restricted chemical weapons materials to Iran.[453]

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[451] Moran and Russell, "The Battlefield," *Energy Security and Global Politics: The Militarization of Resource Management*, 27.

[452] Bruce Blair, Chen Yali, and Eric Hagt, "The Oil Weapon: Myth of China's Vulnerability," *China Security* 3 (2006): 40.

[453] Kai He, *China's Crisis Behavior: Political Survival and Foreign Policy After the Cold War*, (Cambridge, U.K.: Cambridge University Press, 2016), 49-55.

After further inspections in a Saudi port by both American and Saudi personnel, the vessel was deemed to be in absence of any such materials,[454] but for Chinese strategic planners, the contemporary precedent was set.

An American embargo against China, including strategic products, is more than a theoretical possibility. With a complete trade embargo in place after the Korean War,[455] including petroleum and petroleum products, and a U.S.-E.U. arms embargo still in place today, the possibilities of the United States utilizing embargoes, sanctions, or interdictions of strategic imports to China is a potent, and realistic threat, more so today given China's massive reliance on imported oil.

The U.S. has even specifically blockaded oil to other countries, including Iraq and considered doing so in the Balkans and with North Korea, and has a general proclivity towards denial and coercion when dealing with oil access and adversaries.[456] China has been subjected to Soviet oil cut-offs, and has even embargoed oil going to North Korea, if only for a short period.[457]

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[454] Patrick E. Tyler, "No Chemical Arms Aboard China Ship," *The New York Times*, September 6, 1993, http://www.nytimes.com/1993/09/06/world/no-chemical-arms-aboard-china-ship.html (accessed September 8, 2016).

[455] Shu G. Zhang, *Economic Cold War: America's Embargo Against China and the Sino-Soviet Alliance, 1949-1963*, (Stanford, CA: Stanford University Press, 2001), 17-49, especially 32-33.

[456] Blair, Yali, and Hagt, "The Oil Weapon: Myth of China's Vulnerability," *China Security*, 39; The United States even had a plan to destroy Saudi Arabia's oil infrastructure during the Cold War if deterrence failed against the Soviet Union, simply to deny them access and control to such a valuable resource base.

[457] Ibid.

Another point of contention is many scholars simply do not think long enough down the supply line in terms of supply interdiction or cut-offs. For example, there is no reason to restrict naval interdiction to waters even remotely close to the East Asia SLOCs which tend to be the point of reference when referring to these types of interdictions, especially the Malacca Strait. However, interdiction can occur anywhere along the SLOCs from the Middle East to Chinese ports. The farther out interception occurs, the greater advantages and lower costs and risks are afforded to the U.S. Navy. However, supply can also be interdicted in foreign ports, export countries, subversion of oil extracting assets in countries like Sudan or South Sudan, where ramifications of such tampering would be minimal. Even a state like Saudi Arabia could potentially be coerced given its reliance on the United States for security from regional enemies.

Interdiction Capability

Other scholars have pointed out that if open war is to commence, it is more difficult to track and intercept oil tankers than many would typically believe. Even if this is the case, although it is quite doubtful this would be beyond the capabilities of the U.S. navy to identify and eliminate targets, the U.S. would not necessarily need to intercept tankers in transit but could exercise military options in the foreign port or in the oil facilities themselves, halting the flow anywhere along the supply lines

Could they be interdicted? It would be logistically difficult, and may require enhanced cooperation in sea lanes with allies and non-belligerents, but it is feasible. First, there is still only a limited number of vessels that go through these waters daily, and interdictions need not impact all vessels, only some. Chinese indigenously produced vessels, which China has been assiduously building up, will be more readily identifiable in the future. For instance, about 18 million barrels of oil transit through the Strait of Hormuz every day. Let's say in any given day, Very Large Crude Carriers (VLCC) are carrying these supplies, resulting in nine VLCCs transiting the Strait daily, well within the capabilities of the U.S. Navy to target and intercept.

The Malacca Strait is a similar story, with 11 to 15 daily VLCC transits. This is a total amount, indicating two-way traffic in 2014, with total VLCC transits at 4,993.[458] This means anywhere from five to seven loaded tankers are inbound to the Asia-Pacific region, through the Straits, coming from the Indian Ocean. Again, this is not an insurmountable number of vessels for interdiction operations and embargoes, with it more important to note, in order to be successful, naval forces do not need to intercept and halt all traffic; only some will be sufficient.

As mentioned earlier in this study, the "tanker wars" between Iraq and Iran during the Iran-Iraq War are typically brought up to reassure those worried about military operations targeting oil tankers, which are incredibly well built, sturdy, and essentially armored vessels. However, this is a false comparison. During the tanker war in the 1980s, these tankers were attacked with Cold War era weapons systems used by two powers that included serious deficiencies in targeting and logistics. Even still, about a quarter of tankers in the Persian Gulf were sunk or damaged beyond repair. Many

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[458] Marcus Hand, "Malacca Strait Traffic Hits an All Time High in 2014, VLCCs and Dry Bulk Lead Growth," *Seatrade Maritime News*, February 27, 2015, http://www.seatrade-maritime.com/news/asia/malacca-strait-traffic-hits-an-all-time-high-in-2014-vlccs-and-dry-bulk-lead-growth.html (accessed October 28, 2016).

analysts claim this is a low amount, demonstrated as evidence that tankers are relatively impervious to military operations, but we should learn the exact opposite lesson. With extremely limited capabilities, the belligerents were able to debilitate a quarter of the tanker fleet. Today, technology has advanced to the point where the limitations realized by both states are not an issue, especially for a force like the U.S. Navy.

SLOCs, Indian Ocean, South China Sea, String of Pearls

China's naval power, and by extension, its energy trade is inexorably linked to its larger grand strategic framework and ambitions, and may very well be central to it, aside from the continuing adaptation to, and coping with, a preponderance of American global military, economic, and political power.[459] Sea lanes continue to matter greatly.

Given the increasing difficulties in conducting U.S. naval operations in China's maritime environment, along with a general aversion to a direct confrontation with a militarily capable, nuclear-armed force, the U.S. may be drawn to impact Chinese oil security farther abroad, well outside the effectiveness of China's most potent military assets and configurations. The only sensible areas for U.S. military intervention to proceed with minimal, to no losses, would be in oil related areas where China is unable to project its own military forces. More and more it seems, the battle for China's oil security will be fought in the Indian Ocean, far from the assiduously built-up military

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[459] Thomas M. Kane, *Chinese Grand Strategy and Maritime Power*, (London, U.K.: Frank Cass Publishers, 2002), 62-64, 139-145.

support in the East and South China Seas.[460] Chinese strategic planners, of course, know that this is an area of extreme vulnerability in times of conflict.

Despite many analysts claiming the demise of the Chinese "string of pearls" approach to the Indian Ocean, developments over the past two years seem to have resurrected this approach with fervor. The pearls extend from one end of the Indian Ocean to the other, potentially connecting East African states and Pakistan, to Sri Lanka and the Seychelles, and the Malacca terminus in the east with Indonesia and Malaysia.[461] In recent years, we have seen more active diplomatic and military engagements along SLOC corridors, whether with political overtures to the Seychelles, or the strengthening of political ties with Malacca Strait associated countries, including Indonesia and Malaysia.

Perhaps the largest leap for China has been the initial construction of its first overseas military facility in Djibouti.[462] This is a burgeoning military facility in a relevant, strategic location along China's key SLOC running from the Middle East to Chinese ports, essentially representing a revival of the pearl necklace approach, where

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[460] Avery Goldstein, "Parsing China's Rise: International Circumstances and National Attributes," in *China's Ascent: Power, Security, and the Future of International Politics*, Robert S. Ross and Zhu Feng, eds., (Ithaca, N.Y.: Cornell University Press, 2008), 82–83.

[461] Khurana, "China's 'String of Pearls' in the Indian Ocean and Its Security Implications," *Strategic Analysis*, 6-8.

[462] U.S.-China Economic and Security Review Commission, "2016 Report to Congress of the U.S.-China Economic and Security Review Commission, One Hundred Fourteenth Congress Second Session," November 2016, Washington, D.C.: U.S. Government Publishing Office 2016), 218-219.

this facility would be the first pearl.[463] In building this base, China also seems to signaling militarily to Japan, as well as to the United States that military materials will be established in-kind in the region.[464] Japan, a core strategic competitor, neighbor, and ally to the United States, also gets its oil from the same sources as China, and may be even less willing to tolerate a strong and overt Chinese military presence along its own SLOCs and in foreign ports where it imports its own oil.

China's forward deployed and force projection naval capabilities are oriented along the route from the mainland through the Indian Ocean to African and Middle Eastern ports. The first long-term force projection exercise on the part of the PLAN was the deployment of a three-vessel task force to the Gulf of Aden in 2009, for the purpose of participating in a multinational naval force to counter the severe increase in piracy in the region. However, this task force never left, remained deployed, and continues to patrol these waters increasing familiarity and developing operational fluency in the region.[465]

And even though the maritime territorial grabs in the South China Sea are related to territoriality and nationalism, so are they important for securing the SLOCs, the potential for undersea energy resources, and the denial of forward strategic operating

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[463] François Dubé, "China's Experiment in Djibouti," October 5, 2016, *The Diplomat*, http://thediplomat.com/2016/10/chinas-experiment-in-djibouti/ (accessed September 5, 2016).

[464] Assaf Orion, "The Dragon's Tail at the Horn of Africa: Chinese Military Logistics Facility in Djibouti," The Institute for National Security Studies, Insight No. 791 (2016).

[465] Andrew S. Erickson and Austin M. Strange, *Six Years at Sea ... and Counting: Gulf of Aden Anti-Piracy and China's Maritime Commons Presence*, (Washington, D.C.: The Jamestown Foundation, 2015).

areas for China's adversaries, including Taiwan and United States. Chinese control over the South China Sea maritime environment is compounded by competing claims of other potential adversaries, that also recognize the strategic importance of the sea lanes not only for uncontested movement of military assets, but also to control the flow of vital resources, like oil. Senior officials in the Ministry of National Defense have mentioned this in the past,[466] where control over sea lanes, using the Spratly's as a base, and submarine warfare, could be used to intercept oil tankers bound for China.

The ability to connect to Middle East and East African oil is vital to Chinese oil security. China's interest especially in the Middle East has always been one of oil security,[467] and the region's importance has been a cornerstone of Chinese energy security policy since the 1990's, has only grown since then, and will continue to rise in significance as it is the only current global source for oil that can satisfy its growing requirements.[468] This situation presents itself as a realistic long-term flashpoint along China's SLOCs from the Persian Gulf to its domestic deep-water ports.

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[466] "MND Admits Strategic Value of Spratly Airstrip," *Taipei Times*, January 6, 2006, http://www.taipeitimes.com/News/taiwan/archives/2006/01/06/2003287638 (accessed September 29, 2016).

[467] Jin Liangxiang, "Energy First: China and the Middle East," *Middle East Quarterly* 12, no. 2 (2005).

[468] Toshi Yoshihara and Richard Sokolsky, "The United States and China in the Persian Gulf: Challenges and Opportunities," *The Fletcher Forum of World Affairs*, 26, no. 1 (2002): 67-69.

Overview

China must treat outside powers as hostile or potentially hostile to further justify the communist party's existence, alongside uninterrupted economic growth, creating a dependency for the economy and security from foreign threats. China's intense military focus on short-term conflicts is further validated by the reality that in wartime, the United States has the clear ability to cut-off oil supplies, eroding its ability to conduct a war over the long-term. This is a major weakness that the Chinese government will attempt to rectify over time. In the meantime, China will deploy naval assets to the Indian Ocean and shore up relationships with key partners in the region, establishing military, re-supply, and logistics bases. Political relationships can be built on resistance to a specific country, or group of countries. For instance, China's strong political and resource relationship with Iran is built largely on distrust in the United States.[469] Even if oil security ultimately is not at stake, certainly the perception exists that it is, and China is responding to this threat politically and militarily.

In a way, China is being socialized into system by adapting to the best practices of similar states. This is happening with oil security, but in a broader sense, with China's preparation for import restrictions via sanctions or containment, and war. In this sense, as Kenneth Waltz may have articulated, much of China's approach as demonstrated both qualitatively and quantitatively, represent a socialization to the best practices of the

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[469] Toshi Yoshihara and Richard Sokolsky, "The United States and China in the Persian Gulf: Challenges and Opportunities," *The Fletcher Forum of World Affairs*, 26, no. 1 (2002): 66.

system in which the state inhabits, hand in hand with competition which "encourages similarities of attributes and of behavior" and where "socialization and competition are two aspects of a process by which the variety of behaviors and of outcomes is reduced."[470] Competition and security can be socialized in the same way norms and patterns of behavior can be established in the international system. The United States established the precedent in the "right" way to establish and maintain oil security, and compete for these critical resources, and it makes sense that China would follow a similar, successful pattern. And, as with the United States and past actions by the Axis powers, China would certainly go to war over a U.S. blockade of Chinese energy supplies.[471]

But, it still remains that an oil cut-off offers no real power unless war is imminent or highly probable, since any cut-off would reduce China's ability to prosecute a long war, go against its recently revamped doctrine of fighting "short wars," and would leave it unable to contemplate any political efforts to reduce tension;[472] its only course in a situation such as that, is war. With respect to the question of oil security, China will have the United States in a position where the onus is on them to make the first military action, meanwhile being prepared for containment and sanctions that may arise in the politically contentious phase of the relationship. This has precedents with both Japan and Germany

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[470] Kenneth N. Waltz, *Theory of International Politics*, (Reading, MA: Addison-Wesley Publishing Company, 1979), 76-77.

[471] Blair, Yali, and Hagt, "The Oil Weapon: Myth of China's Vulnerability," *China Security*, 41-43.

[472] Charles L. Glaser, *Rational Theory of International Politics: The Logic of Competition and Cooperation*, (Princeton, NJ: Princeton University Press, 2010), 280-281.

in the lead up to World War Two as political relationships broke down and the situation worsened in both countries. This subsequently forced both states to take drastic and desperate action in order to directly control and enhance their oil security, including Japan's surprise attack at Pearl Harbor and its push south into the East Indies' oil fields,[473] and Germany's development of synthetic fuels and its own disastrous push East into the Soviet Union, of which a "prime motive" was oil.[474]

As we see a narrowing of capabilities between the United States and China, we also see a narrowing of geographic areas critical to their oil security. This applies not necessarily to just the United States or China, but instead to both. As Charles Glaser has pointed out in a recent article, this is extremely problematic. The idea of an oil or energy-based security dilemma is profoundly more difficult to manage than a typical security dilemma, because no two states can be satisfied at the same time with any level of security present along the energy sensitive SLOCs, as these areas are necessarily mutually exclusive to one another.[475] In a typical security dilemma, there is a possibility of passivity in the dilemma according to some theoretical approaches based on the primacy of offensive or defensive military technology, or a clear delineation between offensive and defensive platforms. This is simply not possible in a situation involving sea lanes since both types of military assets must be deployed to the same location and the distinction between offense and defense is rendered a moot point given the overlap in

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[473] Yergin, *The Prize: The Epic Question for Oil, Money, and Power*, 316-319.

[474] Ibid., 334.

[475] Charles L. Glaser, How Oil Influences U.S. National Security, *International Security* 38, no. 2 (2013): 122.

location. In fact, besides SLOC security, the United States and China have several points of contention regarding oil supply security as codified by Glaser including SLOC security, alliance entrapment, especially regarding Japan, near sea resources, and access vulnerabilities.[476]

This is all quite problematic as the United States will ultimately resort to a less accommodationist approach towards China. Colin Dueck describes the Obama Doctrine as one of retrenchment and accommodation so that American resources could be redirected towards domestic purposes; however, while U.S. grand strategy under the Obama Administration has been marked by the drawdown of American military forces globally, one region has been the exception: the Asia-Pacific. And, the key foreign policy successes for the administration came when the president employed more traditional, realist-driven strategies, including responses to Chinese maritime aggression in the East and South China Seas, where deterrence proved the most effective approach.[477]

In some ways, this situation demonstrates an oil-based security dilemma within the confines of preparatory containment. This idea for oil security is independent of what is typically thought of in terms of hard power and military strength. A state normally does not have to prepare separately for containment as opposed to open warfare; military materials are used to counter hard power in containment scenarios and those same materials will be used in the case of open conflict, and that military power will be

[476] Ibid.,131-142.

[477] Colin Dueck, *The Obama Doctrine: American Grand Strategy Today*, (New York, NY: Oxford University Press, 2015), 101.

subjected to the same doctrinal discipline and strategic orientation. The political and economic statecraft conducted under each scenario, however, will matter greatly, and will represent a reversion back to the mercantilism of the 18th and 19th centuries.

Given the relative success of deterrent approaches, it is reasonable to assume this will occur with higher frequency going forward, as this transition is already underway. The United States was largely accommodating since China's opening to the West, but has been more confrontational as China has stepped up territorial claims in the South China Sea, threatening vital SLOCs and key regional allies. Moving forward, these SLOCs will remain crisis prone as China continues to draw on the market, but ultimately prepares for containment and war.

CHAPTER VI

CONCLUSION

A Brief View of Energy Security

Energy security is ultimately an enduring conflict fought by nearly all animal species, not just our own. From the smallest species to the largest, all strive for energy security daily, whether through food consumption or photosynthesis, and embark on a struggle to gather, economize, and conserve sufficient amounts of energy at an affordable cost, whether demarcated monetarily or in the level of bodily risk. Looking at the span of human civilization this is certainly true as confidence surrounding food security was perhaps the first critical form of energy security on a sizable scale, where a sufficiently-fed population was needed to translate human energy into productive energy, then used in the broader economy, and in many cases, for military power.

A favored strategy, then as now, has been to cut-off this energy source by destroying sources of sustenance: burning crops, destroying granaries and other food stores, and slaughtering livestock all to starve out an enemy or to deprive of them of their most fundamental source of strength. Later, in addition to human-based energy, horse-based energy became incredibly important for military power, requiring even more food sources to power this military weapon that would dominate the battlefield for nearly six millennia.

In the 18th century, other forms of energy and mechanical power began to take root. With the Industrial Revolution heralding many new technologies, among them was the steam engine and the consequent diffusion of this new form of energy production into industry, enhancing human-based energy itself, and in some cases, beginning to supplant it entirely. By this time, coal had become an important source of energy, but its reign would not last long. Entering the 20th century, there would be yet another radical shift in energy use, as more aspects of society and the military were mechanized, increasing efficiency, output, and lethality to untold heights as states ported over combustion technology to military vehicles, which would begin to have a meaningful impact in World War One.

This is a shift that would impact not only the military, heralding naval advancements along with the eventual use of air power, but motorized transportation, with roads strung out across countries like veins through a human body, became deeply ingrained and integral to our societies, and our economies. Oil would fuel this shift and would become the lifeblood of economies and militaries, utterly vital to the survival of both, and key to their success and efficacy. Just as previous societies were forced to secure their granaries and food stores as the core of societal energy, so today must we do the same, on a grander scale, with petroleum, into a clouded future.

The Research

The study utilized a focused, comparative case study approach, mixed with several data driven aspects, and ultimately a principal components analysis (PCA) that was used to create an "Oil Security Ratings" (OSR) system for added clarity and insights in the comparative approach, resulting in an intuitive study, illuminating the key questions posed above.

Before setting out to answer these questions, however, the concept of grand strategy as a theoretical referent was introduced and thoroughly explored. Although at times difficult to grasp as a coherent concept, a grand strategy is necessary for any state wishing to survive over the long-term, neglected only at the greatest peril. Any contest for survival can be lost at the outset with a poorly developed grand strategy that does not properly utilize, or account for, all forms of statecraft, including not just military, but also economic and political, and in the notion of this work, oil. Focusing only on the military aspects of grand strategy constrains and confuses, robbing the state of the necessary synergies for coherent, and cohesive national policies that when properly coordinated, can be adroitly employed to appropriate effect. When fighting for survival, why focus on only one mean to that end, when there are multiple from which to draw?

Despite the inherent difficulties present concerning grand strategic scope, it became understood in this work to mean the concept itself entails the "national reconciliation of security related means and ends, consistent with all available resources to the state, under the constraints of an indeterminate future." It is the state's answer to the question of its long-term viability as a secure, independent, political entity, engaging all forms of power, influence, leverage, and purpose at its disposal. At its core, it accounts for the temporal and relative threat environment, posing any number of risks to the state.

An understanding of energy security presents its own difficulties. Again, this is a relative concept based on the specific threat environment to a state, the structure of the economy, and even the dominant forms of fuel used throughout the state, and for what purposes. In restricting the scope of this research to petroleum, a difficulty emerges in that the global oil market is highly developed and interconnected, in some cases, depending on crude blend, resulting in a "global" price for oil. This means, for instance, Iceland, a country notorious for its overwhelming reliance on renewable sources of energy, will still pay the same global rate for oil imports, regardless of the amount of geothermal energy drawn by the domestic population and industry. So, in terms of affordability, the market is highly dependent on international politics and the state of the oil industry in general.

Energy security, as Yergin put it, can seem vague, and difficult to pin down. And, it is much more complex than usually defined, as simply being "affordable access to reliable supplies." Just as with grand strategy, it is no use to limit the way a state pursues something as vital the security of its energy supplies, the core lifeblood of an economy, without which all modern equipment and technology would cease to operate, from vehicles and military aircraft, to medical equipment and the lights in your own home. All is dependent on this strategic resource, and should be treated and equipped as such. And, the threats have only expanded, now including sophisticated attacks on the technological infrastructure of oil and gas companies. It should also be noted, the frequently trotted out objective of energy independence is illusory and unviable, and even negates important aspect of energy security, specifically diversification. In general, an understanding of energy security is akin to that of grand strategy, where a means-end chain is necessarily attached to feasible energy objectives consistent with the specific threats presented to the state, in order to maintain broadly resilient (including in multiple political scenarios) and affordable energy supplies, over the long-term. With the United States, the oil security stakes are even broader, considering its political and economic stake in the actual global oil market itself, as a coordination and supply mechanism, replicated as a source of supply for numerous allies around the world. This process is also highly dependent on the current global political scenario in which these states operate. For instance, a state operating in a non-contentious political environment will have more options, and be more able to rely on sources for petroleum, like the market, without fear. But, given the temporal dimension of energy security, a state must be prepared for worsening political conditions, and perhaps even war, where these varying scenarios necessarily produce different conditions under which states operate and pursue their objectives.

In terms of oil security, the United States has occupied an enviable position for many decades, especially for a state with such massive demand requirements. With an explicit strategy to militarily intercede on the Arabian Peninsula and the command of the commons with the world's largest and most capable naval force. The strategy of the U.S. is also broadly global and expansive, with strong stakes in international markets to the benefit of militarily weaker allies without the blessing of domestic oil sources. Oil is explicitly and demonstrably a key part of U.S. grand strategy, meaning the two are essentially fused in objectives and approach.

Similarly, China has elevated oil concerns to the top of its own agenda, and did so rather quickly after the country became a net importer of oil in 1993, for the first time in over three decades. This was a pivotal, watershed moment for China, with oil company executives and government officials appearing on television in tears, wrought with shame after failing to domestically provide what is required for the country capably function and grow. Despite the rhetorical autarky, China cannot provide for 1.3 billion people and an advancing, growing economy based on purely domestic sources, just as this is not possible for any oil consuming state, even the United States which includes consideration of its recent tight oil and gas blessing. Just as oil is a primary concern for the United States, so it is with China, where overseas expansion, especially through the Indian Ocean, appears to be directly related not just to trade routes, but oil routes. The "String of Pearls" appears to be alive and well.

After analyzing the "loose" data not attached to the OSR, and the OSR itself, some of these concepts become much clearer. Perhaps the most intriguing results were the final OSR scores themselves, which demonstrate the overall oil security approach of the United States to be dominant over the entire study period, while China is clearly, rapidly "catching up," and moving to perhaps eventually converge with the United States. Both countries are quite conscious of their oil security compared to the other 28 countries in the study, even, surprisingly, Japan. Looking at Table 5-2, China is clearly moving up and away from the other top importers in the study, mirroring Japans conspicuous drop. For the overall scores, the United States averaged 6.44 throughout the study while China averaged 2.58, with the group average at 1.05. Perhaps fueling further concern, is the noticeable increase in the OSR for China while there has been a notable decrease for the United States over the past ten years, although the drop for the U.S. is not entirely outside the 22-year average.

Other key metrics, for better or worse, also demonstrate convergence between the two countries. Both production-to-reserve and consumption-to-reserve ratios demonstrate China to be in a better position than the U.S., and despite China's reputation as being notoriously energy inefficient, it is not as energy intensive as once thought, consistently raising GDP output per unit of energy consumed, slowly closing the gap with the United States. China has also been able to restrict the growth of oil as a component of its primary energy consumption, and unexpectedly scored better than the United States, most likely due to the heavy American reliance on Canada and new domestic sources resulting from the tight oil boom. Per barrel costs, refining, and return on average capital employed scores also demonstrate similar convergence.

Both states have parallel import dependency after China closed that gap over the past few years, indicating a much higher dependence on overseas oil for China despite U.S. moderation and slight decrease, and nearly identical trajectories indicated concerning oil value as a component of GDP. Oil price volatility is also extremely similar, indicating no major differences in price swings in the per barrel dollar costs between both countries.

The U.S. however, maintains large leads in other key areas, namely with MIT's economic complexity scores indicating the highly diverse, technologically advanced, and industrially competitive American economy continues to significantly outperform what China has on offer, although here the gap is also slowly closing. Most expectedly, the United States scores significantly higher than China, and the other countries in the study, on the power measure, although one can observe notable increases in Chinese ratings here as well. As a reminder, this indicator measures not just direct power, but encompasses the entirety of state power, including latent measures such as the economy and population size. This was notable in a study on oil security, as previous studies had simply not included, or marginalized the importance of power in securing overseas supplies.

Specific Questions

Specifically, early in Chapter I, the following questions were posed: How do the United States and China approach the issue of oil security? Where have their approaches converged or diverged? And, do their respective approaches pose a threat to each other's oil security needs? Ultimately, it was stated this research aims at determining if and how both state's approaches created an atmosphere whereby they affect or even prevent acceptable levels oil security. And, if so, what would this imply for greater management of international life?

It was determined that due to their large size and oil requirements, both the United States and China deploy highly complex and diverse strategies in order to secure their respective oil supplies. These are multifaceted efforts designed to create and protect multiple diverse avenues to achieve optimal supply security. On many of the indicators, referenced further below, China has made significant gains in security, especially in terms of diversification, which was given the highest weighting by the PCA in Chapter V. In recent years, China has even surpassed the U.S. diversification score due to increases in domestic supply concentration resulting from the North American tight oil boom. Broader economic and technological advancement which catalyze new energy technologies and general state power are two more important measures where China is behind but has gained significant ground. The other indicators, data, and comparisons gleaned many other insights as well.

Chinese convergence with the United States is clearly revealed on multiple independent indicators, other data presented, and the final OSR scores. China has been able to learn much from the United States and through observation of global events pertaining to weaknesses in the oil supply chain. For instance, even though China has yet to experience any significant oil supply shocks, it has embarked on a multi-year effort to construct a potent strategic petroleum reserve, filling available capacity during times of low pricing. This is clearly a learned practice from the experience of the United States (and The Netherlands) in 1973, and the subsequent construction and earmarking of strategic reserves in OECD countries, and the formation of the International Energy Agency. There is convergence in many areas including the militarization of supply lines, and increasing technological proficiency in the energy sector. There is also convergence in some negative areas including increases in overseas supply dependency and a concentration in overseas supply centering on the Middle East, given the region's relatively close proximity and large reserves.

Over the course of the study, much of the oil security gains made by China were largely not encroaching on the security of the United States. But, judging by the model, outside indicators, and the comparison conducted throughout the study, the United States will eventually enter a critical stage with the maritime supply routes running from the Middle East, where it has overlapping security concerns with China. As time goes on, this maritime region will become more critical and militarized, as is already starting to occur, projecting insecurity and strategic vulnerability across the Indian Ocean to the South China Sea.

Final Thoughts

Throughout the study period, much of the oil security approaches of both states were not mutually exclusive, and in many cases, were complementary, as has been pointed out. For instance, China's exploration and exploitation of new sources of oil only adds to global supply, in turn facilitating lower prices and increasing market flexibility. But, the harmonizing benefits end when political rivalry grows between the two powers, and the view of oil quickly becomes one not of arteries to keep flowing, but arteries to cut for political, economic, or military gain. To that end, it was necessary that this research had contended, counter to arguments made by Gholz and Press[478] and Andrews-Speed,[479] that market-based, "cost-effective" approaches to energy security are not the key ways to conceive of oil security in the cases of the United States and China. While eminently important, there are still other factors to consider, and cannot be taken out of context, especially with Chinese perceptions that relations between themselves and the U.S. will

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[478] Gholz and Press, "Protecting 'The Prize:' Oil and the U.S. National Interest," *Security Studies*, 453-485.

[479] Philip Andrews-Speed, "Do Overseas Investments by National Oil Companies Enhance Energy Security at Home? A View from Asia," in *Oil and Gas for Asia: Geopolitical Implications of Asia's Rising Demand*, edited by Philip Andrews-Speed, Mikkal E. Herberg, Tomoko Hosoe, John V. Mitchell, and Zha Daojiong, NBR Special Report no. 41, 2012.

deteriorate, heralding conditions where individual relationships, political comradery, and military assets will matter a great deal.

The expansive nature of American grand strategy, in particular its enduring dominance of the global commons, and the Persian Gulf, is in direct conflict with oil supplies directed through China's sea lines of communication. Growing desire and proficiency as demonstrated in this study to close capability gaps on the part of the Chinese mixed with SLOCs connected to the South China Sea issue, comes together in a potentially toxic mix. This presents many difficulties, as discussed in Chapter V, but especially in the non-exclusivity of oil-related SLOCs that necessarily must be occupied by both powers at the same time in order to provide security, creates frictional overlap, especially given China's proclivity to prepare for a point when containment is a political reality. When it comes to the maritime oil routes, there are too many significant points of contention and as China has consistently built up its oil security capabilities and in many ways has adopted the approach of the United States, one can only begin to expect a confrontation over vital supplies.

That is perhaps one of the most pertinent issues in light of a holistic view of this study, as within the military dimension, there is a focus on maneuvering over a key element that can be used as a form of strategic coercion, or at least something with the perception to be used successfully for strategic coercion. As China's "comprehensive" power has grown over the last thirty years so too has its multiple levers of power which gives it multiple symmetric and asymmetric points of leverage to utilize during, or leading up to a conflict. This of course leads to counter-coercion capabilities to be deployed against the United States and its allies in such a conflict. Although the power relationship between the two is considerably wide, it is important to recognize China does have a growing array of political, economic, and military levers to deploy if needed, but as referenced in Chapter V, it does not have a credible threat to counter American naval operations in the Indian Ocean, promoting a key area of vulnerability that is still years off from being rectified.

These problems become more acute as political conditions worsen. When taken as a unified component of grand strategy, oil security is intertwined and securitized by both states at high levels. As contention arises politically into the second zone outlined in Chapter II many of these issues intersect or have the potential to be used as levers against one another, particularly given the disproportionate power relationship between the U.S. and China. This is fundamentally the most flawed part of previous works on energy security, and oil security in particular. If one does not consider changes in political scenarios in which states operate and are ultimately constrained by, then analysis will fail. Under normal conditions, now, and during the study period, there is not much in the way of overlap between the United States and china in terms of securing their oil supply; however, this all changes as political conflict escalates to the "adverse" section, and further convergence occurs between both states in their security methods. Here, supply lines are constrained and targeted, China can longer rely as heavily on the market and will need to fall back on political allies for "sanctions resistant" oil supplies, security dilemmas (both traditional and oil-based) are enhanced and brought to the fore. China is no longer part of the global market but a bifurcated market reliant on political allies and those that are well enough integrated and dependent on China for exports, income, and investments.

For instance, one can consider the indicators production-to-reserves and consumption-to-reserves, one looking at the long-term domestic availability of oil reserves in terms of producing assets located in-state, and the other long-term domestic availability of oil reserves in terms of local consumption. Both indicators tell us something different about the longevity of reserves on hand within the state in question, but have varying importance whether a state has free, unabated access to global markets, or is being "contained" in some manner, offering potential restrictions to that supply. In this case, domestic, fully controllable resources jump in importance as the political scenario worsens, and a state is required to fall back on its most politically reliable sources of oil. Power will, of course, also have a heightened status in these more implacable political scenarios as both hard and soft power have roles to play, along with political power, especially that derived from economic dependence. This delineation of potential future scenarios is import to include in analyses about oil security, otherwise the analyst will be prone to miss crucial aspects of the security apparatus. One must recognize these are approaches to counter not necessarily circumstances as they exist now, but to instead prepare for what is to come. Having secure supply lines direct to China allows for future relief of political pressure should it be exerted through sanctions or containment from the United States and its allies in the future. If China was not preparing its energy supply lines then it would simply model its security exactly like the United States and rely on the market with the U.S. navy to patrol the commons and ensure the flow of oil.

Finally, it should also be noted, at the time of this writing, the world is awash in inexpensive oil. This can certainly ameliorate some of the negative impacts and irritants to the U.S.-Chinese energy relationship, and may reduce the possibility for conflict based on oil supplies. However, two items in particular should be noted. One, oil prices mostly likely will not stay low for an extended period. Oil price cycles have had more than a century to play out, with plentiful examples of high and low pricing periods, and multiple peaks and troughs. And, as noted in the introductory chapter, some companies are even beginning to position for a recovery based on drastically reduced capital investment in the sector. Additionally, decline rates of tight oil wells have been particularly high, conveying a degree of uncertainty as to how long, and how much, these wells will ultimately produce,[480] even if producers have developed some techniques to mitigate this problem.[481] Second, and perhaps more important, is the irrelevance of price if the political relationship significantly deteriorates between the two countries, and if China is forced to rely on more direct means to secure its oil supplies. Despite the pessimistic outlook, there remain many avenues for a cooperative relationship between the United States and China when it comes to oil, assuming amicable political relations are maintained. Joint patrols of the SLOCs, an accommodating political settlement between the various parties in the South China Sea dispute, and China's assistance as an intermediary in political disputes, not mention active exploitation of new resources by Chinese NOCs, adding liquidity to the global supply of oil. All these cooperative

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[480] Henrik Wachtmeister, Linnea Lund, Kjell Aleklett, and Mikael Höök, "Production Decline Curves of Tight Oil Wells in Eagle Ford Shale," *Natural Resources Research*, (2017): 1-15.

[481] Ernest Scheyder and Terry Wade, "U.S. Shale Oil's Achilles Heel Shows Signs of Mending," *Reuters*, July 1, 2016, http://www.reuters.com/article/us-usa-shale-declinerates-idUSKCN0ZH3RQ (accessed April 10, 2017).

measures are possible, especially in a low-price environment where oil-related tensions are necessarily reduced. Furthermore, U.S. and Chinese grand strategy need not clash in the future given the joint desire of both states for economic growth and limited appetite for any type of armed conflict. However, none of these discount the variability of possibility over the long-term, where worst-case scenarios must be taken seriously.

This research set out to understand the dynamics of two countries that have had enormous demands and impacts on the global supply of oil. The United States, which has been concerned with oil supply security since the beginning of the 20th century, and responsible for countless innovations in exploration, extraction, refining, as well as developing the necessary approaches to securing this vital resource, including with the use of ample military power, has seen many successes. Comparatively, China, a relative newcomer to global oil supply concerns, not overly concerned or reliant on oil until the late 20th century, and with no real background in dealing with massive demand issues or overseas supplies, has seemingly at times, been "crossing the river by feeling the stones," trying new approaches, discarding those that fail, and retaining those that succeed. In both cases, there is new understanding of these oil security approaches and how they may serve to create, or abate, conflict in the future. Grand strategy and oil security are both complex, future oriented enterprises: as with many theoretical approaches in international relations, the shadow of the future looms large.

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IMF Data
World Bank Databank
United Nations Statistics Division
BP (workbooks and annual reports)
IEA
EIA International Statistics
United Nations Comtrade
MIT Observatory of Economic Complexity
CEIC Data
The Shift Project
OECD
UNCTAD
SIPRI Military Expenditure Database
OPEC

Newspapers, Websites, Archival Materials, and Miscellaneous Online Resources:

The Guardian
The Diplomat
The People's Daily Online
Financial Times
Economist
Oil and Gas Journal
Wall Street Journal
Taipei Times
Reuters
Platts
Argus Media
Washington Post
New York Times
China Vitae
The American Presidency Project at UCSB
George F. Kennan Papers at Public Policy Papers, Department of Rare Books and Special Collections, Princeton University Library

APPENDIX A

Table A1: Final OSR Scores

Countries	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	1.08698023	1.0860229	1.0912429	1.07790477	1.0822372	1.09396211	1.08477717	1.08366728	1.0830566	1.05866883
Austria	0.78663851	0.78964836	0.78889339	0.79312093	0.78818764	0.77745507	0.7813703	0.78397986	0.77188605	0.76705272
Belgium	0.46924343	0.47068642	0.47056263	0.48226919	0.4628216	0.46563198	0.45957314	0.45392887	0.44874872	0.43062822
Bulgaria	0.53893111	0.40374634	0.37757982	0.40119166	0.34657493	0.39262193	0.38899041	0.42058919	0.41356689	0.44792506
China	2.10598056	2.11281903	2.12151389	2.1703892	2.22362168	2.25728654	2.30260139	2.3494208	2.34763696	2.44241344
Cyprus	0.35943459	0.32686006	0.36753292	0.32313818	0.40048944	0.32861015	0.38463308	0.38845194	0.37739337	0.3682773
Czech Republic	0.50691193	0.51834859	0.55171987	0.53972908	0.52648316	0.54102317	0.55336585	0.59695006	0.58959052	0.61442502
Denmark	0.73539499	0.73526452	0.69613961	0.70896763	0.667214	0.6493545	0.64498816	0.68866564	0.71384908	0.6423733
Finland	0.53507298	0.51227543	0.49710113	0.53174945	0.51334681	0.52140608	0.50255226	0.49278834	0.48534253	0.48709789
France	1.6105506	1.57912508	1.58711703	1.59771625	1.57140367	1.52811705	1.54272187	1.52556877	1.44637631	1.44852441
Germany	1.85686867	1.80722808	1.77648033	1.82423627	1.77138259	1.6860385	1.69158082	1.66055512	1.55808749	1.53770146
Greece	0.63807585	0.63746375	0.64935593	0.65006132	0.62310671	0.61692785	0.62597585	0.6590196	0.60947472	0.60194422
Hungary	0.50258415	0.47767276	0.50516609	0.51380512	0.52333513	0.5116141	0.51155963	0.51784482	0.50915163	0.51807455
India	1.54505826	1.55864666	1.60046543	1.64071158	1.6434634	1.67036348	1.67800469	1.67617104	1.59973229	1.6533349
Indonesia	0.78538828	0.80546402	0.86447366	0.89792653	0.91972609	0.92504908	0.84174886	0.84178715	0.855201	0.83738389
Ireland	0.41479299	0.41443436	0.40879107	0.42970883	0.46091729	0.41161971	0.42248331	0.43567527	0.44386552	0.4403939
Italy	1.35043202	1.27958313	1.2663574	1.25037497	1.30099267	1.28533226	1.30754808	1.30594029	1.26064728	1.25652976
Japan	2.21971526	2.38204988	2.40807566	2.41189302	2.22696177	2.12895234	2.0526853	2.13857813	2.15738573	2.03838505
Luxembourg	0.4961808	0.4984805	0.49454204	0.49680058	0.4805754	0.49035105	0.48439489	0.4574487	0.46800258	0.48406223
Malta	0.37074449	0.36191282	0.40308613	0.36868335	0.37534234	0.3689494	0.3803259	0.38043112	0.39555201	0.3753518
Netherlands	0.81150639	0.80420231	0.8001085	0.80765231	0.80113027	0.78684952	0.80654386	0.81464854	0.78186238	0.78146365
Poland	0.62595875	0.63325945	0.65703777	0.66864582	0.66801565	0.67359463	0.66851916	0.64979403	0.62034392	0.62346245
Portugal	0.4970104	0.49272782	0.47477681	0.4831507	0.5034475	0.49702194	0.5046879	0.50470576	0.49766753	0.50816549
Rep. of Korea	0.64604738	0.66782668	0.69765558	0.73738457	0.74018614	0.72231993	0.67299974	0.6910411	0.6942023	0.70454763
Romania	0.58725209	0.54249267	0.55512083	0.57755602	0.58526468	0.57768663	0.56087598	0.57651879	0.62536949	0.62802959
Slovakia	0.45461938	0.48314837	0.45284125	0.47871889	0.4902153	0.48783371	0.49400149	0.4912854	0.48464779	0.48070291
Spain	0.90566147	0.887934	0.88939432	0.90868474	0.91487292	0.91970192	0.9291139	0.90162482	0.87335435	0.90740844
Sweden	0.63393609	0.59725514	0.60538301	0.60006043	0.60064069	0.5968476	0.59408407	0.59108423	0.58897666	0.57118942
United Kingdom	1.4666033	1.41311273	1.42061286	1.39449157	1.40334871	1.41140783	1.47351592	1.44444822	1.42147531	1.41856869
United States	6.55756726	6.55673511	6.4498239	6.30327814	6.26414763	6.35019606	6.46761947	6.4681125	6.55119168	6.59929131

Table A1: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1.06698796	1.07485708	1.08266876	1.07973952	1.07449923	1.08496705	1.09002175	1.05839257	1.08339362	1.10043073	1.13039802	1.14801479
0.77816083	0.78907529	0.78289594	0.76661149	0.7672426	0.772354	0.75533254	0.72103779	0.72681083	0.73214684	0.73203072	0.75259583
0.44438652	0.44654971	0.44029427	0.42777236	0.41277871	0.41878056	0.40217304	0.39587517	0.38422304	0.37339955	0.35863792	0.39389973
0.44910652	0.47626399	0.44932926	0.4195929	0.40889333	0.38363877	0.40921991	0.44507886	0.43671456	0.42265075	0.40314401	0.43496453
2.50967706	2.50258713	2.52150226	2.55117809	2.64140441	2.74893708	2.83739101	2.97501602	3.05519918	3.19129797	3.35158855	3.51379019
0.37177017	0.38333264	0.41890799	0.26365101	0.31972124	0.35688705	0.35665129	0.36484781	0.36930192	0.40093005	0.38522033	0.38699581
0.6061055	0.60555468	0.61022204	0.59918023	0.60107146	0.63254667	0.6075621	0.57889309	0.5928461	0.61248523	0.60631587	0.63447226
0.64966944	0.68609388	0.64387507	0.65974268	0.65006499	0.66885457	0.68315924	0.67889171	0.71735546	0.72233755	0.69016929	0.69406856
0.48235692	0.47245533	0.44717108	0.42828137	0.44979283	0.44321805	0.41124703	0.38300118	0.35271107	0.36996665	0.37777917	0.39955736
1.46226423	1.4777622	1.46205801	1.41941302	1.40033682	1.40539015	1.37282012	1.3507033	1.30476123	1.28896265	1.27078366	1.3067315
1.53856007	1.55151231	1.52434719	1.45774993	1.42620531	1.43905602	1.41568031	1.36460362	1.33181224	1.33700803	1.30985263	1.34253006
0.61539933	0.60644144	0.59218323	0.59358933	0.59075208	0.59575828	0.61193403	0.60896343	0.5852881	0.57540365	0.56724686	0.57738284
0.55254714	0.55156129	0.55299404	0.52960973	0.5223593	0.51652588	0.47301518	0.47444169	0.49503211	0.49572292	0.48916446	0.52602867
1.65859662	1.64803416	1.63163765	1.62861745	1.68849105	1.72514257	1.68793256	1.7092967	1.7473185	1.75181613	1.74305734	1.75264657
0.8612616	0.89039502	0.87851099	0.86897844	0.88404044	0.89513916	0.90290364	0.87844534	0.90146572	0.95098944	0.95845359	0.96837398
0.44206723	0.45117012	0.46101623	0.49554221	0.49961415	0.54532741	0.56244352	0.5702556	0.54543294	0.52844482	0.55649214	0.57238259
1.27148815	1.28195168	1.26630695	1.22115358	1.19348007	1.18745946	1.16175663	1.12418507	1.08589198	1.0848259	1.04823423	1.06455597
1.95350094	1.89378785	1.83755458	1.72794107	1.61213644	1.53074821	1.48302673	1.51584607	1.51697344	1.51391416	1.50488161	1.40000054
0.5114631	0.51066933	0.4262731	0.43170434	0.51674549	0.45085572	0.43901435	0.44786662	0.45280462	0.50960745	0.50622409	0.50711721
0.38238728	0.41274959	0.37075104	0.36927743	0.37265015	0.37721679	0.37983481	0.3835061	0.47158371	0.38051186	0.4435879	0.40301144
0.78753894	0.79252121	0.77350463	0.75778286	0.75608335	0.75883613	0.74447228	0.73242334	0.70971506	0.7226014	0.70337936	0.7218242
0.62650384	0.62925407	0.62163947	0.6149564	0.61129305	0.63388579	0.628459	0.60205555	0.60379229	0.61327321	0.59953359	0.62958305
0.52304539	0.51326076	0.51080176	0.48957927	0.48424367	0.50336906	0.48405725	0.48017018	0.48108979	0.47364287	0.46093964	0.4491695
0.73496987	0.73007063	0.72631049	0.73065696	0.72583085	0.73050521	0.662365	0.65821227	0.67601078	0.67746224	0.68200776	0.71864599
0.62625394	0.61183651	0.63021178	0.60650349	0.61896473	0.64576815	0.62457284	0.60558897	0.62275832	0.61960558	0.63712318	0.67043776
0.4738265	0.48529518	0.47157478	0.45539349	0.44528648	0.47473775	0.46181738	0.45699528	0.45144271	0.44970336	0.46069103	0.47913391
0.91331181	0.99249165	0.99087379	0.97713531	0.97637939	0.99866751	0.98015126	0.95815233	0.93091971	0.91000968	0.87897886	0.8868048
0.59249674	0.60058934	0.58795732	0.57211581	0.5624895	0.57720248	0.55606726	0.52776566	0.50891177	0.51601472	0.52655954	0.55690393
1.45100828	1.46003234	1.45134498	1.42774485	1.41395867	1.40015888	1.34001114	1.27302242	1.24079025	1.2347531	1.24787678	1.26715907
6.75234899	6.78709767	6.74672733	6.71817356	6.61652147	6.40831136	6.3030879	6.39011731	6.329364	6.18213439	6.05886939	5.87434853

Table A2: Final OSR Scores (normalized)

Countries	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.12621077	0.12606402	0.12686421	0.12481956	0.1254837	0.12728104	0.12587306	0.12570292	0.1256093	0.12187082
Austria	0.08017043	0.08063182	0.08051608	0.08116414	0.0804079	0.07876267	0.07936285	0.07976287	0.07790897	0.07716806
Belgium	0.03151592	0.03173712	0.03171814	0.03351268	0.0305315	0.03096231	0.03003353	0.0291683	0.02837422	0.02559647
Bulgaria	0.04219857	0.02147566	0.01746451	0.02108405	0.01271167	0.01977036	0.01921368	0.02405756	0.02298109	0.02824796
China	0.28241659	0.28346488	0.28479774	0.29229	0.30045017	0.30561077	0.31255722	0.31973432	0.31946087	0.33398946
Cyprus	0.01468297	0.00968952	0.01592439	0.00911898	0.0209764	0.00995779	0.01854573	0.01913113	0.01743593	0.0160385
Czech Republic	0.03729024	0.03904341	0.044159	0.04232089	0.04029038	0.04251927	0.04441131	0.05109248	0.04996431	0.05377127
Denmark	0.07231514	0.07229514	0.06629756	0.06826401	0.06186346	0.05912572	0.05845639	0.06515185	0.0690123	0.05805555
Finland	0.04160714	0.03811243	0.03578632	0.04109767	0.03827667	0.0395121	0.03662194	0.03512519	0.0339838	0.03425289
France	0.20647055	0.20165323	0.20287834	0.20450313	0.20046959	0.19383404	0.19607286	0.19344341	0.18130374	0.18163303
Germany	0.24422943	0.23661987	0.23190645	0.23922711	0.231125	0.21804233	0.21889193	0.2141359	0.19842831	0.19530327
Greece	0.05739678	0.05730295	0.05912594	0.05923407	0.05510211	0.05415494	0.05554193	0.06060732	0.05301242	0.05185805
Hungary	0.03662683	0.03280808	0.03702262	0.03834692	0.03980781	0.03801106	0.03800271	0.03896618	0.03763358	0.0390014
India	0.19643102	0.19851402	0.20492456	0.21109402	0.21151585	0.21563945	0.2168108	0.21652971	0.20481217	0.21302909
Indonesia	0.07997877	0.08305625	0.09210203	0.09723012	0.10057185	0.10138783	0.08861847	0.08862434	0.09068059	0.08794935
Ireland	0.02316904	0.02311406	0.02224898	0.02545553	0.03023958	0.0226826	0.02434791	0.02637015	0.02762566	0.02709348
Italy	0.16659614	0.15573548	0.15370807	0.15125807	0.15901742	0.15661679	0.16002232	0.15977586	0.15283275	0.15220156
Japan	0.29985134	0.32473614	0.32872571	0.32931089	0.30096218	0.28593801	0.27424679	0.28741357	0.29029665	0.27205466
Luxembourg	0.03564524	0.03599776	0.03539402	0.03574024	0.03325303	0.03475157	0.03383854	0.02970787	0.03132571	0.03378754
Malta	0.0164167	0.01506287	0.02137446	0.01610074	0.01712152	0.01614153	0.01788547	0.0179016	0.02021953	0.01712297
Netherlands	0.0839825	0.08286284	0.08223528	0.0833917	0.08239191	0.08020277	0.08322178	0.08446417	0.07943828	0.07937716
Poland	0.05553931	0.05665846	0.06030351	0.06208295	0.06198635	0.06284157	0.06206353	0.0591931	0.0546786	0.05515665
Portugal	0.03577241	0.03511592	0.03236415	0.03364781	0.03675917	0.03577418	0.03694932	0.03695205	0.03587314	0.03748241
Rep. of Korea	0.05861876	0.06195738	0.06652995	0.07262013	0.07304959	0.07031083	0.06275038	0.06551599	0.06600058	0.06758645
Romania	0.04960585	0.04274453	0.04468034	0.0481195	0.04930119	0.04813952	0.04556257	0.0479605	0.05544898	0.05585676
Slovakia	0.02927415	0.03364745	0.02900158	0.03296844	0.03473077	0.03436568	0.03531116	0.0348948	0.0338773	0.03327258
Spain	0.09841584	0.09569834	0.09592219	0.09887928	0.09982789	0.10056814	0.10201093	0.09779705	0.09346337	0.09868364
Sweden	0.05676219	0.05113924	0.05238519	0.05156928	0.05165823	0.05107677	0.05065314	0.05019329	0.04987021	0.04714355
United Kingdom	0.1844044	0.17620466	0.17735438	0.17335017	0.1747079	0.17594331	0.18546406	0.18100818	0.17748659	0.17704102
United States	0.96481455	0.96468699	0.94829823	0.92583376	0.91983532	0.93302595	0.95102616	0.95110174	0.96383722	0.97121056

Table A2: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.12314609	0.12435237	0.12554985	0.12510082	0.12429752	0.12590216	0.12667701	0.12182847	0.12566097	0.12827264	0.13286642	0.13556695
0.07887086	0.08054397	0.07959672	0.07710042	0.07719717	0.07798071	0.07537143	0.07011428	0.07099925	0.07181722	0.07179942	0.07495192
0.02770552	0.02803713	0.02707821	0.02515869	0.02286026	0.0237803	0.02123449	0.02026907	0.01848287	0.01682371	0.01456085	0.01996624
0.02842907	0.03259212	0.02846321	0.02390483	0.02226466	0.01839331	0.02231472	0.02781166	0.02652947	0.02437358	0.02138333	0.0262612
0.34430052	0.34321368	0.34611324	0.35066234	0.36449342	0.38097745	0.39453684	0.41563381	0.42792535	0.44878836	0.47335982	0.49822423
0.01657393	0.01834638	0.02379984	0	0.00859519	0.01429245	0.01425631	0.01551278	0.01619557	0.02104394	0.01863575	0.01890792
0.05249594	0.05241151	0.05312698	0.05143435	0.05172426	0.0565492	0.05271923	0.04832447	0.05046337	0.05347391	0.05252819	0.05684438
0.059174	0.06475762	0.05828576	0.06071816	0.05923463	0.06211495	0.06430776	0.06365357	0.06954981	0.07031353	0.06538235	0.06598008
0.03352613	0.03200828	0.02813238	0.02523671	0.02853428	0.02752641	0.02262547	0.01829557	0.0136523	0.01629747	0.01749507	0.02083352
0.18373925	0.18611499	0.18370764	0.17717046	0.1742462	0.17502084	0.17002808	0.16663772	0.15959511	0.1571733	0.15438658	0.15989714
0.19543489	0.19742038	0.19325615	0.18304724	0.17821167	0.18018159	0.17659826	0.16876855	0.16374185	0.16453833	0.16037559	0.16538482
0.05392062	0.05254744	0.05036176	0.0505773	0.05014237	0.05090979	0.05338942	0.05293405	0.04930478	0.04778956	0.04653918	0.04809296
0.04428581	0.04413469	0.04435432	0.04076966	0.03965822	0.038764	0.0320941	0.03231278	0.03546915	0.03557505	0.03456968	0.04022071
0.21383567	0.21221652	0.20970305	0.20924007	0.21841829	0.22403672	0.21833267	0.22160765	0.22743614	0.22812559	0.22678293	0.22825289
0.09160964	0.09607559	0.09425385	0.09279258	0.09510148	0.09680284	0.09799308	0.09424379	0.09777266	0.10536431	0.10650851	0.10802924
0.02734999	0.0287454	0.03025475	0.03554734	0.03617154	0.04317908	0.04580286	0.0470004	0.04319525	0.04059109	0.04489055	0.04732645
0.15449458	0.15609857	0.15370034	0.14677863	0.14253647	0.14161355	0.13767348	0.13191402	0.12604395	0.12588053	0.12027127	0.12277328
0.2590425	0.24988889	0.24126871	0.22446571	0.20671364	0.19423738	0.186922	0.19195299	0.1921258	0.19165684	0.19027221	0.17419465
0.03798791	0.03786623	0.02492886	0.02576143	0.03879766	0.02869721	0.02688201	0.028239	0.02899596	0.03770345	0.0371848	0.03732171
0.01820146	0.0228558	0.01641771	0.01619181	0.01670883	0.01740886	0.01781019	0.01837297	0.03187467	0.01791397	0.0275831	0.02136301
0.08030846	0.08107221	0.07815709	0.07574705	0.07548653	0.07590851	0.07370663	0.07185961	0.06837858	0.07035397	0.06740737	0.07023483
0.05562287	0.05604446	0.0548772	0.05385273	0.05329116	0.05675447	0.05592258	0.05187511	0.05214135	0.05359471	0.05148852	0.05609489
0.03976339	0.03826348	0.03788653	0.03463327	0.03381535	0.03674715	0.03378678	0.03319092	0.03333189	0.03219032	0.030243	0.02843872
0.07224998	0.07149896	0.07092255	0.07158884	0.07084903	0.07156557	0.06112014	0.06048356	0.06321195	0.06343445	0.06413124	0.06974764
0.05558456	0.05337447	0.05619127	0.05255695	0.05446718	0.05857596	0.05532686	0.05241676	0.05504871	0.05456541	0.05725074	0.06235764
0.03221847	0.03397654	0.0318733	0.02939282	0.02784348	0.03235816	0.03037756	0.02963836	0.02878719	0.02852056	0.03020489	0.03303206
0.09958858	0.11172631	0.11147831	0.10937229	0.10925641	0.11267303	0.10983461	0.10646233	0.10228775	0.09908239	0.09432557	0.09552524
0.05040981	0.05165035	0.04971395	0.04728556	0.04580991	0.04806531	0.04482542	0.04048698	0.03759681	0.03868564	0.04030209	0.04495368
0.18201379	0.18339712	0.18206541	0.17844767	0.17633434	0.17421893	0.16499869	0.15472977	0.1497888	0.14886334	0.15087512	0.15383096
0.99467326	1	0.9938115	0.9894344	0.97385183	0.94193464	0.92580459	0.93914561	0.92983254	0.90726324	0.88836756	0.86008177

Table A3: GDP per Unit of Energy Use

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	5.620827	5.580193	5.809565	5.916615	5.772485	5.851124	5.955925	6.120618	6.244525	6.506984
Austria	9.933432	9.873523	10.13782	9.965289	9.603579	9.885554	10.0666	10.45337	10.84206	10.39936
Belgium	6.125903	6.212493	6.061517	6.10126	5.873256	6.084416	6.103661	6.301944	6.458518	6.5246
Bulgaria	3.358071	3.085063	3.239581	3.070723	3.13708	3.422669	3.681101	3.800024	3.927951	3.929086
China	2.45121	2.636566	2.846615	2.942678	3.147662	3.441705	3.687275	3.893267	4.000953	4.240547
Cyprus	9.680836	9.079801	8.415023	10.1352	9.263596	9.681202	9.506189	9.899331	9.725379	10.18132
Czech Republic	4.137368	4.27014	4.532542	4.749783	4.800001	4.736342	4.87433	5.308654	5.266552	5.284553
Denmark	9.588077	9.328609	9.510682	9.893697	8.997284	10.02657	10.41769	11.19211	11.94765	11.68696
Finland	4.780879	4.524245	4.403669	4.822278	4.647213	4.760937	4.972509	5.210616	5.534004	5.523378
France	7.59523	7.426096	7.899212	7.741674	7.42845	7.842124	7.891618	8.173934	8.40822	8.288946
Germany	7.925463	7.927419	8.161205	8.216574	8.013073	8.233065	8.447154	8.814894	9.032436	8.918034
Greece	10.07082	10.03595	9.959326	10.07917	10.04616	10.09701	9.962343	10.2279	10.09321	10.16586
Hungary	5.98998	5.822261	6.188507	6.047241	5.895625	6.220263	6.562394	6.825856	7.256956	7.35959
India	4.968332	5.104376	5.224817	5.32648	5.544617	5.558231	5.740485	5.93481	6.018644	6.205582
Indonesia	8.797889	8.590715	9.226385	9.06742	9.418581	9.540174	8.472769	8.152098	7.890896	7.990316
Ireland	7.980548	8.043014	8.104105	8.80861	9.028007	9.530544	9.78517	10.33331	10.98422	11.17403
Italy	11.96022	11.92062	12.33285	11.68736	11.84801	11.89635	11.75927	11.76156	11.97025	12.15594
Japan	8.381806	8.335471	7.975756	7.92187	7.960897	7.999875	7.987474	7.848477	7.866088	8.020577
Luxembourg	6.563093	6.744057	7.254366	8.308215	8.313847	9.051494	9.981913	10.38325	10.51633	10.20867
Malta	9.842821	8.037861	9.364987	10.82264	11.41569	10.69768	12.75982	12.25378	14.5885	12.33445
Netherlands	7.364248	7.393898	7.565382	7.649036	7.632354	8.176854	8.457011	8.982568	9.137574	9.036526
Poland	3.737357	3.785482	4.182154	4.325834	4.416472	4.792465	5.404164	5.797958	6.309301	6.343181
Portugal	11.83324	11.75507	11.56949	10.91097	11.40404	11.30578	10.96384	10.61318	10.93982	11.06881
Rep. of Korea	5.422929	5.140289	5.265379	5.232929	5.162236	5.01514	5.17898	5.185795	5.185731	5.3381
Romania	4.404366	4.587847	5.055311	5.00104	5.0717	5.13276	5.495977	6.194844	6.349751	6.596638
Slovakia	3.33119	3.458593	3.741989	3.884255	4.077423	4.319894	4.632385	4.59712	4.629065	4.563892
Spain	10.18775	10.51233	10.19713	10.01662	10.43816	10.18358	10.11164	10.07721	10.12056	10.25763
Sweden	5.552364	5.44186	5.300162	5.444308	5.401701	5.705131	5.842354	6.218892	6.868517	6.565096
United Kingdom	7.123506	7.237798	7.470998	7.646449	7.526004	7.984395	8.172605	8.405683	8.690027	8.897338
United States	4.861167	4.908696	5.013218	5.084687	5.162975	5.340896	5.531491	5.638178	5.707686	5.873559

Source:

World Bank, World Development Indicators (2016). GDP per unit of energy use (constant 2011 PPP per kg of oil equivalent).

Retrieved from http://data.worldbank.org

Table A3: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
6.52892	6.647926	6.808116	6.976678	6.899474	6.921371	6.921945	7.024338	7.322612	7.406779	7.653168	7.669692
10.47627	9.976562	10.09573	9.978973	10.29286	10.79551	10.89807	11.02935	10.53089	11.16347	11.23345	11.24032
6.878132	6.661047	6.876628	7.044914	7.289489	7.659365	7.494646	7.604896	7.269697	7.835378	8.307962	8.023539
4.27492	4.383264	4.801863	4.874314	5.060885	5.541735	5.9343	6.443624	6.315926	5.96306	6.25893	6.883953
4.378881	4.231291	4.054339	4.16794	4.302628	4.659641	4.999246	5.059781	5.108799	5.151673	5.298872	5.302631
10.36744	9.794803	10.91446	11.15631	11.2103	11.1369	10.89515	10.91942	11.44363	11.85136	12.29494	13.33837
5.314356	5.262003	5.393558	5.810446	6.068233	6.398635	6.725352	6.83069	6.633146	7.015383	6.982352	7.054823
11.86576	11.26549	11.95185	12.59292	12.18759	12.59022	12.85631	12.76523	12.24718	13.40914	13.91891	13.78619
5.343947	5.166649	5.315746	5.919842	5.655417	6.030555	6.328325	6.151675	5.781147	6.164057	6.298327	6.42158
8.361342	8.281214	8.389033	8.482309	8.81715	9.134998	9.110621	9.239712	9.130219	9.6852	9.679393	9.700937
9.122779	9.10597	9.147537	9.280098	9.363549	10.21373	10.21319	10.29187	10.17374	11.09663	11.10024	10.92821
10.44644	10.74133	11.07132	10.93688	11.56424	11.94521	11.82616	11.69606	11.78555	11.05321	10.31884	11.33851
7.688407	7.820482	8.227749	8.125103	8.502882	8.730003	8.890246	8.843259	8.624098	9.025632	9.413275	10.00769
6.258868	6.608524	6.756391	7.102776	7.378116	7.605798	7.549877	7.427527	7.8275	8.070313	8.12102	8.397902
8.050452	8.410841	8.286387	8.605186	8.869465	9.476239	9.850676	9.627179	9.765843	10.5769	10.86876	11.37619
11.80551	12.56276	12.72293	13.44295	14.23392	14.62952	14.54438	14.18926	14.13351	15.86461	15.8969	16.26003
12.16431	11.71043	11.73372	11.72023	12.10979	12.44324	12.56612	12.67025	12.45804	12.76259	12.83197	13.08956
8.050183	8.253096	8.185291	8.32528	8.477998	8.741272	8.996555	8.914164	8.836429	9.499626	9.878869	9.954114
10.18497	9.791144	9.179124	9.289562	9.880454	11.02259	10.93755	11.00346	10.9	11.30453	11.41666	12.29624
13.60265	12.09696	11.98395	11.69594	12.63958	12.52022	13.63899	14.24741	14.06042	14.34067	13.58454	16.61577
9.034959	8.792981	8.850757	9.121682	9.633633	9.672678	9.812231	9.608657	9.13016	10.00229	9.750523	9.850987
6.499603	6.563254	6.882002	7.037335	7.115954	7.661603	7.844676	8.365689	8.127078	8.483731	8.911398	9.033653
10.70675	10.90468	10.79592	10.61706	11.34191	11.54306	11.87142	11.67286	12.32478	12.44598	12.59898	12.38731
5.514283	5.562639	5.679072	5.846825	6.050281	6.136643	6.17489	6.16006	6.015692	5.986386	6.054448	6.221471
6.698839	6.820279	7.551344	7.885096	8.233367	8.837733	9.620725	10.1551	10.03116	9.917572	10.22935	11.62876
4.734837	5.01641	5.362507	5.56121	6.094193	7.055169	7.261189	7.512917	7.410036	7.830693	8.279671	8.131271
10.2477	10.22248	10.10564	10.26542	10.70335	10.95121	11.45164	12.01124	12.02229	12.09439	11.79754	12.47307
6.539204	6.849395	6.877608	7.211205	7.754103	8.041707	8.070804	8.359303	7.903124	8.286666	8.210067	8.463399
9.324753	9.47367	9.751293	9.996625	10.43541	11.1072	11.23276	11.41602	11.21412	12.33344	12.14116	12.52944
5.911582	6.063461	6.16594	6.341966	6.573296	6.575191	6.728538	6.881026	6.894186	7.082096	7.413261	7.356794

Table A4: GDP per Unit of Energy Use (modified)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.22377095	0.22090224	0.23709561	0.2446532	0.23447781	0.24002962	0.24742844	0.25905556	0.26780324	0.28633251
Austria	0.5282354	0.5240059	0.54266493	0.53048446	0.50494819	0.52485527	0.53763689	0.56494236	0.59238339	0.56112933
Belgium	0.25942867	0.26554182	0.2548831	0.25768891	0.24159211	0.25649974	0.25785842	0.27185694	0.28291087	0.28757618
Bulgaria	0.06402324	0.04474922	0.05565799	0.04373683	0.04842155	0.06858378	0.08682875	0.09522456	0.10425604	0.10433617
China	0	0.0130859	0.02791509	0.03469702	0.04916863	0.06992769	0.08726462	0.1018074	0.10940989	0.12632493
Cyprus	0.51040244	0.46797013	0.42103765	0.54247996	0.48094583	0.51042828	0.49807258	0.52582791	0.51354712	0.54573598
Czech Republic	0.11904062	0.12841415	0.1469394	0.16227634	0.16582167	0.16132743	0.1710692	0.20173193	0.19875958	0.20003043
Denmark	0.50385377	0.48553566	0.49838978	0.52543016	0.46214454	0.53481082	0.5624234	0.61709647	0.67043664	0.65203226
Finland	0.16447168	0.14635365	0.13784113	0.1673944	0.15503503	0.1630638	0.17800052	0.19481057	0.21764135	0.21689117
France	0.3631613	0.35122065	0.38462204	0.37350006	0.35138684	0.3805917	0.38408592	0.40401707	0.42055736	0.41213677
Germany	0.38647533	0.38661342	0.40311842	0.4070274	0.39266049	0.40819164	0.42330605	0.44926803	0.46462622	0.45654959
Greece	0.53793482	0.53547304	0.53006348	0.53852432	0.53619385	0.5397838	0.53027648	0.54902447	0.53951552	0.54464452
Hungary	0.24983268	0.23799193	0.26384844	0.25387524	0.24317134	0.26609037	0.29024438	0.30884447	0.33927958	0.34652541
India	0.17770563	0.18731016	0.19581314	0.20299042	0.21839062	0.21935175	0.23221865	0.24593775	0.25185632	0.26505391
Indonesia	0.4480675	0.43344128	0.47831878	0.46709605	0.49188757	0.50047188	0.42511444	0.40247547	0.38403494	0.39105387
Ireland	0.39036426	0.39477428	0.39908723	0.44882439	0.46431354	0.49979202	0.51776829	0.55646628	0.6024197	0.61582005
Italy	0.67132407	0.66852836	0.69763127	0.65206049	0.66340218	0.66681492	0.65713725	0.65729892	0.67203217	0.68514165
Japan	0.41869257	0.41542138	0.39002595	0.38622167	0.38897693	0.39172872	0.39085323	0.38104022	0.38228353	0.39319026
Luxembourg	0.29029373	0.30306956	0.33909673	0.41349714	0.41389475	0.46597169	0.5316581	0.55999198	0.56938726	0.54766685
Malta	0.52183838	0.39441049	0.4881039	0.59101236	0.63288094	0.58219034	0.72777481	0.69204903	0.85687731	0.69774423
Netherlands	0.34685426	0.34894751	0.36105407	0.36695993	0.36578221	0.40422322	0.42400195	0.4611056	0.47204883	0.46491497
Poland	0.09080035	0.09419791	0.12220245	0.13234608	0.13874501	0.16528964	0.20847481	0.23627617	0.27237634	0.27476822
Portugal	0.66235944	0.65684073	0.64373902	0.59724834	0.63205846	0.62512143	0.6009809	0.57622475	0.59928512	0.60839165
Rep. of Korea	0.2097996	0.18984557	0.19867677	0.19638584	0.191395	0.18101021	0.19257711	0.19305824	0.19305372	0.20381078
Romania	0.13789034	0.15084387	0.18384623	0.18001477	0.18500328	0.18931403	0.21495669	0.26429582	0.27523206	0.29266197
Slovakia	0.06212547	0.07111996	0.09112736	0.10117116	0.11480858	0.13192672	0.15398819	0.15149853	0.15375381	0.14915267
Spain	0.54618993	0.56910486	0.54685214	0.53410837	0.56386856	0.54589553	0.54081666	0.53838594	0.5414464	0.55112337
Sweden	0.21893755	0.2111361	0.2011324	0.21130893	0.20830093	0.2297227	0.23941047	0.26599358	0.31185628	0.29043514
United Kingdom	0.32985818	0.33792705	0.35439068	0.36677729	0.35827403	0.39063585	0.40392324	0.42037825	0.44045258	0.45508847
United States	0.17013991	0.1734954	0.18087452	0.18592014	0.19144718	0.20400817	0.21746394	0.22499591	0.22990308	0.24161351

Notes:

Inversed and normalized.

Table A4: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.28788116	0.29628284	0.30759205	0.31949231	0.31404181	0.31558771	0.31562823	0.32285705	0.34391481	0.3498569	0.36725165	0.36841822
0.56655907	0.53128032	0.53969343	0.53145054	0.55361056	0.58909701	0.59633762	0.60560582	0.57041518	0.61507452	0.62001502	0.62050004
0.31253509	0.29720916	0.31242891	0.32430969	0.34157637	0.36768915	0.3560602	0.36384371	0.34017908	0.38011544	0.41347928	0.39339937
0.12875162	0.13640057	0.16595313	0.17106807	0.18423975	0.21818715	0.24590174	0.28185937	0.27284406	0.24793216	0.26882021	0.31294604
0.13609113	0.12567146	0.11317888	0.12119896	0.13070777	0.15591243	0.17988812	0.18416181	0.18762242	0.19064927	0.20104133	0.20130671
0.55887581	0.51844837	0.59749473	0.61456904	0.61838066	0.61319872	0.59613147	0.5978449	0.63485347	0.66363869	0.69495487	0.76861971
0.20213448	0.19843843	0.20772604	0.23715781	0.25535724	0.27868321	0.30174901	0.30918574	0.29523939	0.32222483	0.31989289	0.32500925
0.66465531	0.62227701	0.67073315	0.71599188	0.6873761	0.71580127	0.73458688	0.72815675	0.69158308	0.77361598	0.8096051	0.80023523
0.20422357	0.19170655	0.20223261	0.24488103	0.22621296	0.25269722	0.27371941	0.26124814	0.23508934	0.2621223	0.27160159	0.28030309
0.41724784	0.4115909	0.41920278	0.42578795	0.4494273	0.47186697	0.47014598	0.47925965	0.47152958	0.51071053	0.51030057	0.51182155
0.47100432	0.46981763	0.47275221	0.48211085	0.48800238	0.54802408	0.54798596	0.55354067	0.54520084	0.6103557	0.61061057	0.59846547
0.56445311	0.58527197	0.60856885	0.59907756	0.64336838	0.67026438	0.6618596	0.6526747	0.65899258	0.60729031	0.55544472	0.62743213
0.36973948	0.3790638	0.40781634	0.40056966	0.42724038	0.44327484	0.45458779	0.45127057	0.43579808	0.46414587	0.49151297	0.53347792
0.26881583	0.2935011	0.30394033	0.32839467	0.34783332	0.36390739	0.35995943	0.35132168	0.37955927	0.39670156	0.40028141	0.41982893
0.3952994	0.4207424	0.41195611	0.43446291	0.45312068	0.49595815	0.52239293	0.50661432	0.51640383	0.57366342	0.59426837	0.63009229
0.66040174	0.71386263	0.72517043	0.77600293	0.83184441	0.85977327	0.85376249	0.82869147	0.82475559	0.94696906	0.94924869	0.97488521
0.68573256	0.65368921	0.65533345	0.65438108	0.68188352	0.70542467	0.71409984	0.72145128	0.70646953	0.72797037	0.73286851	0.75105404
0.3952804	0.4096058	0.40481886	0.4147019	0.4254836	0.44407041	0.46209307	0.45627637	0.45078838	0.49760924	0.52438332	0.52969552
0.54599366	0.51819005	0.47498221	0.48277899	0.52449522	0.60512857	0.59912486	0.60377802	0.59647388	0.62503318	0.63294942	0.69504665
0.78727754	0.68097774	0.67299937	0.65266623	0.71928602	0.71085936	0.7898431	0.83279678	0.81959553	0.83938082	0.785999	1
0.46480434	0.447721	0.45179991	0.47092688	0.50706997	0.5098265	0.51967876	0.5053067	0.47152541	0.53309669	0.51532225	0.52241489
0.28581142	0.2903051	0.3128083	0.32377462	0.32932502	0.36784715	0.38077187	0.41755473	0.40070909	0.42588834	0.45608109	0.46471214
0.58283067	0.59680428	0.58912596	0.57649867	0.62767216	0.6418731	0.6650549	0.65103681	0.69706154	0.70561811	0.71641971	0.70147608
0.21624908	0.21966295	0.22788297	0.23972612	0.25408986	0.2601869	0.26288709	0.26184011	0.25164792	0.24957895	0.25438404	0.26617565
0.29987723	0.30845074	0.360063	0.38362547	0.40821296	0.45088044	0.50615868	0.54388488	0.53513487	0.5271157	0.54912683	0.64792341
0.16122117	0.18109987	0.20553388	0.21956206	0.25718999	0.32503368	0.33957843	0.3573501	0.35008684	0.37978469	0.41148197	0.40100511
0.55042232	0.54864182	0.54039307	0.55167333	0.58259063	0.60008924	0.63541896	0.67492601	0.67570613	0.6807963	0.65983906	0.70753063
0.2886072	0.31050629	0.31249809	0.33604962	0.37437753	0.39468201	0.39673622	0.41710388	0.38489822	0.4119758	0.40656801	0.42445293
0.48526343	0.49577678	0.51537662	0.53269674	0.56367441	0.61110193	0.61996631	0.63290423	0.61865035	0.69767292	0.6840982	0.71151028
0.24429788	0.25502035	0.26225523	0.27468245	0.29101405	0.29114784	0.30197394	0.3127394	0.31366848	0.32693469	0.35031452	0.34632802

Table A5: Crude Oil Proved Reserves (used for all indicators requiring reserve data)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	1.5237	1.7679	1.61459	1.61472	1.56009	1.80018	1.80018	2.895	2.895	2.895
Austria	0.08498	0.0932	0.09473	0.1008	0.1008	0.07649	0.09	0.08712	0.08568	0.08568
Belgium	0	0	0	0	0	0	0	0	0	0
Bulgaria	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
China	24	24	24	24	24	24	24	24	24	24
Cyprus	0	0	0	0	0	0	0	0	0	0
Czech Republic	0.015	0.015	0.015	0.015	0.006	0.006	0.006	0.015	0.015	0.015
Denmark	0.755	0.72962	0.77994	0.73591	1.03153	0.9571	0.8617	0.94348	1.06927	1.06927
Finland	0	0	0	0	0	0	0	0	0	0
France	0.17084	0.17743	0.17743	0.15159	0.13831	0.11731	0.12737	0.10705	0.10705	0.14517
Germany	0.449	0.44931	0.44931	0.3684	0.33872	0.38535	0.41048	0.38849	0.35697	0.37969
Greece	0.041	0.041	0.041	0.041	0.014	0.012	0.01	0.01	0.01	0.01
Hungary	0.1585	0.14696	0.13903	0.13214	0.12854	0.11954	0.12779	0.13138	0.10972	0.10972
India	6.12674	6.04907	5.92086	5.776	5.814	4.33306	4.33968	3.97199	4.8378	4.72785
Indonesia	6.58129	5.779	5.779	5.779	5.16687	4.97971	4.97971	4.97971	4.97971	4.97971
Ireland	0	0	0	0	0	0	0	0	0	0
Italy	0.69215	0.74698	0.6205	0.6205	0.6205	0.68462	0.72927	0.62176	0.62176	0.62176
Japan	0.05975	0.05985	0.05424	0.04933	0.04887	0.05041	0.06019	0.06019	0.05858	0.05858
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	0.14465	0.14465	0.13209	0.11322	0.10693	0.08806	0.11322	0.1258	0.10693	0.10693
Poland	0.03	0.04221	0.03679	0.03531	0.03133	0.04006	0.04006	0.11488	0.11488	0.11488
Portugal	0	0	0	0	0	0	0	0	0	0
Rep. of Korea	0	0	0	0	0	0	0	0	0	0
Romania	1.15	1.56875	1.56875	1.606	1.606	1.606	1.606	1.42614	1.42614	1.42614
Slovakia	0.015	0.015	0.015	0.015	0.009	0.009	0.009	0.009	0.009	0.009
Spain	0.02139	0.02252	0.02252	0.02024	0.02	0.03	0.03	0.014	0.014	0.02101
Sweden	0	0	0	0	0	0	0	0	0	0
United Kingdom	3.99431	4.14363	4.55426	4.51693	4.29295	4.51693	5.0028	5.19087	5.15325	5.0028
United States	25.926	24.971	24.149	23.604	23.548	23.324	23.887	22.37	23.168	23.517

Source:

Energy Information Administration, International Energy Statistics (2016). Crude Oil Proved Reserves (billion barrels).
Retrieved from https://www.eia.gov

Notes:

Data taken from Former Czechoslovakia and applied to both Czech Republic and Slovakia for the period 1992-1995
Republic of Korea reserve data from 2004-2013 listed as NA and converted to 0 by author

Table A5: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
3.5	3.5	3.5	1.491	1.437	1.59179	1.5	1.5	3.318	3.318	1.42566	1.43325
0.08568	0.08568	0.062	0.062	0.062	0.05	0.05	0.05	0.05	0.05	0.05	0.0467
0	0	0	0	0	0	0	0	0	0	0	0
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
24	18.25	18.25	18.25	18.25	16	16	16	20.35	20.35	20.35	23.7168
0	0	0	0	0	0	0	0	0	0	0	0
0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1.1133	1.347	1.277	1.32	1.328	1.277	1.188	1.06	1.06	0.812	0.9	0.805
0	0	0	0	0	0	0	0	0	0	0	0
0.14004	0.14847	0.14847	0.14649	0.1584	0.1215	0.1198	0.1033	0.10115	0.09163	0.09001	0.08518
0.3643	0.34231	0.442	0.39435	0.3672	0.367	0.367	0.276	0.276	0.276	0.276	0.25416
0.009	0.009	0.006	0.007	0.007	0.005	0.01	0.01	0.01	0.01	0.01	0.01
0.11092	0.10248	0.10248	0.10248	0.10248	0.02018	0.02018	0.02018	0.02657	0.02657	0.03172	0.02732
4.84015	5.36717	5.3712	5.41687	5.84784	5.62464	5.62464	5.62464	5.62464	5.682	5.60635	5.47614
5	5	4.7	4.7	4.301	4.3	4.37	3.99	3.99	3.99	3.88534	4.03
0	0	0	0	0	0	0	0	0	0	0	0
0.62176	0.6217	0.6217	0.6217	0.6217	0.6	0.4065	0.4065	0.42368	0.47645	0.52315	0.52128
0.05858	0.0585	0.0585	0.0585	0.0585	0.0585	0.04412	0.04412	0.04412	0.04412	0.04412	0.04412
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.10693	0.106	0.106	0.106	0.106	0.1	0.1	0.1	0.1	0.31	0.2874	0.24386
0.11488	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.09638	0.155	0.15652
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.95562	0.95562	0.95562	0.95562	0.95562	0.6	0.6	0.6	0.6	0.6	0.6	0.6
0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
0.02101	0.15763	0.15763	0.15763	0.15763	0.15	0.15	0.15	0.15	0.15	0.15	0.15
0	0	0	0	0	0	0	0	0	0	0	0
4.93	4.715	4.665	4.487	4.02948	3.875	3.6	3.41	3.08448	2.85768	2.82744	3.12228
23.844	24.023	23.106	22.592	23.019	22.311	22.812	20.554	22.315	25.181	28.95	33.403

Table A6: Crude Oil Production

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	590.728	558.479	592.3986	613.7945	631.7486	658.6932	613.9726	610.98	792.5656	732
Austria	23.98	22.454	22.02102	23.58411	22.49727	19.678	21.41611	19.025	20.4	21.06849
Belgium	0	0	0	0	0	0	0	0	0	0
Bulgaria	1.062	0.964	1.06	1	0.7	0.6	0.8	0.785	0.851	0.603
China	2845	2890	2939.288	2990	3131.339	3200.342	3198.187	3195	3248.762	3300.104
Cyprus	0	0	0	0	0	0	0	0	0	0
Czech Republic	2.323	2.171	2.535	3.012	4.255	3.46	3.812	8.46027	7.76667	7.16986
Denmark	162.919	174.109	184.978	186.0767	207.9235	230.4822	238.3534	300.2	362.9344	346.6927
Finland	0	0	0	0	0	0	0	0	0	0
France	70.258	68.106	69.13302	61.5	55.16393	45.59875	39.85015	41.75068	44.00273	40.17808
Germany	85.283	81.395	78.67404	78.34	78.44387	75.496	77.418	76.296	86.81786	83.863
Greece	14.058	11.549	11.122	9.621	9	9.89845	7.12015	0.96673	5.64863	5.79178
Hungary	46.359	45.18	60.56	57.8	60.32514	65.157	50.35	46.68493	46.56954	45.72404
India	589.151	564	634.9002	750.4521	731.0246	759.6247	751.4219	742.6603	739.2415	745.3973
Indonesia	1579.236	1589.377	1590.2	1578.685	1627.486	1605	1605.118	1558.762	1518.38	1421.616
Ireland	0	0	0	0	0	0	0	0	0	0
Italy	85.632	86.442	89.15595	96.756	104.9684	114.267	109.5514	85.598	95.5	82.46
Japan	20.033	19.29	17.54698	17.815	18.33743	17.46	17.38	16.31781	18	17.33425
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	66.69	66.6	103.22705	86.9726	81.2377	76.72847	78.98	58.635	54.58	46.20274
Poland	3.219	4.986	5.06	4.654	5.06	6.06	7.44	11.06	14.41803	16.56164
Portugal	0	0	0	0	0	0	0	0	0	0
Rep. of Korea	0	0	0	0	0	6	8	9	13	12
Romania	142.641	137	141.7809	141	142	140.87	138.3108	132	128.418	131.214
Slovakia	2.323	1.27	1.26	1.4	1.6	1.5	1.2	0.909	1	1.7
Spain	31.141	24.243	20.55402	17.045	10.5	7.6	10.58	6.07945	6.35137	8.69863
Sweden	0.018	0.01	0.08099	0.081	0	0	0	0	0	0.46
United Kingdom	1986.181	2083.874	2592.67104	2755.685	2827.0387	2750.542	2856.3452	2922	2507.75755	2540.70362
United States	8996.233	8835.613	8644.86	8625.597	8607.273	8611.411	8391.849	8107.14	8109.984	8053.822

Source:

Energy Information Administration, International Energy Statistics (2016). Production of Crude Oil, NGPL, and Other Liquids (Mbbl/d). Retrieved from https://www.eia.gov

Notes:

Data taken from Former Czechoslovakia and applied to both Czech Republic and Slovakia for 1992

Offshore production data for United Kingdom, Germany, and The Netherlands combined with domestic production data

Table A6: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
707.4711	593.9863	521.5442	538.2603	518.7461	551.6148	553.0557	557.5973	569.226	495.6575	484.2159	412.1808
22.15753	21.51507	22.17923	20.41644	22.15342	22.91781	22.7459	23.4	24.40548	25.74521	24.83607	20.24384
0	0	0	0.02	0.49	0	0	0	0	0	0	0
0.74	0.6	1	1	1.1	1.2	1.2	1.4	1.6	1.4	1.4	1.4
3394.752	3422.771	3502.614	3632.622	3706.735	3764.82	3835.182	3848.959	4137.36	4132.685	4181.148	4266.115
0	0	0	0.02	0.02	0.02	0.2	0.2	0.1	0.1	0.00847	0
8.26849	9.67397	11.32514	11.51507	9.50137	7.4137	7.41257	6.50411	6.09863	9.16164	6.15847	7
371.5416	375.9266	390.4473	378.5456	343.4048	312.9557	288.3129	261.6807	247.1594	223.9464	205.0462	178.2012
0	0	0.05	0.22	0.4	0	0	0	5.9	4.2	3.5	0
38.9863	39.38219	39.1612	35.40274	38.93699	24.33151	25.5	26.15068	31.08493	30.83014	27.25137	25.25753
89.8627	94.29874	83.90147	109.72602	126.9534	80.32603	89.08197	91.33151	81.26027	96.40274	99.74044	100.56438
4.06164	3.31414	3.13607	2.72849	2.73836	1.24658	1	1.16767	2.33425	1.75068	1.6694	1.24658
38.35068	40.9	42.85792	37.26712	34.42466	27.56438	32.57923	30.41096	29.31781	22.55616	22.90437	23
782.9534	785.3274	806.6092	783.5584	805.1818	807.231	808.9125	797.4329	873.9083	904.4121	898.7846	890.8099
1329.027	1232.97	1168.639	1135.347	1088.052	1029.764	1052.501	1040.279	1029.518	1009.918	969.7924	910.8301
0	0	0	0.02	0.04	0	0	0	1.3	1.1	1.1	1.1
89.46164	101.1493	112.1667	124.6082	124.3425	126.3699	119.9618	102.2767	107.5863	103.1781	104.9672	112.7753
15.48493	16	17	18.58082	19.1005	19.90685	20.57104	19.14247	19.60411	18.78493	18.04044	17.96575
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0.04	0.04	0.02	0.02	0.02	0	0	0	0
65.14794	64.94795	61.23826	49.84246	41.97329	67.05753	52.4918	46.25479	36.69315	38.33972	39.98088	38.54247
16.32603	16.12877	27.65301	31.09863	33.4	27.58082	28.07923	25.34521	20.00548	19.72603	19.07104	25.22466
0	0	0	0.02	1.6	2.24932	3.7541	1	1	1.92603	2	2
11	10	9	10.2	11.9	13.91781	14.32787	18.76164	21.06575	19.99178	21.2459	20
130.706	123.961	121.2486	112.3069	103.6603	102.7343	104.4296	100.1768	95.83895	94.03514	90.34199	92.39162
6.33151	6.25774	7.1804	8.95068	9.32	4.60055	6.74787	3.95342	4.36712	5.78082	5.2	5.2
9.91	11.597	12.19727	11.29315	11.19452	2.74795	2.66667	4.33699	3.5726	3.16712	4.00273	8.33699
1.06	1.08	1.4	1.6	2.3	3.7	4.5	6.5	7.5	8.4	8.4	8.4
2503.27958	2334.56626	2017.65906	1805.98591	1637.49118	1636.41967	1535.41316	1451.90833	1347.24329	1107.58307	949.41169	857.16002
8041.871	7791.745	7671.18	7335.542	7322.323	7473.707	7571.03	8151.521	8627.932	9052.082	10059.37	11256.13

Table A7: Production to Reserves

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.85849201	0.88469663	0.86608025	0.86125459	0.85219555	0.86644501	0.87551245	0.92296798	0.90007377	0.90770984
Austria	0.89700282	0.9120632	0.91515178	0.91460119	0.91853667	0.90609923	0.91314578	0.92029241	0.91309524	0.91024745
Belgium	0	0	0	0	0	0	0	0	0	0
Bulgaria	0.974158	0.97654267	0.97420667	0.97566667	0.98296667	0.9854	0.98053333	0.98089833	0.97929233	0.985327
China	0.95673229	0.95604792	0.95529833	0.95452708	0.95237755	0.95132813	0.95136091	0.95140938	0.95059174	0.94981092
Cyprus	0	0	0	0	0	0	0	0	0	0
Czech Republic	0.94347367	0.94717233	0.938315	0.926708	0.74115417	0.78951667	0.76810333	0.79413343	0.81101103	0.82553341
Denmark	0.92123783	0.91290016	0.91343312	0.90770883	0.92642766	0.91210323	0.89903796	0.88386293	0.87611075	0.88165493
Finland	0	0	0	0	0	0	0	0	0	0
France	0.84989364	0.85989579	0.85778306	0.85191965	0.85442242	0.8581234	0.88580274	0.85764598	0.84996734	0.89898051
Germany	0.93067195	0.93387822	0.93608861	0.92238301	0.91546997	0.92849088	0.93115969	0.92831723	0.91122918	0.91938161
Greece	0.87484951	0.89718573	0.90098707	0.91434963	0.76535714	0.69892215	0.74011453	0.96471436	0.79382501	0.78860003
Hungary	0.89324268	0.88778783	0.84100985	0.84034357	0.82870176	0.80105149	0.85618789	0.8702999	0.84507946	0.84789214
India	0.96490138	0.96596832	0.96086066	0.95257704	0.95410664	0.93601219	0.93679972	0.93175436	0.94422606	0.94245375
Indonesia	0.91241517	0.8996154	0.89956342	0.9002907	0.88503051	0.88235761	0.88234896	0.88574673	0.88870663	0.89579919
Ireland	0	0	0	0	0	0	0	0	0	0
Italy	0.95484262	0.95776148	0.94755532	0.94308471	0.93825388	0.93907941	0.94516947	0.94975027	0.94393737	0.95159242
Japan	0.87762268	0.8823584	0.88192021	0.86818417	0.8630415	0.87357866	0.89460542	0.90104667	0.88784568	0.89199383
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	0.83171898	0.83194608	0.71475605	0.71961668	0.72269933	0.68196807	0.74538332	0.8298746	0.81369401	0.84228935
Poland	0.9608355	0.95688486	0.94979886	0.95189153	0.94105011	0.94478532	0.93221168	0.96485985	0.95419063	0.94737989
Portugal	0	0	0	0	0	0	0	0	0	0
Rep. of Korea	0	0	0	0	0	0	0	0	0	0
Romania	0.95472699	0.9681243	0.96701193	0.96795455	0.96772727	0.96798409	0.96856573	0.9662165	0.96713326	0.96641767
Slovakia	0.94347367	0.96909667	0.96934	0.96593333	0.93511111	0.93916667	0.95133333	0.963135	0.95944444	0.93105556
Spain	0.46860846	0.60707393	0.66686424	0.69261734	0.808375	0.90753333	0.87127667	0.84150005	0.83441071	0.84888149
Sweden	0	0	0	0	0	0	0	0	0	0
United Kingdom	0.8185028	0.81643776	0.79221104	0.7773211	0.75963635	0.77773669	0.7916035	0.79453733	0.82237782	0.81463244
United States	0.87334625	0.87085024	0.86933729	0.86661825	0.86658508	0.86523902	0.87177021	0.86771989	0.87223135	0.87499915

Notes:

Production converted to billion barrels per year then divided by proved reserves for ratio

Lower scores are originally better, indicating reserves will last a longer amount of time given the rate of production

However, for the model, all scores are reversed so higher is better: lowest score is 0 and highest is 1

States with 0 production and 0 reserves automatically receive the worst score, in this case 0

States with any production and 0 reserves also receive the lowest score of 0 since this is an indicator of reserve longevity

States without any production but some reserves also receive the score of 0 since they lack the capacity to exploit the reserves

Table A7: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.92622087	0.93805571	0.94561039	0.86823272	0.86823777	0.87351384	0.86542311	0.86431799	0.93738171	0.94547469	0.87603019	0.89503158
0.90560809	0.908345	0.86942873	0.87980644	0.86958067	0.83269999	0.83395493	0.82918	0.82184	0.81205997	0.81869669	0.84177727
0	0	0	0	0	0	0	0	0	0	0	0
0.98199333	0.9854	0.97566667	0.97566667	0.97323333	0.9708	0.9708	0.96593333	0.96106667	0.96593333	0.96593333	0.96593333
0.94837148	0.93154458	0.92994772	0.92734756	0.9258653	0.91411504	0.91250991	0.91219562	0.92579182	0.92587567	0.92500644	0.93434477
0	0	0	0	0	0	0	0	0	0	0	0
0.79880008	0.76460006	0.72442159	0.71979996	0.7688	0.81959997	0.81962746	0.84173332	0.8516	0.77706676	0.8501439	0.82966667
0.87818855	0.89813422	0.88839995	0.89532641	0.9056154	0.91054908	0.91141902	0.90989297	0.91489323	0.89933444	0.91684237	0.9192007
0	0	0	0	0	0	0	0	0	0	0	0
0.89838618	0.90318247	0.90372575	0.9117892	0.91027777	0.92690534	0.92230801	0.90759924	0.88782996	0.87719086	0.88949283	0.89177039
0.90996463	0.89945067	0.93071485	0.89844048	0.87380721	0.92011171	0.91140349	0.87921739	0.89253624	0.87251087	0.86809688	0.85557917
0.83527793	0.86559321	0.80922241	0.85772874	0.85721409	0.90899966	0.9635	0.95738005	0.91479988	0.93610018	0.9390669	0.95449983
0.87380095	0.85432767	0.84735421	0.8672668	0.8773907	0.50143713	0.41073246	0.44995043	0.59725252	0.69013932	0.73644089	0.69271596
0.94095679	0.94659299	0.94518686	0.9472022	0.9497436	0.94761632	0.94750721	0.94825215	0.94328943	0.94190243	0.94148486	0.94062504
0.90298103	0.90999319	0.90924399	0.91182944	0.90766357	0.9125898	0.91209088	0.90483663	0.90582104	0.90761402	0.90889492	0.91750546
0	0	0	0	0	0	0	0	0	0	0	0
0.94748215	0.94061526	0.93414694	0.92684254	0.92699853	0.92312498	0.89228522	0.90816483	0.90731448	0.92095706	0.92676474	0.92103479
0.90351657	0.90017094	0.89393162	0.88406839	0.88082594	0.87579487	0.82981801	0.84163641	0.83781731	0.8445943	0.85075339	0.85137129
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.77762089	0.77635847	0.78913241	0.82837266	0.85546933	0.75524002	0.80840493	0.83117002	0.86607	0.95485807	0.949224	0.94231116
0.94812847	0.93891885	0.89527549	0.8822266	0.8735111	0.89554888	0.89366135	0.90401534	0.92423739	0.92529569	0.95509078	0.94117684
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.95007671	0.95265297	0.95368898	0.95710427	0.96040685	0.9375033	0.93647199	0.93905911	0.94169797	0.94279529	0.94504196	0.9437951
0.74322209	0.74621388	0.70879489	0.6370002	0.62202222	0.81342214	0.72633638	0.83966686	0.82288902	0.76555563	0.78911111	0.78911111
0.82783674	0.97314658	0.97175662	0.97385016	0.97407854	0.99331332	0.9935111	0.98944666	0.99130667	0.99229334	0.99026002	0.97971332
0	0	0	0	0	0	0	0	0	0	0	0
0.81466591	0.81927536	0.84213386	0.85309007	0.85167211	0.84585982	0.84432617	0.84459046	0.84057481	0.85853286	0.87743851	0.89979649
0.87689637	0.881614	0.87882019	0.8814858	0.88389383	0.87773282	0.87886086	0.85524447	0.85887541	0.86878957	0.87317202	0.87700244

Table A8: Total Petroleum Consumption

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	730	761	788	811	831	848	852	875	872.4473	871.537
Austria	229	235	233	233	254	254	266	253	250.4432	266.7507
Belgium	509	500	553	550	593	611	622	593	606.3169	609.0784
Bulgaria	129.72	117.4867	126.2421	130.5694	118.5727	106.7719	103.038	97.2558	99.8835	101.3068
China	2661.601	2959.491	3160.605	3363.155	3610.085	3916.27	4105.835	4363.601	4795.715	4917.882
Cyprus	37.87891	38.00176	43.04325	43.0625	42.25984	42.74868	46.19695	48.58415	49.49666	51.12806
Czech Republic	241	154	159	169	173	169	175	174	169.8205	178.9425
Denmark	192	199	211	223	235	227	223	220	210.0014	213.42
Finland	225	212	220	203	203	204	210	211	214.3366	212.2915
France	1933	1879	1866	1915	1943	1962	2040	2034	2000.573	2054.444
Germany	2841	2908	2883	2882	2922	2917	2923	2836	2766.758	2807.451
Greece	323	333	340	355	368	374	392	383	399.2117	405.7268
Hungary	164	161	162	155	145	149	156	149	143.2492	138.1534
India	1274.907	1351.07	1433.274	1654.673	1740.919	1835.491	1924.373	2031.25	2147.438	2263.73
Indonesia	706.9233	764.8971	777.5163	807.307	858.5001	942.2718	905.6036	963.7306	1036.704	1077.005
Ireland	101	104	114	117	122	134	150	168	169.9713	182.4359
Italy	1894	1891	1869	1942	1920	1934	1943	1891	1853.764	1834.533
Japan	5446	5364	5622	5659	5704	5667	5472	5606	5480.14	5379.643
Luxembourg	40	40	40	37	39	41	42	45	48.0874	51.1455
Malta	12.34046	13.23204	14.24959	15.10058	16.05776	17.13797	18.01485	20.5726	18.15885	15.06027
Netherlands	769	764	764	767	761	793	802	828	854.5167	893.6603
Poland	279	293	304	318	361	391	404	420	411.2751	404.6836
Portugal	279	266	271	290	281	298	326	337	332.7096	333.8811
Rep. of Korea	1527	1684	1840	2008	2101	2255	1917	2084	2135.325	2132.045
Romania	250.0131	248.4779	220.7677	244.2085	256.993	269.9123	249.5256	215.5687	224.2383	228.9057
Slovakia	241	64	65	65	68	74	74	68	66.7708	71.6699
Spain	1104	1053	1116	1187	1199	1266	1356	1396	1433.21	1492.323
Sweden	371	365	390	388	413	394	401	392	361.6541	368.7562
United Kingdom	1815	1829	1833	1816	1852	1810	1792	1811	1765.437	1746.977
United States	17032.86	17236.73	17718.16	17724.59	18308.91	18620.3	18917.15	19519.34	19701.08	19648.71

Source:

Energy Information Administration, International Energy Statistics (2016). Total Petroleum Consumption (thousand barrels per day).

Retrieved from https://www.eia.gov

Notes:

Take data from Former Czechoslovakia and applied to both Czech Republic and Slovakia for 1992

Table A8: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
892.9044	926.3619	943.0754	964.0238	972.0699	987.7175	994.8418	987.3589	1012.503	1056.386	1074	1079.849
273.3348	288.5049	295.0399	298.969	298.5241	293.057	284.4937	269.3841	277.6373	263.6847	260.5536	264.0348
617.2534	654.5605	656.5464	664.1222	642.4901	649.2025	702.1131	638.0899	669.3756	628.543	606.5667	629.4712
105.7342	102.2144	99.45404	103.8974	105.0473	105.3586	104.2734	98.53575	90.33471	83.58478	87.29907	89
5160.714	5578.111	6437.484	6795.444	7263.328	7479.921	7697.132	8069.821	8938.357	9504.048	10175.14	10480
50.88289	51.59596	51.54117	55.50742	57.10441	58.18123	60.20686	58.45014	55.9974	55.42329	51.99584	53
175.994	187.6663	205.9117	212.9455	211.4975	211.2203	215.0183	205.4504	201.4504	196.9156	193.9025	187.4792
197.1537	188.2836	185.3328	183.4496	190.443	190.6447	181.0861	166.5296	167.4666	163.9882	155.4888	154.7967
219.0167	223.191	220.7555	219.46	222.1847	226.7107	217.0098	202.6315	212.0016	206.1419	198.1415	194.3373
1991.499	2000.84	2008.49	1990.08	1991.493	1978.269	1940.079	1863.1	1821.623	1779.465	1738.839	1712.791
2710.407	2679.232	2648.031	2624.065	2635.784	2406.689	2533.447	2434.471	2466.927	2392.202	2389.133	2435.084
408.3841	428.7414	419.7628	423.8732	444.0885	449.9534	428.8555	403.3863	372.4537	350.9592	306.1464	282.6093
140.3951	135.2236	136.2087	154.7507	163.1479	160.8912	158.8874	158.2126	149.2444	143.1962	132.8541	129.474
2333.439	2426.328	2571.551	2550.25	2701.63	2888.055	2957.302	3067.781	3305.45	3460.983	3617.852	3660
1125.65	1142.673	1232.572	1279.15	1246.765	1268.299	1308.844	1341.342	1487.193	1575.093	1697.704	1718
179.4126	176.2529	181.7639	196.6408	203.3296	193.7099	191.3719	165.1986	164.3274	143.9356	136.3369	138.9436
1870.135	1859.656	1828.926	1780.573	1776.589	1728.681	1666.766	1544.241	1544.228	1493.832	1370.12	1259.81
5286.909	5397.285	5288.016	5298.138	5168.259	5009.216	4769.588	4362.753	4429.229	4438.935	4697.331	4556.808
52.0003	55.6641	62.7981	64.8348	61.629	61.0077	61.1579	57.4145	60.0825	61.4003	59.241	58.4652
18.04836	17.98227	18.20814	18.91285	17.91038	19.05603	36.57995	39.79178	47.07293	42.37904	42.32033	42
898.3208	918.649	947.874	1009.314	999.4792	1111.233	1068.726	1005.201	1019.788	1019.215	1011.312	1014.236
406.4323	430.6671	454.1396	470.7792	502.2729	523.7027	539.2175	543.8049	567.5863	560.363	534.3604	507.3222
343.1548	325.9784	327.9607	336.9216	302.7077	308.017	292.591	276.0945	273.6921	256.3956	230.2374	237.6668
2149.151	2175.38	2155.127	2191.338	2179.915	2240.481	2142.318	2188.487	2268.518	2259.383	2321.622	2328.303
232.2845	219.6054	225.0889	221.8847	217.6266	224.0453	230.9489	201.3468	192.3497	188.4475	190.1107	188
80.077	74.9422	74.5762	78.4885	78.6082	83.286	85.9413	80.657	83.6967	82.1711	70.6075	73.1588
1504.53	1542.357	1571.431	1607.264	1588.168	1611.205	1546.976	1467.517	1441.006	1385.319	1300.928	1208.127
373.1707	370.2619	368.3842	359.5589	354.4685	350.3767	336.7751	318.2608	335.8233	314.7532	300.2257	295.8285
1738.64	1759.363	1789.241	1819.457	1805.916	1750.644	1730.691	1634.528	1617.56	1576.548	1527.383	1502.453
19761.31	20033.51	20731.16	20802.16	20687.42	20680.38	19497.96	18771.4	19180.13	18882.07	18490.21	18961.13

Table A9: Consumption to Reserves

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.82512962	0.84288421	0.8218619	0.81667719	0.80557852	0.82806164	0.82725061	0.88968048	0.89000233	0.8901171
Austria	0.01641563	0.07966738	0.10223794	0.1562996	0.08025794	-0.2120539	-0.0787778	-0.0599747	-0.0668974	-0.1363679
Belgium	0	0	0	0	0	0	0	0	0	0
Bulgaria	-2.15652	-1.858843	-2.0718911	-2.1771887	-1.885269	-1.5981162	-1.507258	-1.3665578	-1.4304985	-1.4651321
China	0.95952148	0.95499107	0.95193247	0.94885202	0.94509662	0.94044006	0.93755709	0.9336369	0.92706517	0.92520721
Cyprus	0	0	0	0	0	0	0	0	0	0
Czech Republic	-4.8643333	-2.7473333	-2.869	-3.1123333	-9.5241667	-9.2808333	-9.6458333	-3.234	-3.1322988	-3.3542675
Denmark	0.90717881	0.90044818	0.90125522	0.88939544	0.91684682	0.9134312	0.90554137	0.91488956	0.9283151	0.92714815
Finland	0	0	0	0	0	0	0	0	0	0
France	-3.1298583	-2.8653835	-2.8386406	-3.6109572	-4.1275757	-5.1045947	-4.8459606	-5.9351705	-5.8211971	-4.1654754
Germany	-1.3094989	-1.3623334	-1.3420244	-1.8554017	-2.1487069	-1.7629558	-1.59914	-1.6645216	-1.8289959	-1.6988322
Greece	-1.8754878	-1.9645122	-2.0268293	-2.1603659	-8.5942857	-10.375833	-13.308	-12.9795	-13.571227	-13.809028
Hungary	0.62233438	0.60012929	0.57469611	0.57185561	0.58826046	0.54504768	0.55442523	0.5860481	0.5234601	0.54041204
India	0.92404753	0.91847663	0.91164375	0.89543704	0.89070598	0.84538543	0.83814564	0.81334136	0.83798113	0.82523527
Indonesia	0.96079386	0.95168932	0.95089229	0.94901072	0.93935351	0.93093389	0.93362157	0.92936101	0.92401225	0.92105829
Ireland	0	0	0	0	0	0	0	0	0	0
Italy	0.00121361	0.07599266	-0.0994118	-0.1423529	-0.1294118	-0.0310975	0.02752753	-0.1100988	-0.0882396	-0.0769502
Japan	-32.268452	-31.712782	-36.832412	-40.871782	-41.602005	-40.032632	-32.182921	-32.995514	-33.145632	-32.519455
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	-0.9404424	-0.9278258	-1.1111363	-1.4726638	-1.597634	-2.2869067	-1.5854973	-1.4023847	-1.9168484	-2.050463
Poland	-2.3945	-1.5336413	-2.016037	-2.2871708	-3.2057134	-2.5625312	-2.6809785	-0.3344359	-0.3067149	-0.2857722
Portugal	0	0	0	0	0	0	0	0	0	0
Rep. of Korea	0	0	0	0	0	0	0	0	0	0
Romania	0.92064802	0.94218682	0.94863413	0.94449807	0.9415925	0.9386563	0.94328964	0.94482829	0.94260944	0.94141488
Slovakia	-4.8643333	-0.5573333	-0.5816667	-0.5816667	-1.7577778	-2.0011111	-2.0011111	-1.7577778	-1.7079269	-1.9066126
Spain	-17.83871	-16.066829	-17.087922	-20.405879	-20.88175	-14.403	-15.498	-35.395714	-36.365832	-24.925649
Sweden	0	0	0	0	0	0	0	0	0	0
United Kingdom	0.83414532	0.83888885	0.85309468	0.85325431	0.84253718	0.85373915	0.86925722	0.87265815	0.87495571	0.87254206
United States	0.76020235	0.74805148	0.73219892	0.72591614	0.71620723	0.70860875	0.71094069	0.68151278	0.68961955	0.69503852

Notes:

Consumption converted to billion barrels per year then divided by reserves for ratio

Lower scores are originally better, indicating reserves will last a longer amount of time given the rate of consumption

However, for the model, all scores are reversed so higher is better

States with any consumption and 0 reserves receive worst score of 0 since this is an indicator of reserve longevity

Table A9: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.90688283	0.90339369	0.90165071	0.7640049	0.75309289	0.77351479	0.75792183	0.75974267	0.88861857	0.88379117	0.72503262	0.72499921
-0.1644165	-0.2290416	-0.7369284	-0.7600594	-0.7574403	-1.1393161	-1.076804	-0.9665039	-1.0267523	-0.9248983	-0.9020413	-1.0636553
0	0	0	0	0	0	0	0	0	0	0	0
-1.5728655	-1.4872171	-1.4200483	-1.5281701	-1.556151	-1.5637259	-1.5373194	-1.3977033	-1.1981446	-1.0338963	-1.1242774	-1.1656667
0.92151414	0.88843778	0.87125032	0.86409112	0.85473344	0.8293643	0.82440918	0.81590721	0.83968057	0.82953427	0.81749749	0.83871349
0	0	0	0	0	0	0	0	0	0	0	0
-3.2825207	-3.5665466	-4.010518	-4.1816738	-4.1464392	-4.139694	-4.232112	-3.9992931	-3.9019597	-3.7916129	-3.7182942	-3.5619939
0.93536235	0.94898032	0.94702704	0.94927341	0.94765686	0.94550876	0.94436328	0.94265726	0.94233461	0.92628609	0.93694065	0.92981268
0	0	0	0	0	0	0	0	0	0	0	0
-4.1906394	-3.9188833	-3.9376901	-3.9585583	-3.5889832	-4.942948	-4.9109252	-5.5830736	-5.5733306	-6.0883414	-6.0511747	-6.3393838
-1.715615	-1.8568247	-1.1867224	-1.4287656	-1.6199923	-1.3935735	-1.5196407	-2.2194997	-2.2624216	-2.1636005	-2.1595418	-2.497032
-15.562244	-16.387846	-24.53557	-21.10196	-22.156043	-31.846598	-14.653226	-13.7236	-12.59456	-11.810011	-10.174344	-9.3152395
0.53800747	0.51837808	0.51486948	0.44882899	0.41892093	-1.9100737	-1.8738306	-1.8616253	-1.0502148	-0.9671288	-0.5287436	-0.7297954
0.8240333	0.83499503	0.8252502	0.82815884	0.8313745	0.81258533	0.80809168	0.80092236	0.78549929	0.77767357	0.76446066	0.75605079
0.91782755	0.91658487	0.90427898	0.90066176	0.89419455	0.89234206	0.89068008	0.87729578	0.86395352	0.85591255	0.84051281	0.8443995
0	0	0	0	0	0	0	0	0	0	0	0
-0.0978501	-0.0918038	-0.0737622	-0.0453742	-0.0430352	-0.0516143	-0.4966042	-0.3865879	-0.3303513	-0.1443985	0.04407187	0.11788166
-31.941649	-32.675368	-31.993604	-32.056758	-31.246402	-30.254083	-38.458287	-35.092585	-35.642534	-35.72283	-37.860513	-36.697981
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
-2.0663714	-2.1632725	-2.2639058	-2.475468	-2.4416029	-3.0560005	-2.9008499	-2.6689837	-2.7222262	-0.2000435	-0.2843733	-0.5180683
-0.2913283	-0.6309763	-0.7198688	-0.7828845	-0.9021541	-0.9833107	-1.0420667	-1.0594396	-1.149502	-1.1221467	-0.2583326	-0.1830603
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.91127871	0.9161215	0.91402707	0.91525092	0.91687731	0.86370578	0.85950609	0.87751403	0.88298727	0.8853611	0.88434932	0.88563333
-2.2475672	-2.0393226	-2.0244792	-2.1831447	-2.1879992	-2.37771	-2.4853972	-2.2710894	-2.3943662	-2.3324946	-1.8635264	-1.9669958
-25.137718	-2.5714033	-2.6387256	-2.7216987	-2.6774809	-2.9205988	-2.7643083	-2.570958	-2.5064479	-2.3709429	-2.1655915	-1.9397757
0	0	0	0	0	0	0	0	0	0	0	0
0.87127716	0.86380329	0.8600058	0.85199425	0.83641578	0.83510063	0.82452716	0.82504319	0.80858706	0.79863385	0.80282701	0.82436061
0.69749714	0.6956154	0.67251478	0.66391694	0.67197062	0.66167636	0.6880258	0.66665559	0.68627616	0.72630334	0.76687645	0.79280866

Table A10: Consumption to Reserves (normalized)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.99681261	0.99722975	0.99673584	0.99661402	0.99635326	0.9968815	0.99686244	0.99832921	0.99833677	0.99833947
Austria	0.97781212	0.9792982	0.97982849	0.98109865	0.97931208	0.9724443	0.97557558	0.97601735	0.97585471	0.97422252
Belgium	0	0	0	0	0	0	0	0	0	0
Bulgaria	0.92675966	0.93375349	0.92874799	0.92627406	0.93313262	0.93987919	0.94201387	0.94531958	0.94381731	0.94300361
China	0.99997011	0.99986367	0.9997918	0.99971943	0.9996312	0.99952179	0.99945406	0.99936196	0.99920755	0.9991639
Cyprus	0	0	0	0	0	0	0	0	0	0
Czech Republic	0.86314041	0.91287868	0.91002016	0.90430312	0.75365905	0.75937609	0.75080053	0.9014446	0.90383403	0.89861895
Denmark	0.99874033	0.9985822	0.99860116	0.99832252	0.99896748	0.99888723	0.99870186	0.99892149	0.99923692	0.9992095
Finland	0	0	0	0	0	0	0	0	0	0
France	0.90389137	0.91010513	0.91073345	0.8925881	0.88045031	0.85749554	0.86357207	0.83798142	0.84065919	0.87955987
Germany	0.94666016	0.94541883	0.94589599	0.93383434	0.92694323	0.93600633	0.93985513	0.93831901	0.93445474	0.9375129
Greece	0.93336243	0.93127083	0.9298067	0.9266693	0.77550632	0.7336494	0.66475904	0.67247704	0.6585746	0.65298753
Hungary	0.992048	0.9915263	0.99092875	0.99086201	0.99124744	0.99023217	0.99045249	0.99119546	0.98972498	0.99012326
India	0.99913666	0.99900577	0.99884523	0.99846446	0.99835331	0.99728851	0.99711842	0.99653565	0.99711455	0.99681509
Indonesia	1	0.99978609	0.99976737	0.99972316	0.99949627	0.99929845	0.9993616	0.99926149	0.99913583	0.99906642
Ireland	0	0	0	0	0	0	0	0	0	0
Italy	0.97745495	0.97921187	0.97509079	0.9740819	0.97438595	0.97669581	0.97807319	0.9748397	0.97535328	0.97561852
Japan	0.21928899	0.23234429	0.11206015	0.01715638	0	0.03687194	0.22129852	0.20220689	0.19867992	0.21339174
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	0.95533103	0.95562746	0.95132063	0.94282665	0.93989052	0.92369627	0.94017567	0.94447784	0.93239067	0.92925144
Poland	0.92116839	0.94139401	0.93006027	0.92369006	0.90210918	0.91722055	0.91443767	0.96956897	0.97022027	0.97071231
Portugal	0	0	0	0	0	0	0	0	0	0
Rep. of Korea	0	0	0	0	0	0	0	0	0	0
Romania	0.99905679	0.99956283	0.99971431	0.99961714	0.99954887	0.99947988	0.99958874	0.99962489	0.99957276	0.9995447
Slovakia	0.86314041	0.96433206	0.96376036	0.96376036	0.93612799	0.93041095	0.93041095	0.93612799	0.93729922	0.93263116
Spain	0.55831139	0.59994118	0.57595092	0.49799652	0.48681609	0.63903234	0.61330565	0.14581492	0.12302229	0.3918059
Sweden	0	0	0	0	0	0	0	0	0	0
United Kingdom	0.99702443	0.99713588	0.99746964	0.99747339	0.9972216	0.99748478	0.99784937	0.99792928	0.99798326	0.99792655
United States	0.99528716	0.99500168	0.99462923	0.99448162	0.99425351	0.99407499	0.99412978	0.99343838	0.99362884	0.99375616

Notes:

States with negative results required use of normalization

States with negative scores receive a score of 0 after normalization

Lowest score is 0 and highest is 1, after normalization

Table A10: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.99873338	0.9986514	0.99861045	0.9953765	0.99512013	0.99559994	0.99523358	0.99527636	0.99830426	0.99819085	0.99446086	0.99446008
0.97356353	0.97204518	0.96011253	0.95956908	0.95963061	0.95065856	0.95212726	0.95471873	0.95330321	0.95569624	0.95623326	0.95243618
0	0	0	0	0	0	0	0	0	0	0	0
0.94047244	0.94248473	0.94406284	0.94152255	0.94086515	0.94068718	0.94130759	0.94458783	0.9492764	0.95313536	0.95101189	0.95003946
0.99907714	0.99830002	0.9978962	0.997728	0.99750814	0.9969121	0.99679568	0.99659593	0.99715448	0.9969161	0.9966333	0.99713176
0	0	0	0	0	0	0	0	0	0	0	0
0.90030462	0.89363151	0.88320054	0.87917929	0.88000712	0.88016559	0.87799426	0.88346427	0.88575109	0.88834365	0.89006625	0.89373848
0.99940249	0.99972244	0.99967655	0.99972933	0.99969135	0.99964088	0.99961397	0.99957389	0.99956631	0.99918925	0.99943958	0.99927211
0	0	0	0	0	0	0	0	0	0	0	0
0.87896865	0.88535347	0.88491161	0.88442132	0.89310437	0.86129338	0.86204575	0.84625383	0.84648274	0.83438271	0.83525593	0.82848455
0.93711859	0.93380091	0.94954476	0.94385803	0.93936522	0.94468486	0.94172294	0.92527997	0.92427154	0.92659331	0.92668866	0.91875943
0.61179626	0.592399	0.40097069	0.48164233	0.45687696	0.22920032	0.63315337	0.65499464	0.68152109	0.69995384	0.73838334	0.75856773
0.99006676	0.98960558	0.98952314	0.98797154	0.98726886	0.93254984	0.93340136	0.93368812	0.95275197	0.95470404	0.96500377	0.96028012
0.99678685	0.99704439	0.99681544	0.99688378	0.99695933	0.99651789	0.99641231	0.99624387	0.99588151	0.99569764	0.99538721	0.99518962
0.99899052	0.99896132	0.9986722	0.99858721	0.99843527	0.99839175	0.9983527	0.99803824	0.99772477	0.99753585	0.99717403	0.99726535
0	0	0	0	0	0	0	0	0	0	0	0
0.97512748	0.97526954	0.97569342	0.97636039	0.97641534	0.97621378	0.96575888	0.96834368	0.96966494	0.97403384	0.9784619	0.98019603
0.22696713	0.20972863	0.22574646	0.22426267	0.24330174	0.26661598	0.07386071	0.15293685	0.14001597	0.13812942	0.08790523	0.11521856
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.92887767	0.92660101	0.92423667	0.91926607	0.92006172	0.90562664	0.90927186	0.91471948	0.91346857	0.97272648	0.97074518	0.96525458
0.97058177	0.96260185	0.96051334	0.95903281	0.95623061	0.95432386	0.9529434	0.95253523	0.95041924	0.95106195	0.971357	0.97312549
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.99883666	0.99895044	0.99890123	0.99892998	0.99896819	0.99771895	0.99762027	0.99804337	0.99817196	0.99822773	0.99820396	0.99823413
0.92462053	0.92951318	0.92986192	0.92613412	0.92602007	0.92156287	0.91903279	0.92406789	0.92117154	0.92262519	0.93364346	0.93121247
0.38682342	0.9170121	0.91543039	0.91348096	0.91451984	0.90880786	0.91247986	0.91702257	0.91853821	0.92172186	0.92654653	0.931852
0	0	0	0	0	0	0	0	0	0	0	0
0.99789683	0.99772124	0.99763202	0.99744379	0.99707778	0.99704688	0.99679846	0.99681058	0.99642395	0.9961901	0.99628862	0.99679454
0.99381392	0.99376971	0.99322697	0.99302497	0.99321419	0.99297233	0.9935914	0.99308931	0.99355029	0.99449072	0.99544397	0.99605324

Table A11: Total Primary Energy Consumption (quadrillion Btu)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	3.8123	3.91522	3.92119	4.03627	4.21412	4.54984	4.58179	4.80368	4.83336	5.00347
Austria	1.2003	1.24066	1.23269	1.28861	1.33825	1.35389	1.37968	1.38403	1.37849	1.43351
Belgium	2.22154	2.22616	2.36474	2.42879	2.57701	2.63674	2.69052	2.64493	2.72286	2.69623
Bulgaria	0.90167	0.80713	0.84447	0.92138	0.94847	0.91626	0.84782	0.77174	0.86773	0.90406
China	29.2631	29.37864	33.2778	34.5918	36.69613	35.9656	36.47588	37.02854	39.76478	41.20136
Cyprus	0.08134	0.07297	0.09299	0.09256	0.09056	0.09221	0.09985	0.10526	0.10312	0.1125
Czech Republic	2.385	1.60239	1.5408	1.565	1.65351	1.4628	1.42265	1.33374	1.3959	1.44135
Denmark	0.79464	0.84161	0.8776	0.88374	0.97945	0.94273	0.9219	0.89472	0.87642	0.88917
Finland	1.13548	1.14658	1.1855	1.13069	1.1434	1.1787	1.22525	1.21317	1.24206	1.25182
France	9.91544	9.80301	9.78224	10.0532	10.53032	10.36364	10.5916	10.71685	10.85524	11.09297
Germany	14.0417	14.07585	14.01695	14.38832	14.4	14.34602	14.33425	14.11612	14.26057	14.61627
Greece	1.02027	1.07296	1.08683	1.12394	1.14511	1.19909	1.27422	1.26643	1.338	1.35539
Hungary	1.03639	1.02379	1.02018	1.03286	1.06709	1.04105	1.04947	1.05058	1.02225	1.05705
India	8.85586	8.7488	10.02929	11.54439	10.89719	11.48554	12.02731	12.87086	13.33337	13.83758
Indonesia	2.63828	2.77514	3.10456	3.24227	3.53148	3.62664	3.50553	3.86352	3.88822	3.90767
Ireland	0.39173	0.40324	0.42274	0.43221	0.45974	0.48946	0.53158	0.56555	0.60157	0.62979
Italy	6.83769	6.82577	6.73242	7.04419	7.07283	7.17779	7.38217	7.50831	7.58188	7.62301
Japan	19.35087	19.53318	20.33493	20.94138	21.30854	21.84352	21.44917	21.94283	22.40816	22.19875
Luxembourg	0.1555	0.16248	0.15657	0.13914	0.14186	0.14123	0.13841	0.14602	0.15498	0.16252
Malta	0.03098	0.03471	0.03589	0.03366	0.03497	0.03735	0.03905	0.04454	0.03919	0.0329
Netherlands	3.46819	3.53956	3.50861	3.57411	3.71317	3.68044	3.68009	3.68314	3.78937	3.93178
Poland	3.83475	3.96796	3.81655	3.70105	4.14003	4.08498	3.8487	3.97659	3.62445	3.45492
Portugal	0.75685	0.76917	0.80845	0.84072	0.87647	0.91333	0.97411	1.02381	1.07048	1.08598
Rep. of Korea	4.82532	5.39448	5.83964	6.36046	6.75771	7.34034	6.90032	7.47238	7.83745	8.13082
Romania	2.05098	1.86929	1.86797	2.01514	2.05075	2.02501	1.73668	1.59261	1.58611	1.71549
Slovakia	2.385	0.77884	0.7458	0.80378	0.78591	0.77533	0.77298	0.76946	0.78498	0.82434
Spain	4.11966	4.02096	4.18134	4.31443	4.40675	4.6969	4.92156	5.1666	5.49989	5.75321
Sweden	2.24492	2.24428	2.25953	2.30952	2.27326	2.31767	2.40288	2.36802	2.27081	2.40492
United Kingdom	9.27266	9.56983	9.53401	9.4535	10.0481	9.75484	9.74074	9.79273	9.72914	9.88082
United States	85.78295	87.42359	89.09135	91.0291	94.0222	94.60218	95.01793	96.65199	98.81445	96.16815

Source:

Energy Information Administration, International Energy Statistics (2016). Total Primary Energy Consumption (quadrillion Btu). Retrieved from https://www.eia.gov

Notes:

Former Czechoslovakia used for both the Czech Republic and Slovakia in 1992

Table A11: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
5.15844	5.30207	5.52519	5.82339	5.8979	5.93112	5.98895	6.02454	5.9444	6.15026	5.99112	5.738
1.44219	1.45833	1.50091	1.55992	1.55464	1.53629	1.53744	1.46943	1.52587	1.47185	1.49402	1.46
2.67482	2.77881	2.80302	2.77702	2.75561	2.75271	2.91554	2.67399	2.84009	2.68611	2.59109	2.612
0.8746	0.88619	0.8749	0.89745	0.91894	0.82256	0.81396	0.71088	0.73966	0.77602	0.75783	0.799
43.47898	49.97824	57.91285	64.42196	70.38981	74.85327	78.93928	85.98877	94.91761	103.6511	105.8824	116.718
0.11064	0.11157	0.11762	0.11986	0.12395	0.12627	0.13082	0.12597	0.12151	0.1201	0.12236	0.127
1.44003	1.5051	1.50243	1.5412	1.58548	1.63158	1.62052	1.5285	1.6012	1.5797	1.57188	1.709
0.8576	0.89932	0.86591	0.84618	0.90188	0.88004	0.84203	0.79443	0.82868	0.79017	0.73857	0.754
1.25949	1.31738	1.34741	1.26669	1.32759	1.33552	1.30333	1.21026	1.29765	1.22941	1.22141	1.204
11.0154	11.11399	11.30579	11.37781	11.40152	11.22115	11.31583	10.75269	11.02566	10.8353	10.69425	10.81
14.31191	14.16747	14.33314	14.09499	14.31034	13.80214	14.09612	13.21092	14.02143	13.47837	13.46572	13.776
1.35968	1.43694	1.42718	1.43536	1.47867	1.49993	1.47097	1.40279	1.34963	1.3078	1.22494	1.151
1.06097	1.08734	1.08541	1.15672	1.14514	1.11117	1.10515	1.03631	1.05312	1.02436	0.9505	0.945
13.70921	14.16086	15.379	16.48388	17.66305	19.06203	19.69181	21.56835	22.85007	23.48259	23.91632	25.428
4.11945	4.15238	4.41745	4.5597	4.97436	5.41859	5.47132	5.87049	6.27101	6.31874	6.42435	6.354
0.62606	0.61914	0.64579	0.6646	0.69863	0.6925	0.69409	0.6217	0.63546	0.59137	0.58158	0.576
7.65325	7.90083	8.08943	8.12898	8.07481	7.96625	7.90432	7.35296	7.6616	7.50472	7.1739	6.976
22.11406	22.11447	22.76243	22.57348	22.89426	22.69544	21.8131	20.60163	21.7935	20.91451	20.30638	20.37
0.17053	0.17882	0.20081	0.20349	0.20138	0.19739	0.19706	0.18621	0.19775	0.19418	0.1896	0.185
0.03939	0.03925	0.03973	0.04122	0.03904	0.04138	0.0776	0.08783	0.10474	0.09226	0.08069	0.081
3.93989	4.00131	4.11291	4.22551	4.14205	4.23654	4.22039	4.06388	4.26909	4.07672	4.04483	3.935
3.45334	3.57164	3.69446	3.67348	3.84993	3.86359	3.89477	3.78799	4.04936	4.06242	3.90525	4.284
1.08306	1.11551	1.11238	1.11245	1.08552	1.11037	1.07015	1.06769	1.11731	1.0671	0.97813	1.051
8.4034	8.70544	8.9219	9.20961	9.33986	9.71557	9.8955	9.97932	10.8242	11.30974	11.51972	11.349
1.68366	1.62925	1.68946	1.66354	1.67453	1.66212	1.67016	1.40513	1.41592	1.51085	1.4609	1.383
0.83801	0.81392	0.79934	0.81934	0.81275	0.78209	0.79734	0.72133	0.76919	0.74081	0.69757	0.718
5.83068	6.13275	6.34333	6.52084	6.5693	6.73513	6.53036	6.1061	6.24412	6.1154	6.02876	5.659
2.27707	2.16357	2.32467	2.34065	2.22836	2.25579	2.2096	2.05961	2.20126	2.14354	2.20315	2.116
9.74661	9.79251	9.85262	9.81502	9.71016	9.37057	9.25897	8.73443	8.92046	8.43198	8.62827	8.438
97.64515	97.94337	100.1608	100.2815	99.62877	101.3174	99.29207	94.5962	97.49562	97.46145	95.05785	97.241

Table A12: Total Petroleum Consumption (quadrillion Btu)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	1.45515	1.51156	1.56499	1.60936	1.65519	1.6817	1.68837	1.73718	1.73692	1.73012
Austria	0.47712	0.48952	0.48515	0.48518	0.53253	0.5324	0.55719	0.52919	0.52413	0.55851
Belgium	1.07554	1.05541	1.16613	1.15902	1.25595	1.29118	1.31584	1.25405	1.28616	1.28952
Bulgaria	0.27724	0.24981	0.27005	0.27742	0.24897	0.22598	0.218	0.20482	0.21068	0.2114
China	5.59055	6.18679	6.58761	7.00805	7.46479	8.12371	8.46609	9.01632	9.85521	10.126
Cyprus	0.08085	0.08119	0.09211	0.092	0.09026	0.09172	0.09919	0.10449	0.10187	0.11083
Czech Republic	0.51063	0.32521	0.33312	0.35104	0.35986	0.34937	0.36215	0.3588	0.34994	0.36788
Denmark	0.40263	0.41718	0.44318	0.46751	0.49405	0.4745	0.46551	0.45879	0.43908	0.44529
Finland	0.47356	0.44441	0.46064	0.42428	0.42559	0.42547	0.43862	0.44137	0.44672	0.44145
France	3.97965	3.85961	3.8328	3.94726	4.01522	4.04712	4.21383	4.19636	4.13925	4.23955
Germany	5.8705	5.99203	5.93679	5.93629	6.0355	6.00835	6.02476	5.84177	5.71972	5.79546
Greece	0.68366	0.70257	0.71751	0.74911	0.77679	0.7866	0.82498	0.80515	0.84275	0.85367
Hungary	0.34358	0.33688	0.33945	0.32364	0.30216	0.31012	0.32415	0.3091	0.29629	0.28453
India	2.66264	2.72436	2.94401	3.27834	3.48274	3.66835	3.87246	4.20568	4.39542	4.49716
Indonesia	1.47928	1.59506	1.6188	1.68933	1.78495	1.97198	1.89021	2.0066	2.15618	2.23574
Ireland	0.2111	0.21672	0.2383	0.24422	0.25523	0.28019	0.31419	0.35253	0.35614	0.38128
Italy	3.98313	3.96411	3.90749	4.05967	4.01811	4.03658	4.05237	3.92504	3.85977	3.80425
Japan	11.1398	11.52757	11.47604	11.51924	11.62482	11.50737	11.09496	11.35784	11.1308	10.87643
Luxembourg	0.08294	0.08298	0.08252	0.07596	0.08031	0.084	0.08587	0.0921	0.09886	0.10503
Malta	0.02667	0.02853	0.03091	0.03278	0.03497	0.03735	0.03905	0.04454	0.03919	0.0329
Netherlands	1.59881	1.58921	1.5939	1.59837	1.59419	1.65209	1.66939	1.72758	1.78943	1.87473
Poland	0.58023	0.60618	0.62524	0.6503	0.7392	0.79598	0.82257	0.85174	0.83676	0.81795
Portugal	0.58325	0.54941	0.55682	0.59889	0.57579	0.61081	0.67396	0.69689	0.68861	0.68983
Rep. of Korea	3.21145	3.52537	3.85281	4.19978	4.39583	4.7103	3.98289	4.3233	4.43752	4.41895
Romania	0.5344	0.52977	0.47518	0.52129	0.54842	0.57894	0.53055	0.45532	0.47322	0.4822
Slovakia	0.51063	0.13554	0.13725	0.1364	0.14354	0.15508	0.15501	0.14173	0.13906	0.14639
Spain	2.28872	2.17591	2.30604	2.46617	2.48851	2.62784	2.82131	2.9098	2.99867	3.12083
Sweden	0.75778	0.74697	0.79976	0.79692	0.85521	0.81031	0.82486	0.80898	0.74376	0.75011
United Kingdom	3.69836	3.72776	3.69829	3.66076	3.74817	3.65244	3.61272	3.64162	3.56062	3.51784
United States	33.52496	33.68724	34.56054	34.43837	35.67535	36.1589	36.81591	37.83771	38.26171	38.18551

Source:

Energy Information Administration, International Energy Statistics (2016). Total Petroleum Consumption (quadrillion Btu).

Retrieved from https://www.eia.gov

Notes:

Former Czechoslovakia used for both the Czech Republic and Slovakia in 1992

Table A12: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1.77617	1.8452	1.88884	1.92146	1.94447	1.9781	2.00753	1.98663	2.02182	2.11336	2.17218	2.18802
0.57007	0.60252	0.61801	0.62376	0.62386	0.61187	0.59578	0.56137	0.57911	0.5496	0.5436	0.55026
1.31199	1.39678	1.40783	1.41248	1.36897	1.3708	1.53556	1.35886	1.4126	1.32166	1.2748	1.27966
0.21696	0.2089	0.21397	0.21245	0.21468	0.21411	0.21277	0.1999	0.18192	0.16812	0.17612	0.18915
10.60977	11.45643	13.15903	13.92917	14.85999	15.28641	15.77846	16.5026	18.27616	19.41441	20.85375	21.05153
0.10929	0.11021	0.11615	0.11851	0.12255	0.12498	0.12965	0.12532	0.11965	0.11832	0.11089	0.12384
0.36097	0.38472	0.42394	0.43821	0.43542	0.43492	0.44402	0.42314	0.41531	0.40583	0.4006	0.38655
0.41076	0.39219	0.38615	0.38153	0.39756	0.39787	0.37831	0.34601	0.34852	0.34112	0.32396	0.32192
0.45551	0.46432	0.4595	0.45347	0.46027	0.46286	0.45019	0.42611	0.44243	0.42876	0.40954	0.40731
4.10482	4.1342	4.16417	4.11806	4.116	4.08804	4.02767	3.85902	3.79037	3.70939	3.674	3.654
5.59674	5.53283	5.48359	5.42134	5.44851	4.96576	5.2475	5.02509	5.09312	4.93635	4.94673	4.95892
0.85855	0.90113	0.88436	0.88906	0.93266	0.94236	0.90308	0.84437	0.78007	0.73397	0.63999	0.58993
0.28719	0.27617	0.27805	0.31485	0.33273	0.32826	0.32506	0.32303	0.30351	0.2914	0.27024	0.27285
4.70871	4.81656	4.95029	5.20629	5.5182	5.88459	6.03016	6.23084	6.69842	7.00296	7.3279	7.07905
2.33955	2.36933	2.53847	2.63515	2.56728	2.61177	2.6911	2.72051	3.00498	3.1707	3.41739	3.29075
0.37368	0.36598	0.37884	0.39849	0.419	0.40103	0.39673	0.33583	0.33235	0.29513	0.28194	0.29125
3.8922	3.8703	3.80277	3.68773	3.68637	3.58413	3.46307	3.18768	3.18165	3.07139	2.8215	2.69303
10.68192	10.93955	10.73961	10.73952	10.45597	10.13323	9.67766	8.78282	8.91975	8.96284	9.51992	9.1454
0.10706	0.11483	0.13045	0.13446	0.12789	0.1267	0.12749	0.11945	0.12512	0.12782	0.12338	0.12325
0.03939	0.03925	0.03973	0.04122	0.03904	0.04138	0.0776	0.08782	0.10472	0.09349	0.09422	0.08088
1.88117	1.92279	1.99094	2.12683	2.11362	2.23285	2.15989	2.03425	2.05765	2.05466	2.04635	1.94804
0.81742	0.86253	0.9102	0.94011	1.00246	1.04673	1.07741	1.08474	1.13536	1.12077	1.06076	1.02304
0.71038	0.67229	0.67906	0.69914	0.62401	0.63519	0.60468	0.56938	0.56344	0.52832	0.46957	0.4932
4.43924	4.50357	4.47411	4.53175	4.50294	4.6114	4.40037	4.4796	4.64676	4.62229	4.77653	4.76997
0.48802	0.45871	0.46809	0.45734	0.4468	0.45877	0.48992	0.4089	0.39348	0.38685	0.39138	0.44133
0.16334	0.15268	0.15223	0.16104	0.16194	0.17169	0.1773	0.16571	0.17327	0.16999	0.14561	0.14632
3.15168	3.22943	3.29836	3.3691	3.32948	3.37824	3.25496	3.08014	3.02276	2.90957	2.74015	2.52721
0.75343	0.75441	0.75159	0.72601	0.7148	0.70391	0.68016	0.64806	0.67994	0.63167	0.60581	0.59839
3.4916	3.53527	3.61235	3.66296	3.64495	3.54081	3.48621	3.30111	3.27944	3.19593	3.11033	3.06198
38.22415	38.81144	40.29178	40.38812	39.95535	39.77396	37.27992	35.40327	36.00954	35.36794	34.57746	35.09936

Table A13: Oil as a Component of TPEC Score

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.61830129	0.61392719	0.60088902	0.60127543	0.60722761	0.63038261	0.63150428	0.63836475	0.64063922	0.65421597
Austria	0.60249938	0.60543582	0.60642984	0.62348577	0.60206987	0.60676274	0.59614548	0.61764557	0.61977961	0.61038988
Belgium	0.51585837	0.5259056	0.50686756	0.52279942	0.51263286	0.51031198	0.51093469	0.52586647	0.52764373	0.5217322
Bulgaria	0.69252609	0.69049595	0.68021363	0.69890816	0.73750356	0.75336695	0.74286995	0.73459974	0.75720558	0.76616596
China	0.80895565	0.78941197	0.8020419	0.79740719	0.79657828	0.77412555	0.76789895	0.7565035	0.75216234	0.75423141
Cyprus	0.0060241	-0.112649	0.00946338	0.00605013	0.00331272	0.00531396	0.00660991	0.00731522	0.0121218	0.01484444
Czech Republic	0.78589937	0.79704691	0.78380062	0.77569329	0.782366	0.76116352	0.74543985	0.73098205	0.74930869	0.74476706
Denmark	0.49331773	0.50430722	0.49500912	0.47098694	0.49558426	0.49667455	0.49505369	0.48722505	0.49900733	0.49920713
Finland	0.5829429	0.61240384	0.61143821	0.6247601	0.62778555	0.63903453	0.64201592	0.63618454	0.64033944	0.64735345
France	0.59864111	0.60628317	0.6081879	0.60736283	0.61869915	0.60948856	0.60215359	0.60843345	0.61868646	0.61781651
Germany	0.58192384	0.57430422	0.57645636	0.58742299	0.58086806	0.58118349	0.57969479	0.58616319	0.59891365	0.60349255
Greece	0.32992247	0.34520392	0.33981395	0.33349645	0.32164596	0.34400254	0.35256078	0.36423648	0.370142	0.37016652
Hungary	0.66848387	0.67094814	0.6672646	0.68665647	0.71683738	0.70210845	0.69112981	0.70578157	0.71015896	0.73082636
India	0.69933581	0.68860187	0.70645878	0.71602311	0.68040018	0.68061145	0.67802776	0.67324017	0.67034441	0.67500387
Indonesia	0.43930136	0.4252326	0.47857345	0.4789669	0.49456035	0.45625152	0.46079195	0.48062906	0.44545833	0.42785854
Ireland	0.46110842	0.46255332	0.43629654	0.4349506	0.44483839	0.42755281	0.40895068	0.37665989	0.40798245	0.39459185
Italy	0.41747432	0.41924354	0.41960098	0.42368534	0.43189501	0.43762913	0.45105978	0.47724055	0.49092178	0.50095172
Japan	0.42432562	0.40984673	0.43564891	0.44992928	0.45445253	0.47319068	0.48273243	0.48238946	0.50327024	0.51004313
Luxembourg	0.46662379	0.48929099	0.4729514	0.45407503	0.43387847	0.40522552	0.37959685	0.36926448	0.36211124	0.35374108
Malta	0.13912201	0.17804667	0.13875731	0.02614379	0	0	0	0	0	0
Netherlands	0.53900738	0.55101482	0.54571753	0.55279216	0.57066603	0.55111617	0.54637251	0.53094914	0.52777638	0.52318543
Poland	0.84869157	0.84723132	0.83617665	0.82429311	0.82145057	0.8051447	0.78627329	0.78581146	0.76913463	0.76325067
Portugal	0.22937174	0.28571057	0.31124992	0.2876463	0.34305795	0.33122749	0.30812742	0.31931706	0.35672782	0.36478572
Rep. of Korea	0.33445865	0.34648567	0.34023159	0.33970499	0.34950893	0.35829948	0.42279633	0.42142932	0.43380564	0.45651853
Romania	0.73944163	0.71659293	0.7456169	0.74131326	0.73257589	0.71410512	0.69450331	0.71410452	0.70164743	0.71891413
Slovakia	0.78589937	0.82597196	0.81596943	0.83030182	0.81735822	0.79998194	0.79946441	0.81580589	0.82284899	0.82241551
Spain	0.44443959	0.45885808	0.44849259	0.42839031	0.43529585	0.44051609	0.42674477	0.43680564	0.45477637	0.45754979
Sweden	0.66244677	0.6671672	0.64605028	0.65494129	0.62379578	0.65037732	0.65672027	0.65837282	0.6724693	0.68809357
United Kingdom	0.60115436	0.61046748	0.61209502	0.61276141	0.62697724	0.62557664	0.62911237	0.62813026	0.63402521	0.64397287
United States	0.60918854	0.61466648	0.61207749	0.62167735	0.62056461	0.61777942	0.61253723	0.60851598	0.61279236	0.60292976

Notes:

Ratios calculated and inversed

Table A13: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.65567691	0.65198498	0.65814026	0.67004442	0.67031147	0.66648795	0.66479433	0.6702437	0.6598782	0.65637875	0.6374334	0.61867898
0.60471921	0.58684248	0.58824313	0.60013334	0.59871096	0.60172233	0.61248569	0.61796751	0.62047226	0.62659238	0.63614945	0.62310959
0.50950344	0.49734599	0.49774529	0.49136845	0.50320619	0.50201801	0.47331884	0.49182308	0.5026214	0.50796505	0.50800628	0.51008423
0.75193231	0.76427177	0.75543491	0.76327372	0.76638301	0.73970288	0.73859895	0.71879923	0.75404916	0.7833561	0.76759959	0.76326658
0.75597933	0.77077164	0.77277875	0.78378227	0.78889004	0.79578167	0.80011903	0.80808424	0.80745238	0.81269461	0.803048	0.81963767
0.01220174	0.01218966	0.01249787	0.01126314	0.01129488	0.0102162	0.00894359	0.00515996	0.01530738	0.01482098	0.09373978	0.02488189
0.74933161	0.74438908	0.71783045	0.71566961	0.72537023	0.7334363	0.72600153	0.7231665	0.74062578	0.74309679	0.74514594	0.7738151
0.52103545	0.56390384	0.55405296	0.54911485	0.55918748	0.54789555	0.55071672	0.56445502	0.57942752	0.56829543	0.56136859	0.5730504
0.63833774	0.64754285	0.65897537	0.64200396	0.65330411	0.65342339	0.65458479	0.64791863	0.6590529	0.65124735	0.664699	0.66170266
0.62735625	0.62801838	0.6316781	0.63806216	0.6389955	0.6356844	0.64406765	0.6411112	0.65622285	0.65765692	0.6564509	0.66197965
0.60894528	0.60946944	0.61741879	0.61537114	0.61926062	0.64021811	0.62773444	0.61962604	0.63676173	0.63375764	0.63264274	0.64003194
0.36856466	0.37288265	0.38034446	0.38060138	0.36925751	0.37173068	0.38606498	0.39807812	0.42201196	0.43877504	0.47753359	0.48746308
0.72931374	0.74601321	0.74382952	0.72780794	0.70944164	0.70458166	0.70586798	0.68828825	0.71179923	0.7155297	0.71568648	0.71126984
0.65652944	0.65986812	0.67811366	0.68415871	0.6875851	0.69129259	0.6937732	0.71111188	0.70685341	0.70178077	0.69360253	0.72160414
0.43207224	0.42940434	0.42535399	0.42207821	0.48389743	0.51799822	0.50814429	0.53657872	0.52081403	0.49820692	0.46805669	0.48209789
0.4031243	0.40888975	0.41336967	0.40040626	0.40025478	0.42089531	0.42841706	0.45981985	0.47699304	0.5009385	0.51521717	0.49435764
0.49143174	0.51014007	0.52990878	0.54634776	0.54347285	0.55008567	0.56187629	0.56647663	0.58472773	0.59073889	0.60669928	0.61395786
0.51696251	0.50532163	0.52818702	0.52424172	0.54329295	0.55351251	0.55633725	0.57368325	0.59071512	0.5714535	0.53118577	0.55103584
0.37219258	0.35784588	0.35038096	0.33923043	0.36493197	0.35812351	0.35303968	0.35851995	0.36728192	0.34174477	0.3492616	0.33378378
0	0	0	0	0	0	0	0.00011386	0.00019095	-0.0133319	-0.1676788	0.00148148
0.52253235	0.51945988	0.51592911	0.49666904	0.48971644	0.47295434	0.48822502	0.49943158	0.51801204	0.49600169	0.49408257	0.50494536
0.76329582	0.7585059	0.75363111	0.74408191	0.73961604	0.7290784	0.72337006	0.71363705	0.71961989	0.72411272	0.7283759	0.76119514
0.34409913	0.39732499	0.38954314	0.3715313	0.42515108	0.42794744	0.43495772	0.46671787	0.49571739	0.50490113	0.51993089	0.53073264
0.47173287	0.48267175	0.49852498	0.50793247	0.51787928	0.52535981	0.55531605	0.5511117	0.57070638	0.59130007	0.58536058	0.5797013
0.71014338	0.71845328	0.72293514	0.72508025	0.73317886	0.72398503	0.70666283	0.7089949	0.72210294	0.74395208	0.73209665	0.68088937
0.80508586	0.812414	0.80955538	0.80345156	0.80075054	0.78047284	0.77763564	0.77027158	0.77473706	0.77053495	0.79126109	0.7962117
0.45946613	0.47341242	0.48002705	0.48333344	0.49317583	0.49841503	0.501565	0.49556345	0.51590296	0.52422245	0.54548697	0.55341756
0.66912304	0.65131241	0.67668959	0.68982548	0.67922598	0.68795411	0.69217958	0.6853482	0.69111327	0.70531457	0.72502553	0.71720699
0.64176262	0.63898224	0.63336148	0.62680056	0.62462513	0.62213505	0.62347756	0.62205776	0.63236873	0.62097514	0.6395187	0.63712017
0.60854021	0.60373591	0.59772905	0.59725253	0.59895771	0.60743209	0.62454283	0.62574321	0.63065479	0.63710842	0.63624824	0.63904773

Table A14: MIT Economic Complexity Indicator

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.346712	0.467949	0.393755	0.107636	0.258258	0.234	0.170094	0.181681	0.134223	-0.276514
Austria	2.13088	2.0899	2.03598	1.98488	1.84836	1.84756	1.81072	1.81224	1.68916	1.72783
Belgium	1.826	1.82785	1.68427	1.61256	1.54476	1.57846	1.61469	1.60032	1.57035	1.23801
Bulgaria	0.679423	0.594231	0.477937	0.490506	0.690222	0.660773	0.647729	0.477192	0.488015	0.468498
China	0.178202	0.162822	0.15557	0.257831	0.316045	0.288427	0.319266	0.293277	0.26445	0.552223
Cyrpus	0.14335167	0.13414567	0.15967467	0.176815	0.24940667	0.26748947	0.21230887	0.3049566	0.30558547	0.15300967
Czech Republic	1.47716789	1.46292526	1.44868263	1.43444	1.40914	1.48535	1.53443	1.53899	1.55234	1.52624
Denmark	1.93529	1.8099	1.75916	1.68299	1.50164	1.4812	1.55042	1.58301	1.56246	1.31634
Finland	2.1258	2.0877	1.99203	1.96899	1.88429	1.89168	1.86294	1.92063	1.88347	1.87205
France	2.02292	1.89944	1.73703	1.76325	1.55599	1.66307	1.68775	1.6577	1.6592	1.48646
Germany	2.22625	2.43743	2.37703	2.27392	2.14742	2.23415	2.20227	2.23537	2.25528	2.09237
Greece	0.151813	0.105755	0.14929	0.183852	0.277305	0.182903	0.249143	0.312809	0.352587	0.154882
Hungary	1.01684	1.01131	0.957779	0.969882	1.04826	1.04198	1.00834	0.985108	1.08822	1.05959
India	-0.114307	0.0273538	-0.003697	0.102434	0.124398	0.19445	0.197834	0.132709	0.152905	0.300856
Indonesia	-0.583769	-0.436026	-0.471696	-0.339011	-0.277266	-0.278167	-0.205093	-0.117758	-0.0465448	0.0445649
Ireland	1.69869	1.58923	1.57004	1.47249	1.41917	1.37383	1.59667	1.63058	1.57258	1.616
Italy	1.77329	1.74401	1.67812	1.6747	1.50114	1.4973	1.5488	1.59941	1.47886	1.48808
Japan	2.3446	2.36409	2.29282	2.40943	2.23526	2.23385	2.23101	2.22444	2.35193	2.69553
Luxembourg	1.826	1.82785	1.68427	1.61256	1.54476	1.57846	1.61469	1.60032	1.57035	1.23801
Malta	0.14335167	0.13414567	0.15967467	0.176815	0.24940667	0.26748947	0.21230887	0.3049566	0.30558547	0.15300967
Netherlands	1.61206	1.53724	1.57352	1.4227	1.35915	1.39245	1.38476	1.37383	1.37108	1.1273
Poland	0.795156	0.767241	0.680541	0.797635	0.96863	1.02184	1.02002	0.943383	1.03185	1.04016
Portugal	0.439095	0.44216	0.382762	0.422194	0.554276	0.522388	0.563539	0.600397	0.609316	0.815259
Rep. of Korea	0.702894	0.758364	0.755974	0.990426	1.00741	0.968257	0.939222	1.03095	1.09177	1.39326
Romania	0.720531	0.719769	0.597547	0.667124	0.675304	0.779787	0.637983	0.60488	0.578479	0.650218
Slovakia	1.34324667	1.34295	1.31309	1.31108	1.2622	1.31402	1.33638	1.31068	1.43909	1.30369
Spain	1.33601	1.25768	1.26515	1.31543	1.21625	1.17507	1.13094	1.24014	1.17698	1.08236
Sweden	2.43091	2.22978	2.26136	2.20024	2.06089	2.06515	2.0448	2.02982	2.038	1.94339
United Kingdom	2.14249	2.09493	1.97789	1.8765	1.77216	1.82104	1.94714	1.94198	1.96008	1.89816
United States	1.92888	1.96117	1.91488	1.8429	1.71194	1.80445	1.8345	1.88075	1.94247	1.6831

Source:

AJG Simoes, CA Hidalgo. The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development. Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence. (2011)

Notes:

Data for Luxembourg is taken from Belgium

Data for both Belgium and Luxembourg interpolated for 2012-2013

Data for the Czech Republic interpolated for 1992-1994

Data for Slovakia interpolated for 1992

Table A14: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
-0.278447	-0.259433	-0.338425	-0.254687	-0.370894	-0.25423	-0.350439	-0.4071	-0.252813	-0.457699	-0.109233	-0.195771
1.78976	1.88805	1.89347	1.91666	1.8761	1.85319	1.8356	1.72874	1.67758	1.79979	1.56851	1.63964
1.18184	1.16731	1.09913	1.17112	1.16198	1.1726	1.0917	1.20746	1.19813	1.15819	1.1247995	1.091409
0.47551	0.452789	0.382056	0.31953	0.426491	0.566168	0.579111	0.353831	0.584884	0.507367	0.586226	0.561561
0.663797	0.578877	0.703504	0.675947	0.815736	0.791568	0.892281	0.762048	0.814251	0.968383	1.00681	0.964874
0.11941633	0.07946867	0.088903	0.099545	0.027035	0.1718583	0.042951	0.03620767	0.04962867	-0.0489227	0.10548033	0.13890533
1.61843	1.63907	1.58204	1.63837	1.65191	1.64929	1.6514	1.55381	1.62205	1.79836	1.62207	1.70505
1.31846	1.33507	1.2425	1.27804	1.20214	1.2141	1.2777	1.29636	1.2793	1.28422	1.18268	1.18973
1.8937	1.88836	1.9782	1.91958	1.87038	1.96379	1.7431	1.72242	1.6622	1.73204	1.59119	1.64344
1.5488	1.5434	1.37623	1.47854	1.41387	1.4051	1.493	1.48649	1.49482	1.46188	1.38358	1.46865
2.15217	2.22438	2.24756	2.13201	2.15098	2.05189	2.0125	1.85774	1.8533	1.95829	1.83957	1.95057
0.245548	0.204318	0.205379	0.157571	0.119851	0.242029	0.194861	0.267714	0.297462	0.172751	0.283137	0.270186
1.19581	1.23719	1.31609	1.31278	1.46558	1.495	1.4502	1.39546	1.37646	1.53932	1.33227	1.33979
0.235124	0.254858	0.106058	0.128285	0.171696	0.173629	0.230391	0.205178	0.178894	0.1021	0.306964	0.261756
0.0184796	0.0062909	-0.0799561	-0.0678491	-0.0387985	-0.0968101	-0.0322018	-0.181814	-0.171946	-0.221288	-0.170807	-0.249507
1.60851	1.49611	1.41759	1.4449	1.43707	1.1793	1.2459	1.39667	1.34714	1.30484	1.23274	1.26556
1.44831	1.50504	1.4467	1.41298	1.37663	1.382	1.3208	1.29447	1.34044	1.36224	1.19693	1.22034
2.63764	2.66402	2.71882	2.58229	2.51793	2.33879	2.3661	2.05808	2.10229	2.31266	2.22882	2.29217
1.18184	1.16731	1.09913	1.17112	1.16198	1.1726	1.0917	1.20746	1.19813	1.15819	1.1247995	1.091409
0.11941633	0.07946867	0.088903	0.099545	0.027035	0.1718583	0.042951	0.03620767	0.04962867	-0.0489227	0.10548033	0.13890533
1.08529	1.11259	0.971682	1.05175	1.04582	1.033	1.0485	1.11008	1.04911	0.976362	1.08893	1.1282
1.03651	0.938386	0.946251	0.966865	1.06149	1.0938	1.0255	1.01729	1.11744	1.13687	0.998564	1.12265
0.734011	0.727634	0.709719	0.592206	0.630455	0.709888	0.688131	0.598529	0.675848	0.560323	0.626132	0.506501
1.45812	1.50253	1.63294	1.66417	1.63866	1.4932	1.4915	1.56496	1.64066	1.80392	1.69997	1.69938
0.640986	0.553908	0.644029	0.658558	0.701114	0.904527	0.934941	0.626236	0.729511	0.717182	0.706564	0.708925
1.32079	1.32694	1.1916	1.30696	1.35213	1.3022	1.3929	1.33733	1.35784	1.50172	1.24316	1.34918
1.04987	0.958014	0.928301	0.929307	0.915851	0.991027	0.93359	0.969969	1.0435	0.96322	0.843965	0.933439
1.98691	2.08744	2.07528	2.02871	1.96475	1.94439	1.8912	1.74779	1.68883	1.86356	1.70885	1.82719
1.79361	1.83193	1.73916	1.70844	1.86746	1.63979	1.584	1.62507	1.56978	1.57063	1.61177	1.71585
1.65071	1.67863	1.61457	1.58606	1.5228	1.4278	1.4671	1.49461	1.5166	1.54044	1.5602	1.58003

Table A15: MIT Economic Complexity Indicator (normalized)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.2817429	0.31845258	0.29598718	0.20935242	0.25495967	0.24761452	0.22826425	0.23177271	0.21740277	0.09303459
Austria	0.82197603	0.80956758	0.793241	0.77776829	0.73643102	0.73618879	0.72503391	0.72549415	0.68822642	0.69993541
Belgium	0.72966058	0.73022074	0.68674576	0.66503249	0.64450315	0.65470726	0.66567744	0.66132631	0.65225161	0.55162147
Bulgaria	0.38248538	0.35668986	0.32147688	0.32528268	0.38575524	0.37683829	0.37288866	0.3212513	0.32452842	0.31861882
China	0.23071929	0.22606234	0.22386649	0.25483038	0.27245715	0.26409462	0.27343245	0.26556317	0.25683456	0.34397014
Cyrpus	0.22016687	0.21737936	0.22510935	0.23029932	0.25227955	0.25775489	0.24104661	0.26909967	0.26929008	0.22309124
Czech Republic	0.62403675	0.61972418	0.61541162	0.61109905	0.60343839	0.62651423	0.6413753	0.64275603	0.64679831	0.63889542
Denmark	0.7627528	0.72478562	0.70942191	0.68635819	0.63144672	0.62525764	0.64621695	0.65608497	0.64986258	0.57533923
Finland	0.82043784	0.80890144	0.77993326	0.77295691	0.74731037	0.74954801	0.74084574	0.75831386	0.74706208	0.74360418
France	0.78928653	0.75189768	0.70272111	0.71066033	0.64790351	0.68032656	0.68779948	0.67870056	0.67915475	0.62685033
Germany	0.85085338	0.91479715	0.89650847	0.86528751	0.82698422	0.85324544	0.84359241	0.85361485	0.85964345	0.81031548
Greece	0.2227289	0.20878287	0.22196495	0.23243007	0.26072696	0.23214272	0.25219971	0.27147732	0.28352181	0.22365817
Hungary	0.4846528	0.48297835	0.46676956	0.47043426	0.49416655	0.49226501	0.48207906	0.47504458	0.50626614	0.49759719
India	0.14214969	0.18504355	0.1756416	0.20777729	0.21442783	0.23563907	0.23666372	0.21694434	0.22305955	0.26785804
Indonesia	0	0.04473551	0.03393489	0.07411095	0.09280689	0.09253407	0.11466035	0.14110475	0.16266759	0.19025495
Ireland	0.69111203	0.65796834	0.65215775	0.62262031	0.6064754	0.59274678	0.66022112	0.67048882	0.65292684	0.6660741
Italy	0.71370037	0.7048346	0.68488359	0.68384804	0.63129533	0.6301326	0.64572643	0.66105077	0.6245491	0.62734085
Japan	0.8866889	0.89259033	0.87101029	0.90631895	0.85358154	0.8531546	0.85229467	0.85030532	0.88890837	0.99294796
Luxembourg	0.72966058	0.73022074	0.68674576	0.66503249	0.64450315	0.65470726	0.66567744	0.66132631	0.65225161	0.55162147
Malta	0.22016687	0.21737936	0.22510935	0.23029932	0.25227955	0.25775489	0.24104661	0.26909967	0.26929008	0.22309124
Netherlands	0.6648811	0.64222614	0.65321147	0.60754426	0.58830178	0.59838478	0.59605631	0.59274678	0.5919141	0.51809929
Poland	0.41752849	0.40907603	0.3828239	0.41827911	0.47005516	0.48616676	0.48561568	0.46241055	0.48919772	0.49171393
Portugal	0.3097158	0.31064386	0.29265858	0.3045983	0.34459177	0.33493632	0.34739654	0.35855688	0.36125749	0.42361553
Rep. of Korea	0.38959223	0.40638814	0.40566447	0.47665483	0.48179746	0.46994222	0.46115063	0.4889252	0.50734106	0.59863004
Romania	0.39493258	0.39470185	0.35769392	0.37876133	0.38123817	0.41287487	0.36993765	0.3599143	0.35192027	0.37364232
Slovakia	0.58348637	0.58339654	0.57435515	0.57374654	0.55894603	0.57463675	0.58140719	0.57362542	0.61250704	0.5715089
Spain	0.58129516	0.5575774	0.55983927	0.57506368	0.5450327	0.53256369	0.51920145	0.55226642	0.53314203	0.50449178
Sweden	0.91282294	0.85192223	0.86148443	0.84297774	0.80078357	0.80207346	0.79591163	0.7913758	0.79385264	0.76520542
United Kingdom	0.82549146	0.81109063	0.77565177	0.74495161	0.71335822	0.72815873	0.76634089	0.76477848	0.77025903	0.7515101
United States	0.7608119	0.77058907	0.7565728	0.73477778	0.69512404	0.72313539	0.73223432	0.74623848	0.76492685	0.68639149

Table A15: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.09244929	0.09820659	0.07428838	0.09964364	0.06445701	0.09978202	0.07065063	0.05349409	0.10021108	0.03817308	0.14368606	0.11748298
0.71868737	0.74844887	0.75009001	0.75711177	0.7448305	0.73789351	0.73256739	0.70021096	0.68472008	0.72172438	0.65169447	0.67323212
0.5346136	0.53021402	0.50956961	0.53136766	0.52860014	0.5318158	0.50731986	0.54237115	0.5395461	0.52745255	0.51734215	0.50723175
0.320742	0.31386225	0.29244481	0.27351239	0.3058994	0.34819258	0.35211163	0.28389848	0.35385965	0.33038807	0.354266	0.34679762
0.37775394	0.35204078	0.38977693	0.38143287	0.42375997	0.41644207	0.44693724	0.40750363	0.42331032	0.46998037	0.48161579	0.46891787
0.21291942	0.20082356	0.2036802	0.20690252	0.18494702	0.22879847	0.18976627	0.18772444	0.19178822	0.16194758	0.2086997	0.21882055
0.66680989	0.67305953	0.65579126	0.67284758	0.67694739	0.67615407	0.67679296	0.64724342	0.667906	0.72129139	0.66791205	0.6930378
0.57598115	0.58101053	0.55298101	0.56374226	0.54076029	0.5443817	0.56363931	0.56928943	0.56412378	0.56561352	0.53486795	0.53700264
0.75015965	0.74854273	0.77574563	0.75799592	0.74309852	0.77138239	0.70455906	0.69829731	0.68006313	0.70121017	0.65856181	0.67438273
0.64572643	0.64409135	0.59347348	0.62445221	0.6048706	0.60221511	0.62883059	0.62685941	0.62938168	0.61940768	0.59569901	0.62145759
0.82842249	0.85028715	0.85730589	0.82231819	0.82806217	0.79805843	0.78613143	0.73927122	0.73792682	0.76971703	0.73376948	0.76737947
0.25111117	0.23862703	0.23894829	0.22447238	0.21305103	0.25004565	0.23576352	0.25782288	0.26683036	0.22906877	0.26249285	0.25857138
0.53884362	0.55137318	0.57526353	0.57426128	0.62052802	0.62943618	0.61587106	0.59929619	0.59354313	0.64285595	0.58016271	0.58243972
0.24795486	0.25393017	0.20887461	0.21560479	0.22874932	0.22933462	0.24652174	0.23888743	0.23092883	0.20767616	0.26970749	0.25601884
0.18235651	0.17866586	0.15255089	0.1562168	0.16501312	0.14744762	0.16701055	0.12170906	0.12469702	0.10975662	0.1250419	0.10121211
0.66380618	0.62977228	0.60599699	0.61426626	0.61189539	0.53384451	0.55401051	0.59966257	0.58466524	0.57185711	0.55002575	0.55996341
0.61529879	0.63247622	0.61481129	0.60460112	0.5935946	0.5952206	0.57668968	0.56871715	0.58263653	0.58923741	0.53918274	0.54627112
0.97541928	0.98340696	1	0.95865971	0.93917196	0.88492967	0.89319894	0.79993272	0.81331919	0.8770177	0.85163155	0.87081347
0.5346136	0.53021402	0.50956961	0.53136766	0.52860014	0.5318158	0.50731986	0.54237115	0.5395461	0.52745255	0.51734215	0.50723175
0.21291942	0.20082356	0.2036802	0.20690252	0.18494702	0.22879847	0.18976627	0.18772444	0.19178822	0.16194758	0.2086997	0.21882055
0.50537896	0.5136452	0.47097928	0.49522329	0.49342773	0.48954593	0.49423922	0.51288519	0.49442392	0.47239635	0.50648113	0.5183718
0.49060873	0.4608975	0.46327896	0.46952073	0.49817249	0.50795573	0.48727498	0.48478905	0.51511375	0.52099701	0.47911896	0.5166913
0.39901423	0.39708332	0.39165879	0.3560767	0.36765822	0.39170996	0.3851221	0.35799126	0.38140289	0.34642276	0.36634925	0.33012585
0.61826918	0.63171621	0.67120341	0.68065963	0.67293538	0.62889115	0.6283764	0.65061956	0.67354097	0.7229749	0.69149961	0.69132096
0.37084693	0.34448035	0.37176833	0.37616761	0.38905325	0.45064524	0.45985437	0.36638074	0.39765166	0.39391853	0.39070348	0.39141837
0.57668665	0.57854883	0.53756886	0.57249903	0.58617618	0.57105774	0.59852104	0.58169485	0.58790513	0.63147095	0.55318085	0.58528294
0.49465404	0.46684071	0.45784383	0.45814844	0.45407406	0.47683681	0.4594453	0.4704606	0.49272525	0.46841705	0.4323075	0.45939958
0.77838296	0.80882271	0.80514075	0.7910397	0.77167307	0.76550821	0.74940267	0.70597916	0.6881265	0.74103347	0.69418841	0.7300209
0.71985312	0.73145614	0.70336606	0.69406426	0.74221437	0.67327754	0.65638473	0.66882043	0.65207902	0.65233639	0.66479329	0.69630796
0.67658404	0.68503801	0.66564111	0.65700849	0.63785382	0.60908851	0.62098826	0.62931809	0.6359765	0.64319508	0.64917827	0.65518265

Table A16: Total Imports of Crude Oil (thousand barrels per day)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	293.9531	353.7087	318.5305	376.4561	405.5776	421.4979	444.5679	485.4475	406.9074	439.8964
Austria	171.162	166.5153	171.7542	167.7978	174.5298	188.7491	186.41	172.3977	158.0335	172.4272
Belgium	662.4071	627.3721	642.9357	587.8944	701.765	727.965	751.0699	715.9401	752.0958	719.7338
Bulgaria	110	117.5862	138.7828	159.3747	136.6836	126.6	110.52	111.66	104.8926	115.8
China	230.0304	312.86	251.9448	349.2681	459.8344	717.8878	579.4103	744.7418	1400.542	1353.277
Cyprus	14.93907	15.65998	18.14	15.94	14.93907	20.78	21.5	23.72	23.03689	23.08
Czech Republic	122.931486	122.5107	138.6433	143.2329	150.9497	141.4568	138.7126	121.4342	114.5701	121.3683
Denmark	114.6796	111.4929	116.3062	137.1506	142.2622	121.9545	121.5827	123.0221	114.3803	89.80964
Finland	177.048	168.0923	202.7803	145.6598	185.4553	184.1037	232.319	228.4598	239.8857	236.9913
France	1540.547	1596.776	1535.35	1595.818	1711.592	1804.071	1844.632	1676.317	1735.719	1740.069
Germany	2011.346	2035.901	2172.649	2064.027	2114.12	2058.253	2238.564	2121.396	2114.478	2147.268
Greece	328.3516	288.7485	299.4504	353.2611	372.9032	373.7305	384.9837	346.8207	407.8902	402.6872
Hungary	113.7284	120.5	110.46	123.4	111.4773	116.9416	123.5688	118.3745	120.5309	114.1462
India	510.7805	606.18	560.6956	546.84	676.2672	672.9841	773.72	873.88	1336.817	1574.12
Indonesia	129.4129	153.92	157.2691	186.4	196.1508	196.6882	181.46	230.14	216.7462	306.74
Ireland	41.8527	39.59856	48.14673	47.05663	45.18665	60.90626	65.67279	59.57835	62.37511	73.67283
Italy	1815.719	1764.996	1761.461	1670.872	1659.881	1783.149	1866.127	1781.772	1836.783	1851.055
Japan	4365.229	4443.791	4715.564	4644.166	4573.432	4729.819	4435.562	4350.213	4350.498	4303.461
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	1159.002	1141.924	1181.758	1256.612	1287.395	1276.533	1299.011	1239.978	1272.331	1285.388
Poland	262.8328	278.9337	268.4296	281.4216	299.123	302.4104	323.3138	329.028	362.3221	355.3483
Portugal	236.3501	236.6905	286.6288	279.3274	248.336	277.4953	285.4973	287.6157	254.8285	266.927
Rep. of Korea	1378.563	1534.698	1604.564	1760.17	2016.64	2442.492	2326.023	2428.839	2474.672	2394.912
Romania	132.0606	151.6	162.3386	168.08	142.7003	123.4088	119.54	85.53008	95.69781	140
Slovakia	91.5619667	90.26	95.2	107.82	106.5281	105.36	108.4	106.92	106.2888	109.7718
Spain	1096.583	1076.726	1098.584	1119.486	1101.97	1141.004	1215.495	1181.739	1169.646	1147.486
Sweden	354.7155	373.6641	371.5439	377.0965	397.9707	417.684	409.8182	403.9602	430.8827	411.8599
United Kingdom	1184.868	1263.756	1095.908	959.7425	1026.423	1006.323	955.1786	823.8275	955.8042	1022.354
United States	6601.393	7358.666	7575.841	7718.564	8137.511	8875.31	9315.803	9381.389	9688.374	10128.8

Source:

Energy Information Administration, International Energy Statistics (2016). Total Imports of Crude Oil including lease condensate (Mbbl/d).

Retrieved from https://www.eia.gov

Notes:

Data for Bulgaria, Romania, China, India, and Indonesia interpolated for 2013

Data for the Czech Republic and Slovakia interpolated for 1992

Data for Cyprus and Malta estimated by author for 2013 based on trend

Table A16: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
441.7029	411.2553	416.0788	399.7105	404.8312	445.6278	398.222	409.925	486.7758	500.9625	511.5351	461.9415
176.1784	164.8467	154.0265	163.7377	167.8848	161.6037	169.2371	162.5053	148.4198	165.7483	154.8412	158.7507
742.312	792.2135	766.6878	714.7819	701.4801	730.2306	735.3741	688.5594	710.8632	645.5417	680.1074	618.4099
124	105.536	117.491	132.58	152.92	142.561	146.837	125.16	120.0334	115.62	128.104	128.966095
1394.782	1805.8	2448.9	2598.9	2904.7	3264	3577.86	4081.893	4753.64	5051.658	5420.54	5667.70712
21.56	19.38	4.86667	0	0	0	0	0	0	0	0	0
124.0105	128.8659	129.7581	156.3864	157.049	145.392	162.507	144.2618	154.6816	138.3016	141.0877	131.3472
80.71976	72.99584	77.34492	57.07263	55.73159	42.10918	50.64481	72.22266	56.0084	61.798	87.22758	99.69288
242.0824	247.6705	250.3742	219.6573	249.9516	250.8569	243.2434	235.9186	227.3414	230.4693	228.0519	235.9958
1636.35	1735.101	1732.579	1714.288	1665.689	1636.854	1692.406	1464.858	1306.568	1308.986	1159.396	1128.688
2140.56	2160.326	2228.536	2279.639	2221.972	2162.669	2129.761	1980.409	1883.266	1827.072	1888.094	1829.656
411.9188	424.0816	433.5929	406.7771	451.3692	458.4651	433.0891	411.7045	429.3298	368.7448	462.1071	468.0175
102.6513	108.5277	112.5197	132.5986	142.0743	143.8229	138.2204	114.2916	121.0036	124.3868	115.8513	115.3215
1609.78	1788.68	1911.982	1938.18	2156	2412.274	2556.691	3185.18	3266.78	3354.54	3695.9	3847.57236
325.1	370.515	405.7101	416.1545	307.8998	298.333	258.033	374	395.2107	384.357	391.7964	404.290852
69.54944	67.11556	59.70798	67.30962	65.65436	69.32014	65.66442	54.85542	62.90819	62.79973	63.16879	66.48746
1815.323	1855.675	1891.905	1942.441	1899.497	1952.495	1812.557	1668.112	1735.95	1585.607	1530.953	1346.338
4110.78	4344.611	4236.415	4303.936	4248.511	4191.87	4224.871	3724.332	3754.633	3643.71	3723.631	3691.767
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
1186.895	1230.366	1283.004	1319.853	1282.684	1330.12	1296.046	1320.45	1346.66	1265.96	1274.44	1204.092
355.0315	346.7933	356.3919	364.3912	412.4007	436.7717	432.582	427.6295	465.3151	487.5088	493.9992	467.4297
257.6924	283.963	280.79	289.6811	297.004	274.7824	257.8666	227.1253	231.7876	217.0987	225.7614	282.3974
2181.827	2211.425	2304.788	2369.181	2438.624	2419.176	2358.526	2348.527	2401.048	2540.234	2573.735	2478.945
127.24	104.34	145.8803	189.58	195	170.68	174	145.88	121.307	112.48	104.9	103.606638
112.2208	112.8533	118.0557	110.3013	114.5333	122.5185	117.414	114.5358	109.2769	120.6307	107.6046	117.6013
1133.848	1161.667	1187.251	1205.179	1209.38	1175.589	1212.856	1112.702	1127.055	1120.534	1233.218	1224.089
372.9428	414.0811	422.1956	412.6254	397.1766	370.0702	432.6793	390.9416	406.7276	388.1883	423.692	352.3245
1136.988	1067.78	1253.856	1165.022	1172.491	1151.44	1198.034	1102.789	1119.792	1179.953	1222.491	1220.767
9939.099	10638.9	11117.96	11311.06	11564.23	11558.67	11392.03	10436.02	10591.72	10406.47	9812.434	9079.948

Table A17: Import Dependence

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.40267548	0.46479461	0.40422652	0.46418755	0.48805969	0.49704941	0.52179331	0.55479714	0.46639768	0.50473635
Austria	0.74743231	0.70857574	0.73714249	0.72016223	0.6871252	0.74310669	0.70078947	0.68141383	0.63101534	0.6463983
Belgium	1.30138919	1.2547442	1.16263237	1.06889891	1.18341484	1.19143208	1.20750788	1.20731889	1.24043351	1.18167678
Bulgaria	0.84798027	1.0008469	1.09933849	1.22061295	1.15274089	1.18570523	1.07261399	1.14810633	1.05014942	1.14306246
China	0.08642558	0.10571412	0.07971411	0.10385132	0.12737495	0.18330907	0.14111875	0.17067138	0.29204029	0.27517476
Cyprus	0.39439018	0.41208565	0.42143658	0.37015965	0.35350512	0.48609688	0.46539869	0.48822507	0.46542312	0.45141552
Czech Republic	0.79007732	0.79552403	0.87197044	0.84753195	0.87254162	0.83702249	0.79264343	0.6978977	0.67465412	0.67825307
Denmark	0.59728958	0.56026583	0.55121422	0.61502511	0.60537106	0.53724449	0.5452139	0.55919136	0.54466446	0.42081173
Finland	0.78688	0.79288821	0.92172864	0.71753596	0.91357291	0.90246912	1.10628095	1.08274787	1.11920083	1.11634851
France	0.79697206	0.84980096	0.82280279	0.83332533	0.8809017	0.91950612	0.90423137	0.82414798	0.86761093	0.84697806
Germany	0.70797114	0.70010351	0.75360701	0.7161787	0.72351814	0.7056061	0.76584468	0.74802398	0.76424393	0.76484612
Greece	1.01656842	0.86711261	0.88073647	0.99510169	1.01332391	0.99927941	0.98210128	0.90553708	1.02173909	0.99250826
Hungary	0.69346585	0.7484472	0.68185185	0.79612903	0.76880897	0.78484295	0.79210769	0.79445973	0.84140714	0.82622795
India	0.40064138	0.44866661	0.39119917	0.33048222	0.38845414	0.36665072	0.40206343	0.43021785	0.62251716	0.69536561
Indonesia	0.18306498	0.20122968	0.20227113	0.2308911	0.22848081	0.20873829	0.20037465	0.23880118	0.20907241	0.28480833
Ireland	0.41438317	0.38075538	0.42233974	0.40219342	0.37038238	0.45452433	0.4378186	0.35463304	0.36697437	0.40382858
Italy	0.95866895	0.93336647	0.94246174	0.86038723	0.86452135	0.92200052	0.96043592	0.94223797	0.99083972	1.00900611
Japan	0.80154774	0.82844724	0.83876983	0.82066902	0.80179383	0.83462485	0.81059247	0.77599233	0.79386622	0.7999529
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	1.50715475	1.49466492	1.54680366	1.63834681	1.69171485	1.60975158	1.61971446	1.49755797	1.48894808	1.43834072
Poland	0.94205305	0.95199215	0.88299211	0.88497358	0.82859557	0.77342813	0.80028168	0.7834	0.88097261	0.8780892
Portugal	0.84713297	0.88981391	1.05767085	0.96319793	0.88375801	0.93119228	0.87575859	0.85345905	0.76591869	0.79946724
Rep. of Korea	0.90279175	0.91134086	0.87204565	0.87657869	0.95984769	1.08314501	1.2133662	1.16546977	1.15892054	1.12329336
Romania	0.52821472	0.61011462	0.73533674	0.68826433	0.55526921	0.45721814	0.47906908	0.39676484	0.42676835	0.61160557
Slovakia	1.42097239	1.4103125	1.46461538	1.65876923	1.56658971	1.42378378	1.46486486	1.57235294	1.59184554	1.53163043
Spain	0.9932817	1.02253181	0.98439427	0.94312216	0.91907423	0.90126698	0.89638274	0.84651791	0.81610232	0.76892603
Sweden	0.95610647	1.02373726	0.95267667	0.9718982	0.96360944	1.06011168	1.02199052	1.03051071	1.19142214	1.11688942
United Kingdom	0.65281983	0.69095462	0.5978767	0.52849257	0.55422408	0.55597956	0.53302377	0.45490199	0.54139808	0.5852132
United States	0.38756809	0.42691775	0.42757493	0.43547208	0.44445633	0.47664699	0.49245277	0.4806202	0.49176867	0.5154944

Notes:

Imports over total consumption (thousand barrels per day)

Table A17: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.49468107	0.44394669	0.44119357	0.41462721	0.41646305	0.45116929	0.40028676	0.41517325	0.4807648	0.47422296	0.47628966	0.42778342
0.64455166	0.57138267	0.52205312	0.54767451	0.56238274	0.55144119	0.59487117	0.60324756	0.53458163	0.6285852	0.59427772	0.60124915
1.20260496	1.21029836	1.16775874	1.07628069	1.09181464	1.12481175	1.04737271	1.07909465	1.06197955	1.02704461	1.12124091	0.98242763
1.17275205	1.0324964	1.18135975	1.27606658	1.45572518	1.35310264	1.40819231	1.27019889	1.32876278	1.38326619	1.4674154	1.44905725
0.27026919	0.32372966	0.3804126	0.38244742	0.3999131	0.43636825	0.46483028	0.505822	0.53182481	0.53152699	0.53272387	0.54081175
0.42371807	0.3756108	0.09442296	0	0	0	0	0	0	0	0	0
0.70462914	0.68667576	0.6301638	0.73439636	0.74255724	0.68834293	0.75578218	0.70217337	0.76783963	0.70233948	0.72762187	0.70059612
0.40942554	0.38769091	0.41732991	0.31110796	0.29264184	0.22087779	0.27967254	0.43369263	0.3344452	0.37684419	0.56098947	0.64402458
1.1053148	1.1096796	1.1341697	1.00089902	1.12497215	1.10650666	1.12088671	1.16427406	1.072357	1.11801288	1.15095475	1.21436183
0.8216675	0.86718628	0.86262765	0.86141663	0.83640214	0.8274173	0.8723387	0.78624765	0.71725489	0.73560649	0.66676443	0.65897591
0.78975593	0.80632286	0.84158229	0.86874334	0.84300231	0.89860759	0.84065741	0.81348638	0.76340565	0.76376159	0.79028417	0.75137285
1.00865533	0.98913144	1.03294742	0.95966695	1.01639471	1.01891685	1.00987186	1.02062093	1.1527065	1.05067712	1.50943176	1.65605838
0.73116013	0.80257958	0.82608306	0.85685299	0.87083131	0.89391402	0.86992675	0.72239253	0.81077481	0.86864596	0.872019	0.89069234
0.68987447	0.73719629	0.74351316	0.75999608	0.79803674	0.83525902	0.86453497	1.03826838	0.98830114	0.96924486	1.02157302	1.05124928
0.28881091	0.32425287	0.32915732	0.32533675	0.24695897	0.23522292	0.19714573	0.27882524	0.26574271	0.24402178	0.23078016	0.23532646
0.38765081	0.38079124	0.32849196	0.34229733	0.32289622	0.35785543	0.34312467	0.33205741	0.38282228	0.43630436	0.46332864	0.47852121
0.97069089	0.99785928	1.03443496	1.09090781	1.06918201	1.12947097	1.08746939	1.08021481	1.12415395	1.06143596	1.11738607	1.06868337
0.77753939	0.80496231	0.80113506	0.81234879	0.8220391	0.83683155	0.8857937	0.85366556	0.84769449	0.8208523	0.79271207	0.81016514
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
1.32123736	1.33932111	1.35355965	1.30767333	1.28335237	1.19697669	1.21270185	1.31361787	1.32052936	1.24209318	1.26018479	1.18719115
0.87353171	0.80524679	0.78476288	0.7740172	0.82106898	0.83400697	0.80224028	0.78636566	0.81981383	0.86998749	0.92446821	0.92136654
0.75095088	0.87110986	0.85616966	0.85978786	0.98115773	0.89210141	0.88132102	0.82263609	0.84689182	0.84673333	0.9805592	1.18820719
1.01520414	1.01656952	1.06944417	1.08115727	1.11867848	1.07975743	1.10092246	1.07312815	1.0584214	1.12430429	1.10859347	1.06470034
0.54777654	0.47512493	0.64810082	0.85440772	0.89603017	0.76181022	0.75341342	0.72452108	0.63065864	0.59687711	0.55178378	0.55109914
1.40141114	1.50587119	1.58302112	1.40531798	1.45701466	1.47105756	1.36621159	1.42003546	1.30562973	1.4680429	1.52398258	1.60747989
0.75362273	0.75317647	0.7555222	0.74983263	0.76149375	0.72963341	0.78401733	0.75822086	0.78213068	0.80886352	0.94795254	1.01321219
0.99938929	1.1183465	1.14607413	1.14758778	1.12048489	1.05620665	1.28477224	1.22836868	1.21113574	1.2333101	1.41124494	1.19097551
0.65395251	0.60691284	0.70077536	0.64031302	0.64925002	0.65772367	0.69222871	0.67468346	0.69227231	0.7484409	0.80038275	0.81251593
0.5029575	0.53105522	0.53629223	0.5437445	0.55899817	0.55891961	0.58426779	0.55595321	0.55222358	0.55112972	0.53068267	0.47887167

Table A18: Import Dependence (modified)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.59732452	0.53520539	0.59577348	0.53581245	0.51194031	0.50295059	0.47820669	0.44520286	0.53360232	0.49526365
Austria	0.25256769	0.29142426	0.26285751	0.27983777	0.3128748	0.25689331	0.29921053	0.31858617	0.36898466	0.3536017
Belgium	0	0	0	0	0	0	0	0	0	0
Bulgaria	0.15201973	0	0	0	0	0	0	0	0	0
China	0.91357442	0.89428588	0.92028589	0.89614868	0.87262505	0.81669093	0.85888125	0.82932862	0.70795971	0.72482524
Cyprus	0.60560982	0.58791435	0.57856342	0.62984035	0.64649488	0.51390312	0.53460131	0.51177493	0.53457688	0.54858448
Czech Republic	0.20992268	0.20447597	0.12802956	0.15246805	0.12745838	0.16297751	0.20735657	0.3021023	0.32534588	0.32174693
Denmark	0.40271042	0.43973417	0.44878578	0.38497489	0.39462894	0.46275551	0.4547861	0.44080864	0.45533554	0.57918827
Finland	0.21312	0.20711179	0.07827136	0.28246404	0.08642709	0.09753088	0	0	0	0
France	0.20302794	0.15019904	0.17719721	0.16667467	0.1190983	0.08049388	0.09576863	0.17585202	0.13238907	0.15302194
Germany	0.29202886	0.29989649	0.24639299	0.2838213	0.27648186	0.2943939	0.23415532	0.25197602	0.23575607	0.23515388
Greece	0	0.13288739	0.11926353	0.00489831	0	0.00072059	0.01789872	0.09446292	0	0.00749174
Hungary	0.30653415	0.2515528	0.31814815	0.20387097	0.23119103	0.21515705	0.20789231	0.20554027	0.15859286	0.17377205
India	0.59935862	0.55133339	0.60880083	0.66951778	0.61154586	0.63334928	0.59793657	0.56978215	0.37748284	0.30463439
Indonesia	0.81693502	0.79877032	0.79772887	0.7691089	0.77151919	0.79126171	0.79962535	0.76119882	0.79092759	0.71519167
Ireland	0.58561683	0.61924462	0.57766026	0.59780658	0.62961762	0.54547567	0.5621814	0.64536696	0.63302563	0.59617142
Italy	0.04133105	0.06663353	0.05753826	0.13961277	0.13547865	0.07799948	0.03956408	0.05776203	0.00916028	-0.0090061
Japan	0.19845226	0.17155276	0.16123017	0.17933098	0.19820617	0.16537515	0.18940753	0.22400767	0.20613378	0.2000471
Luxembourg	1	1	1	1	1	1	1	1	1	1
Malta	1	1	1	1	1	1	1	1	1	1
Netherlands	0	0	0	0	0	0	0	0	0	0
Poland	0.05794695	0.04800785	0.11700789	0.11502642	0.17140443	0.22657187	0.19971832	0.2166	0.11902739	0.1219108
Portugal	0.15286703	0.11018609	0	0.03680207	0.11624199	0.06880772	0.12424141	0.14654095	0.23408131	0.20053276
Rep. of Korea	0.09720825	0.08865914	0.12795435	0.12342131	0.04015231	0	0	0	0	0
Romania	0.47178528	0.38988538	0.26466326	0.31173567	0.44473079	0.54278186	0.52093092	0.60323516	0.57323165	0.38839443
Slovakia	0	0	0	0	0	0	0	0	0	0
Spain	0.0067183	0	0.01560573	0.05687784	0.08092577	0.09873302	0.10361726	0.15348209	0.18389768	0.23107397
Sweden	0.04389353	0	0.04732333	0.0281018	0.03639056	0	0	0	0	0
United Kingdom	0.34718017	0.30904538	0.4021233	0.47150743	0.44577592	0.44402044	0.46697623	0.54509801	0.45860192	0.4147868
United States	0.61243191	0.57308225	0.57242507	0.56452792	0.55554367	0.52335301	0.50754723	0.5193798	0.50823133	0.4845056

Notes:

Normalization off negative scores doesn't make sense since importing more than consumption doesn't decrease dependence conceptually

Values inverted

Negatives values adjusted to 0

Table A18: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.50531893	0.55605331	0.55880643	0.58537279	0.58353695	0.54883071	0.59971324	0.58482675	0.5192352	0.52577704	0.52371034	0.57221658
0.35544834	0.42861733	0.47794688	0.45232549	0.43761726	0.44855881	0.40512883	0.39675244	0.46541837	0.3714148	0.40572228	0.39875085
0	0	0	0	0	0	0	0	0	0	0	0.01757237
0	0	0	0	0	0	0	0	0	0	0	0
0.72973081	0.67627034	0.6195874	0.61755258	0.6000869	0.56363175	0.53516972	0.494178	0.46817519	0.46847301	0.46727613	0.45918825
0.57628193	0.6243892	0.90557704	1	1	1	1	1	1	1	1	1
0.29537086	0.31332424	0.3698362	0.26560364	0.25744276	0.31165707	0.24421782	0.29782663	0.23216037	0.29766052	0.27237813	0.29940388
0.59057446	0.61230909	0.58267009	0.68889204	0.70735816	0.77912221	0.72032746	0.56630737	0.6655548	0.62315581	0.43901053	0.35597542
0	0	0	0	0	0	0	0	0	0	0	0
0.1783325	0.13281372	0.13737235	0.13858337	0.16359786	0.1725827	0.1276613	0.21375235	0.28274511	0.26439351	0.33323557	0.34102409
0.21024407	0.19367714	0.15841771	0.13125666	0.15699769	0.10139241	0.15934259	0.18651362	0.23659435	0.23623841	0.20971583	0.24862715
0	0.01086856	0	0.04033305	0	0	0	0	0	0	0	0
0.26883987	0.19742042	0.17391694	0.14314701	0.12916869	0.10608598	0.13007325	0.27760747	0.18922519	0.13135404	0.127981	0.10930766
0.31012553	0.26280371	0.25648684	0.24000392	0.20196326	0.16474098	0.13546503	0	0.01169886	0.03075514	0	0
0.71118909	0.67574713	0.67084268	0.67466325	0.75304103	0.76477708	0.80285427	0.72117476	0.73425729	0.75597822	0.76921984	0.76467354
0.61234919	0.61920876	0.67150804	0.65770267	0.67710378	0.64214457	0.65687533	0.66794259	0.61717772	0.56369564	0.53667136	0.52147879
0.02930911	0.00214072	0	0	0	0	0	0	0	0	0	0
0.22246061	0.19503769	0.19886494	0.18765121	0.1779609	0.16316845	0.1142063	0.14633444	0.15230551	0.1791477	0.20728793	0.18983486
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0
0.12646829	0.19475321	0.21523712	0.2259828	0.17893102	0.16599303	0.19775972	0.21363434	0.18018617	0.13001251	0.07553179	0.07863346
0.24904912	0.12889014	0.14383034	0.14021214	0.01884227	0.10789859	0.11867898	0.17736391	0.15310818	0.15326667	0.0194408	0
0	0	0	0	0	0	0	0	0	0	0	0
0.45222346	0.52487507	0.35189918	0.14559228	0.10396983	0.23818978	0.24658658	0.27547892	0.36934136	0.40312289	0.44821622	0.44890086
0	0	0	0	0	0	0	0	0	0	0	0
0.24637727	0.24682353	0.2444778	0.25016737	0.23850625	0.27036659	0.21598267	0.24177914	0.21786932	0.19113648	0.05204746	0
0.00061071	0	0	0	0	0	0	0	0	0	0	0
0.34604749	0.39308716	0.29922464	0.35968698	0.35074998	0.34227633	0.30777129	0.32531654	0.30772769	0.2515591	0.19961725	0.18748407
0.4970425	0.46894478	0.46370777	0.4562555	0.44100183	0.44108039	0.41573221	0.44404679	0.44777642	0.44887028	0.4693173	0.52112833

Tabl A19: Individual Herfindahl-Hirschman Index Scores

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.1587425	0.17034955	0.1619673	0.1607507	0.15396576	0.15267187	0.18141943	0.15244456	0.13420964	0.14419335
Austria	0.16335924	0.16405687	0.1647545	0.17883525	0.14742346	0.1325841	0.13708802	0.13704596	0.13956156	0.12442483
Belgium	0.68892344	0.68779946	0.68667548	0.6855515	0.7610432	0.72062377	0.7915943	0.78049118	0.66921272	0.71261416
Bulgaria	0.257309	1	1	1	0.89188887	0.74505277	1	1	1	1
China	0.25881208	0.16014137	0.24013946	0.17392097	0.18656091	0.1358052	0.11168331	0.07849179	0.09791509	0.09395009
Cyprus	0.69087716	0.70557792	0.52274666	0.96069434	0.45156909	0.81331028	0.46645032	0.42068847	0.42683354	0.49961495
Czech Republic	0.97546394	0.99964265	0.81889568	0.99294985	0.86435299	0.80618471	0.77376957	0.68572191	0.68540991	0.52757795
Denmark	0.43960431	0.41959632	0.67053818	0.56145134	0.77631571	0.94227545	0.98479089	0.70427249	0.47507517	0.92733571
Finland	0.22047066	0.30646033	0.31595497	0.29060166	0.24135764	0.23298438	0.27752353	0.3089069	0.29258418	0.29905342
France	0.14477314	0.14738252	0.1499919	0.14781683	0.13939725	0.13184236	0.12318807	0.12047121	0.12579218	0.10802076
Germany	0.11073974	0.10706412	0.13297765	0.14108579	0.15945342	0.15792208	0.15608543	0.15682745	0.15472202	0.16116579
Greece	0.24906306	0.33250045	0.25268938	0.20631843	0.23491599	0.23804071	0.24940435	0.2749295	0.25038183	0.25143639
Hungary	0.85111743	0.96061277	0.93110525	0.89820978	0.93141475	0.99655507	0.98258081	0.99752655	1	1
India	0.17810356	0.19809882	0.19484841	0.1948753	0.19288061	0.16242054	0.17666747	0.1752864	0.51559874	0.32711
Indonesia	0.41733837	0.33670764	0.22490977	0.2197979	0.18312719	0.15741079	0.18439387	0.23490977	0.24112269	0.1958541
Ireland	0.99992095	0.99999739	0.99981456	0.91549379	0.74393302	0.99971953	0.99986077	0.99971304	0.93654998	0.93493087
Italy	0.17376584	0.1764769	0.17918796	0.18435734	0.17221392	0.17280328	0.15917177	0.13609206	0.13106261	0.13116532
Japan	0.15535104	0.15721398	0.15450153	0.15895115	0.15856839	0.16684254	0.16800934	0.15071066	0.16143571	0.1667823
Luxembourg	0.67096553	0.67582752	0.68068951	0.6855515	0.7610432	0.72062377	0.7915943	0.96917937	0.89452365	0.70287342
Malta	1	1	0.78056108	1	0.98515853	1	1	1	1	1
Netherlands	0.1637913	0.16629529	0.15860233	0.15694519	0.15647937	0.16261359	0.14409425	0.13407694	0.14100484	0.13172096
Poland	0.37981699	0.35071618	0.32161536	0.40541765	0.5692431	0.63791535	0.66686575	0.79839255	0.87107732	0.8971184
Portugal	0.12410463	0.12724247	0.1596123	0.16323593	0.17513677	0.14532584	0.12743795	0.1195378	0.1682667	0.15484128
Rep. of Korea	0.1555219	0.15782069	0.1505243	0.1747566	0.16695947	0.14095582	0.14001661	0.12801197	0.14603112	0.15276821
Romania	0.3582156	0.53382894	0.40803152	0.32978227	0.36692604	0.53295752	0.65220411	0.61335519	0.55513265	0.37446309
Slovakia	0.99433564	0.99432733	0.99431903	0.99008307	0.98824245	0.98387665	0.97636776	0.97410676	0.97199778	0.97028087
Spain	0.12435503	0.11994878	0.10949194	0.11149711	0.11283462	0.1063516	0.1026241	0.0953146	0.10037911	0.09324831
Sweden	0.19466239	0.20314807	0.20613206	0.28272515	0.23567928	0.19593311	0.25489925	0.25771419	0.21511247	0.25574885
United Kingdom	0.31084911	0.31557027	0.36001641	0.44635954	0.43417838	0.56257441	0.463498	0.57638404	0.57123294	0.56185847
United States	0.13359813	0.10821539	0.1069066	0.11043424	0.10944799	0.11351245	0.10767211	0.10049176	0.10614382	0.10882183

Source:

All data for HHI indicator originates from the UN Comtrade database:

United Nations. 2016. *UN comtrade database*. http://comtrade.un.org/.

Notes:

Lower value indicates greater diversity

Data for Belgium and Luxembourg interpolated for 1992-1994 and Belgium-Luxembourg data used for both Belgium and Luxembourg 1995-1998

Data for Austria, France, Italy, Poland, and Slovakia interpolated for 1992-1993

Data for Czech Republic and United Kingdom interpolated for 1992

Data gaps for Bulgaria, Cyprus, and Malta filled by MIT's Observatory for Economic Complexity

Re-scaled

Table A19: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.16259229	0.15090585	0.14495257	0.147514	0.14484153	0.14144902	0.13618293	0.13035294	0.12809921	0.10650749	0.10083297	0.1065238
0.13375353	0.13933644	0.14466423	0.17260473	0.13414684	0.14769393	0.14371538	0.20047665	0.16966836	0.16916219	0.15995929	0.15080187
0.66921059	0.64275037	0.65061498	0.63925019	0.6689547	0.7035779	0.68523643	0.70068791	0.67023353	0.67923029	0.79691102	0.70690708
1	1	1	1	1	0.99851968	0.81075932	0.75044423	0.82526498	0.908567	0.97319497	0.89910501
0.09099197	0.08911377	0.08470769	0.09151426	0.09507447	0.09038942	0.10425566	0.09957687	0.09153821	0.09121489	0.09443908	0.09432978
0.53540171	0.51835127	0.44731666	1	0.904616	0.7592	1	1	1	0.80867347	1	1
0.49767952	0.49940598	0.51695965	0.5369426	0.51435666	0.494265	0.49960793	0.57134052	0.47389578	0.44186521	0.49250878	0.49188958
0.95536655	0.78306128	0.99999888	0.96186322	0.99996171	0.92528549	0.86704172	0.71142605	0.45017379	0.43179392	0.49145137	0.44884439
0.36930007	0.46850869	0.62334943	0.66301064	0.44146699	0.57877976	0.69758175	0.76815794	0.88975522	0.77355626	0.73863918	0.74290847
0.10420366	0.11093287	0.11022903	0.09920198	0.09434581	0.09324186	0.09831666	0.10056997	0.10733732	0.09061415	0.09299651	0.09780431
0.16407199	0.15803284	0.18074949	0.17850106	0.18101883	0.16644129	0.16061954	0.17685504	0.19525698	0.20293384	0.17874972	0.15825886
0.26188349	0.29392144	0.28243289	0.2543786	0.22088812	0.22079114	0.20858262	0.18261599	0.19716588	0.19714173	0.16910954	0.21621913
0.99859987	1	0.99978704	0.99984304	1	0.88933926	1	1	0.99983477	0.99431901	0.99987825	0.89477222
0.24074645	0.3794	0.555125	0.539253	0.13676834	0.12840496	0.11932028	0.09505944	0.08706465	0.09912445	0.0954928	0.10514812
0.21135355	0.16415862	0.132089	0.18840111	0.20626067	0.17761577	0.2373456	0.16270227	0.24783503	0.20128305	0.18283886	0.18303137
0.98676361	0.98991025	0.92459366	0.61485556	0.66608325	0.37834056	0.29767918	0.24445815	0.29022296	0.39469669	0.22660385	0.22660385
0.12805864	0.13870129	0.14747093	0.14383555	0.13581243	0.15093993	0.14601243	0.14169488	0.12636323	0.10472309	0.12486179	0.12496675
0.16400686	0.16701763	0.17474216	0.18991795	0.19770039	0.18038199	0.18031379	0.18807802	0.17369635	0.1899803	0.18200792	0.18284841
0.52571346	0.50571949	0.99400555	0.97515294	0.47167078	0.9357141	0.98199993	0.9538647	0.92398799	0.55805728	0.57810844	0.59317366
1	0.73884332	1	1	1	1	1	1	0.44186414	0.99517721	0.52	0.99775533
0.11911375	0.14004041	0.15944311	0.14385679	0.14903375	0.14193023	0.12444623	0.13026968	0.13359605	0.12668449	0.12920959	0.13205187
0.93101668	0.91026357	0.92727198	0.95068624	0.92405983	0.91230868	0.85356508	0.86754813	0.88615147	0.85348672	0.92045196	0.90363162
0.11949086	0.13715409	0.09679167	0.11930482	0.08447391	0.09020831	0.10718388	0.10144339	0.09737284	0.12745665	0.11470007	0.18081442
0.15233213	0.16258643	0.15779708	0.15851421	0.16311092	0.15397624	0.17927334	0.16564462	0.16715818	0.16707662	0.16812195	0.17711383
0.43161678	0.71167133	0.4741245	0.44230805	0.38373625	0.39417583	0.5091873	0.49739927	0.47448428	0.5748046	0.53549859	0.48654673
0.97164593	0.97365417	0.98882307	0.99998592	0.9999599	0.99998869	0.99725629	0.99999323	0.99999885	0.99966782	0.9999995	0.99448516
0.08711658	0.09704045	0.09029575	0.09027652	0.08799808	0.09654867	0.08184923	0.08333241	0.09607873	0.10245271	0.09852552	0.09334702
0.17547951	0.18466793	0.21352724	0.22103145	0.25013451	0.23993561	0.25961364	0.27110852	0.34223231	0.35810705	0.26692548	0.25788042
0.50784209	0.57908816	0.53151442	0.53511325	0.49257336	0.61576943	0.46809934	0.47513944	0.53981252	0.44982172	0.29119136	0.21642585
0.10441438	0.10571619	0.1029811	0.10045464	0.10268519	0.10547383	0.10368804	0.09740752	0.10069483	0.11438545	0.13728575	0.16741501

Table A20: Individual Herfindahl-Hirschman Index Scores (modified)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.8412575	0.82965045	0.8380327	0.8392493	0.84603424	0.84732813	0.81858057	0.84755544	0.86579036	0.85580665
Austria	0.83664076	0.83594313	0.8352455	0.82116475	0.85257654	0.8674159	0.86291198	0.86295404	0.86043844	0.87557517
Belgium	0.31107656	0.31220054	0.31332452	0.3144485	0.2389568	0.27937623	0.2084057	0.21950882	0.33078728	0.28738584
Bulgaria	0.742691	0	0	0	0.10811113	0.25494723	0	0	0	0
China	0.74118792	0.83985863	0.75986054	0.82607903	0.81343909	0.8641948	0.88831669	0.92150821	0.90208491	0.90604991
Cyprus	0.30912284	0.29442208	0.47725334	0.03930566	0.54843091	0.18668972	0.53354968	0.57931153	0.57316646	0.50038505
Czech Republic	0.02453606	0.00035735	0.18110432	0.00705015	0.13564701	0.19381529	0.22623043	0.31427809	0.31459009	0.47242205
Denmark	0.56039569	0.58040368	0.32946182	0.43854866	0.22368429	0.05772455	0.01520911	0.29572751	0.52492483	0.07266429
Finland	0.77952934	0.69353967	0.68404503	0.70939834	0.75864236	0.76701562	0.72247647	0.6910931	0.70741582	0.70094658
France	0.85522686	0.85261748	0.8500081	0.85218317	0.86060275	0.86815764	0.87681193	0.87952879	0.87420782	0.89197924
Germany	0.88926026	0.89293588	0.86702235	0.85891421	0.84054658	0.84207792	0.84391457	0.84317255	0.84527798	0.83883421
Greece	0.75093694	0.66749955	0.74731062	0.79368157	0.76508401	0.76195929	0.75059565	0.7250705	0.74961817	0.74856361
Hungary	0.14888257	0.03938723	0.06889475	0.10179022	0.06858525	0.00344493	0.01741919	0.00247345	0	0
India	0.82189644	0.80190118	0.80515159	0.8051247	0.80711939	0.83757946	0.82333253	0.8247136	0.48440126	0.67289
Indonesia	0.58266163	0.66329236	0.77509023	0.7802021	0.81687281	0.84258921	0.81560613	0.76509023	0.75887731	0.8041459
Ireland	7.9053E-05	2.6134E-06	0.00018544	0.08450621	0.25606698	0.00028047	0.00013923	0.00028696	0.06345002	0.06506913
Italy	0.82623416	0.8235231	0.82081204	0.81564266	0.82778608	0.82719672	0.84082823	0.86390794	0.86893739	0.86883468
Japan	0.84464896	0.84278602	0.84549847	0.84104885	0.84143161	0.83315746	0.83199066	0.84928934	0.83856429	0.8332177
Luxembourg	0.32903447	0.32417248	0.31931049	0.3144485	0.2389568	0.27937623	0.2084057	0.03082063	0.10547635	0.29712658
Malta	0	0	0.21943892	0	0.01484147	0	0	0	0	0
Netherlands	0.8362087	0.83370471	0.84139767	0.84305481	0.84352063	0.83738641	0.85590575	0.86592306	0.85899516	0.86827904
Poland	0.62018301	0.64928382	0.67838464	0.59458235	0.4307569	0.36208465	0.33313425	0.20160745	0.12892268	0.1028816
Portugal	0.87589537	0.87275753	0.8403877	0.83676407	0.82486323	0.85467416	0.87256205	0.8804622	0.8317333	0.84515872
Rep. of Korea	0.8444781	0.84217931	0.8494757	0.8252434	0.83304053	0.85904418	0.85998339	0.87198803	0.85396888	0.84723179
Romania	0.6417844	0.46617106	0.59196848	0.67021773	0.63307396	0.46704248	0.34779589	0.38664481	0.44486735	0.62553691
Slovakia	0.00566436	0.00567267	0.00568097	0.00991693	0.01175755	0.01612335	0.02363224	0.02589324	0.02800222	0.02971913
Spain	0.87564497	0.88005122	0.89050806	0.88850289	0.88716538	0.8936484	0.8973759	0.9046854	0.89962089	0.90675169
Sweden	0.80533761	0.79685193	0.79386794	0.71727485	0.76432072	0.80406689	0.74510075	0.74228581	0.78488753	0.74425115
United Kingdom	0.68915089	0.68442973	0.63998359	0.55364046	0.56582162	0.43742559	0.536502	0.42361596	0.42876706	0.43814153
United States	0.86640187	0.89178461	0.8930934	0.88956576	0.89055201	0.88648755	0.89232789	0.89950824	0.89385618	0.89117817

Notes:

Inverted for model

Table A20: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.83740771	0.84909415	0.85504743	0.852486	0.85515847	0.85855098	0.86381707	0.86964706	0.87190079	0.89349251	0.89916703	0.8934762
0.86624647	0.86066356	0.85533577	0.82739527	0.86585316	0.85230607	0.85628462	0.79952335	0.83033164	0.83083781	0.84004071	0.84919813
0.33078941	0.35724963	0.34938502	0.36074981	0.3310453	0.2964221	0.31476357	0.29931209	0.32976647	0.32076971	0.20308898	0.29309292
0	0	0	0	0	0.00148032	0.18924068	0.24955577	0.17473502	0.091433	0.02680503	0.10089499
0.90900803	0.91088623	0.91529231	0.90848574	0.90492553	0.90961058	0.89574434	0.90042313	0.90846179	0.90878511	0.90556092	0.90567022
0.46459829	0.48164873	0.55268334	0	0.095384	0.2408	0	0		0.19132653	0	0
0.50232048	0.50059402	0.48304035	0.4630574	0.48564334	0.505735	0.50039207	0.42865948	0.52610422	0.55813479	0.50749122	0.50811042
0.04463345	0.21693872	1.1176E-06	0.03813678	3.8291E-05	0.07471451	0.13295828	0.28857395	0.54982621	0.56820608	0.50854863	0.55115561
0.63069993	0.53149131	0.37665057	0.33698936	0.55853301	0.42122024	0.30241825	0.23184206	0.11024478	0.22644374	0.26136082	0.25709153
0.89579634	0.88906713	0.88977097	0.90079802	0.90565419	0.90675814	0.90168334	0.89943003	0.89266268	0.90938585	0.90700349	0.90219569
0.83592801	0.84196716	0.81925051	0.82149894	0.81898117	0.83355871	0.83938046	0.82314496	0.80474302	0.79706616	0.82125028	0.84174114
0.73811651	0.70607856	0.71756711	0.7456214	0.77911188	0.77920886	0.79141738	0.81738401	0.80283412	0.80285827	0.83089046	0.78378087
0.00140013	0	0.00021296	0.00015696	0	0.11066074	0	0	0.00016523	0.00568099	0.00012175	0.10522778
0.75925355	0.6206	0.444875	0.460747	0.86323166	0.87159504	0.88067972	0.90494056	0.91293535	0.90087555	0.9045072	0.89485188
0.78864645	0.83584138	0.867911	0.81159889	0.79373933	0.82238423	0.7626544	0.83729773	0.75216497	0.79871695	0.81716114	0.81696863
0.01323639	0.01008975	0.07540634	0.38514444	0.33391675	0.62165944	0.70232082	0.75554185	0.70977704	0.60530331	0.77339615	0.77339615
0.87194136	0.86129871	0.85252907	0.85616445	0.86418757	0.84906007	0.85398757	0.85830512	0.87363677	0.89527691	0.87513821	0.87503325
0.83599314	0.83298237	0.82525784	0.81008205	0.80229961	0.81961801	0.81968621	0.81192198	0.82630365	0.8100197	0.81799208	0.81715159
0.47428654	0.49428051	0.00599445	0.02484706	0.52832922	0.0642859	0.01800007	0.0461353	0.07601201	0.44194272	0.42189156	0.40682634
0	0.26115668	0	0	0	0	0	0	0.55813586	0.00482279	0.48	0.00224467
0.88088625	0.85995959	0.84055689	0.85614321	0.85096625	0.85806977	0.87555377	0.86973032	0.86640395	0.87331551	0.87079041	0.86794813
0.06898332	0.08973643	0.07272802	0.04931376	0.07594017	0.08769132	0.14643492	0.13245187	0.11384853	0.14651328	0.07954804	0.09636838
0.88050914	0.86284591	0.90320833	0.88069518	0.91552609	0.90979169	0.89281612	0.89855661	0.90262716	0.87254335	0.88529993	0.81918558
0.84766787	0.83741357	0.84220292	0.84148579	0.83688908	0.84602376	0.82072666	0.83435538	0.83284182	0.83292338	0.83187805	0.82288617
0.56838322	0.28832867	0.5258755	0.55769195	0.61626375	0.60582417	0.4908127	0.50260073	0.52551572	0.4251954	0.46450141	0.51345327
0.02835407	0.02634583	0.01117693	0.00001408	4.0099E-05	1.1309E-05	0.00274371	6.7712E-06	1.1498E-06	0.00033218	4.9615E-07	0.00551484
0.91288342	0.90295955	0.90970425	0.90972348	0.91200192	0.90345133	0.91815077	0.91666759	0.90392127	0.89754729	0.90147448	0.90665298
0.82452049	0.81533207	0.78647276	0.77896855	0.74986549	0.76006439	0.74038636	0.72889148	0.65776769	0.64189295	0.73307452	0.74211958
0.49215791	0.42091184	0.46848558	0.46488675	0.50742664	0.38423057	0.53190066	0.52486056	0.46018748	0.55017828	0.70880864	0.78357415
0.89558562	0.89428381	0.8970189	0.89954536	0.89731481	0.89452617	0.89631196	0.90259248	0.89930517	0.88561455	0.86271425	0.83258499

Table A21: Annual Values of Crude Oil Imports

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	1380000000	1630000000	1570000000	1880000000	2750000000	2790000000	2080000000	3020000000	4490000000	4270000000
Austria	1030000000	902000000	970000000	1030000000	1250000000	1290000000	858000000	996000000	1610000000	1500000000
Belgium	7270000000	5940000000	4610000000	3290000000	4390000000	4360000000	2970000000	3980000000	6680000000	6480000000
Bulgaria	97109858	29594582	239000000	2929626	918000000	771000000	438000000	580000000	792000000	11570732
China	1720000000	2320000000	1570000000	2360000000	3410000000	5460000000	3270000000	4640000000	1.49E+10	1.17E+10
Cyprus	106000000	85394424	103000000	100000000	113000000	146000000	109000000	151000000	236000000	192000000
Czech Republic	835000000	606000000	673000000	805000000	1050000000	893000000	620000000	638000000	1130000000	1070000000
Denmark	710000000	635000000	602000000	689000000	803000000	740000000	498000000	602000000	1160000000	567000000
Finland	1330000000	1080000000	1270000000	1210000000	1570000000	1410000000	1090000000	1460000000	2420000000	2010000000
France	8920000000	8290000000	8780000000	9610000000	1.27E+10	1.24E+10	8690000000	1.04E+10	1.76E+10	1.54E+10
Germany	1.42E+10	1.27E+10	1.29E+10	1.31E+10	1.61E+10	1.45E+10	1.05E+10	1.34E+10	2.19E+10	1.92E+10
Greece	1720000000	1670000000	1470000000	1330000000	2010000000	1580000000	1710000000	1010000000	2980000000	3350000000
Hungary	778000000	676000000	591000000	679000000	767000000	688000000	543000000	672000000	1070000000	953000000
India	4080000000	3410000000	3290000000	3440000000	5220000000	4250000000	3690000000	9470000000	1.57E+10	1.29E+10
Indonesia	1040000000	917000000	1070000000	1320000000	1520000000	1470000000	1060000000	1590000000	2520000000	2890000000
Ireland	289000000	242000000	271000000	278000000	326000000	425000000	329000000	305000000	546000000	550000000
Italy	9440000000	8260000000	8580000000	9020000000	1.13E+10	1.1E+10	7910000000	9720000000	1.71E+10	1.48E+10
Japan	2.96E+10	2.78E+10	2.72E+10	2.96E+10	3.31E+10	3.46E+10	2.21E+10	2.65E+10	4.46E+10	3.88E+10
Luxembourg	29476.96	28816.2	28155.45	27494.7	36708.95	36501.24	24862.48	33297	97488	25610
Malta	4422.2	4387.1	4352	379	8246	1822	2017	7907	986	766.75
Netherlands	7690000000	6500000000	6400000000	7640000000	9370000000	8490000000	5720000000	7600000000	1.22E+10	1.08E+10
Poland	1510000000	1500000000	1440000000	1580000000	1980000000	2030000000	1380000000	1820000000	3460000000	2900000000
Portugal	1540000000	1330000000	1580000000	1700000000	1650000000	1710000000	1220000000	1640000000	2430000000	2220000000
Rep. of Korea	9550000000	9150000000	8880000000	1.08E+10	1.44E+10	1.78E+10	1.12E+10	1.48E+10	2.52E+10	2.14E+10
Romania	810000000	833000000	896000000	1050000000	1040000000	838000000	551000000	478000000	823000000	954000000
Slovakia	216000000	697288	499000000	623000000	762000000	682000000	490000000	643000000	1010000000	876000000
Spain	7140000000	5560000000	5900000000	6210000000	7870000000	7280000000	5250000000	6510000000	1.16E+10	9940000000
Sweden	2340000000	2190000000	2110000000	2110000000	3030000000	3040000000	1890000000	2470000000	4300000000	3530000000
United Kingdom	6100000000	6120000000	4970000000	5110000000	6300000000	5970000000	3600000000	3680000000	7800000000	7060000000
United States	4.12E+10	4.1E+10	4.09E+10	4.55E+10	5.33E+10	5.74E+10	4.07E+10	5.34E+10	9.39E+10	7.93E+10

Notes:

Values in US dollars

Luxembourg calculated as fraction of Belgium for 1995-1998

Various gaps in data filled by MIT's Observatory for Economic Complexity

Data for Belgium and Luxembourg interpolated for 1992-1994

Data for Czech Republic and Slovakia interpolated for 1992

Data for Bulgaria interpolated for 1994

Data for Malta interpolated for 1992, 1993, and 2001

Data for Cyprus derived from EIA international statistics

Table A21: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
3930000000	4770000000	6510000000	8410000000	1.05E+10	1.28E+10	1.57E+10	1.01E+10	1.53E+10	2.15E+10	2.23E+10	1.95E+10
1540000000	1730000000	2150000000	3080000000	3750000000	4190000000	6040000000	3410000000	4040000000	6180000000	6360000000	6530000000
6670000000	8370000000	9580000000	1.25E+10	1.54E+10	1.77E+10	2.44E+10	1.43E+10	2.01E+10	2.72E+10	2.9E+10	2.85E+10
84104586	87917999	575000000	1240000000	2100000000	3680000000	4900000000	2720000000	3080000000	4020000000	4750000000	4490000000
1.28E+10	1.98E+10	3.39E+10	4.77E+10	6.64E+10	7.99E+10	1.29E+11	8.93E+10	1.35E+11	1.97E+11	2.21E+11	2.2E+11
201000000	176000000	94115791	2180000000	1420000000	1450000000	333000000	67327930	65181650	1939	191	0
2040000000	1290000000	1670000000	2840000000	3660000000	3540000000	6060000000	3220000000	4430000000	5580000000	5880000000	5410000000
658000000	805000000	1110000000	1110000000	1340000000	1290000000	1650000000	1620000000	1600000000	2310000000	2870000000	3680000000
2170000000	2540000000	3300000000	4050000000	5880000000	6390000000	8240000000	5230000000	6560000000	9460000000	9210000000	9340000000
1.47E+10	1.84E+10	2.46E+10	3.34E+10	3.99E+10	4.28E+10	5.98E+10	3.18E+10	3.53E+10	5.25E+10	4.76E+10	4.56E+10
1.89E+10	2.33E+10	3.1E+10	4.36E+10	5.22E+10	5.49E+10	7.91E+10	4.34E+10	5.26E+10	7.09E+10	7.68E+10	7.57E+10
3250000000	4140000000	4650000000	6890000000	8350000000	8330000000	1.3E+10	7390000000	1.11E+10	1.24E+10	1.65E+10	1.61E+10
835000000	995000000	1200000000	2190000000	2890000000	2980000000	4440000000	2620000000	2950000000	4650000000	4400000000	4490000000
1.46E+10	1.81E+10	2.46E+10	3.48E+10	4.76E+10	5.41E+10	8.66E+10	6.49E+10	8.86E+10	1.22E+11	1.49E+11	1.48E+11
3220000000	4030000000	5830000000	6800000000	7850000000	9060000000	1.01E+10	7360000000	8530000000	1.12E+10	1.08E+10	1.36E+10
270000000	282000000	628000000	1260000000	1530000000	1960000000	2110000000	1320000000	1810000000	2400000000	2410000000	2490000000
1.43E+10	1.81E+10	2.36E+10	3.36E+10	3.99E+10	4.53E+10	5.88E+10	3.35E+10	4.61E+10	5.79E+10	5.69E+10	4.65E+10
3.65E+10	4.59E+10	5.6E+10	7.98E+10	9.9E+10	1.04E+11	1.55E+11	8E+10	1.06E+11	1.42E+11	1.53E+11	1.46E+11
69018	17797	86983	164648	45632	25731	58111	115625	100809	61725	65435	40049
377	3130	8639	29183	68000	49000	1145	524	49000	36090	565	5054
1.01E+10	1.22E+10	1.66E+10	2.36E+10	2.87E+10	2.95E+10	4.2E+10	2.59E+10	3.59E+10	4.54E+10	5.32E+10	5.22E+10
2920000000	3430000000	4220000000	6150000000	8490000000	1E+10	1.49E+10	8430000000	1.23E+10	1.8E+10	1.96E+10	1.8E+10
2080000000	2720000000	3710000000	4930000000	6330000000	6460000000	8880000000	4730000000	6650000000	8450000000	9560000000	9360000000
1.92E+10	2.31E+10	2.99E+10	4.26E+10	5.59E+10	6.03E+10	8.59E+10	5.08E+10	6.87E+10	1.01E+11	1.08E+11	9.93E+10
1070000000	1090000000	1920000000	3290000000	3950000000	4440000000	5950000000	3110000000	3360000000	4420000000	4170000000	4190000000
926000000	1080000000	1410000000	1860000000	2610000000	3010000000	4020000000	2400000000	3040000000	4650000000	4230000000	4530000000
1.02E+10	1.2E+10	1.59E+10	2.22E+10	2.73E+10	2.95E+10	4.11E+10	2.28E+10	3.01E+10	4.08E+10	4.62E+10	4.53E+10
3410000000	4420000000	5630000000	7550000000	8860000000	9110000000	1.33E+10	7320000000	1.05E+10	1.45E+10	1.7E+10	1.28E+10
7600000000	9750000000	1.56E+10	2.16E+10	2.88E+10	2.35E+10	3.82E+10	2.32E+10	3.01E+10	4.54E+10	4.79E+10	4.01E+10
8.26E+10	1.07E+11	1.43E+11	1.9E+11	2.33E+11	2.53E+11	3.63E+11	2.01E+11	2.67E+11	3.43E+11	3.22E+11	2.79E+11

Table A22: Gross Domestic Product (USD, nominal)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	3.25E+11	3.12E+11	3.23E+11	3.68E+11	4.01E+11	4.36E+11	3.99E+11	3.89E+11	4.15E+11	3.78E+11
Austria	1.95E+11	1.9E+11	2.03E+11	2.4E+11	2.37E+11	2.12E+11	2.18E+11	2.17E+11	1.96E+11	1.97E+11
Belgium	2.36E+11	2.26E+11	2.46E+11	2.9E+11	2.81E+11	2.55E+11	2.61E+11	2.6E+11	2.38E+11	2.38E+11
Bulgaria	1.04E+10	1.08E+10	9700000000	1.31E+10	1.01E+10	1.12E+10	1.46E+10	1.35E+10	1.31E+10	1.41E+10
China	4.25E+11	4.43E+11	5.62E+11	7.32E+11	8.61E+11	9.58E+11	1.03E+12	1.09E+12	1.21E+12	1.33E+12
Cyprus	6910000000	6590000000	7430000000	9910000000	9990000000	9500000000	1.02E+10	1.04E+10	9930000000	1.03E+10
Czech Republic	3.45E+10	4.05E+10	4.74E+10	5.95E+10	6.68E+10	6.16E+10	6.64E+10	6.47E+10	6.15E+10	6.74E+10
Denmark	1.53E+11	1.43E+11	1.56E+11	1.85E+11	1.88E+11	1.74E+11	1.77E+11	1.78E+11	1.64E+11	1.65E+11
Finland	1.13E+11	8.93E+10	1.03E+11	1.34E+11	1.32E+11	1.27E+11	1.34E+11	1.35E+11	1.26E+11	1.29E+11
France	1.41E+12	1.33E+12	1.4E+12	1.61E+12	1.61E+12	1.46E+12	1.51E+12	1.5E+12	1.37E+12	1.38E+12
Germany	2.12E+12	2.07E+12	2.21E+12	2.59E+12	2.5E+12	2.22E+12	2.24E+12	2.2E+12	1.95E+12	1.95E+12
Greece	1.16E+11	1.09E+11	1.17E+11	1.37E+11	1.46E+11	1.43E+11	1.44E+11	1.43E+11	1.3E+11	1.36E+11
Hungary	3.85E+10	3.99E+10	4.3E+10	4.62E+10	4.65E+10	4.71E+10	4.86E+10	4.9E+10	4.72E+10	5.37E+10
India	2.93E+11	2.84E+11	3.33E+11	3.67E+11	4E+11	4.23E+11	4.29E+11	4.67E+11	4.77E+11	4.94E+11
Indonesia	1.39E+11	1.58E+11	1.77E+11	2.02E+11	2.27E+11	2.16E+11	9.54E+10	1.4E+11	1.65E+11	1.6E+11
Ireland	5.6E+10	5.25E+10	5.72E+10	6.92E+10	7.59E+10	8.28E+10	9.01E+10	9.87E+10	9.98E+10	1.09E+11
Italy	1.32E+12	1.06E+12	1.1E+12	1.17E+12	1.31E+12	1.24E+12	1.27E+12	1.25E+12	1.14E+12	1.16E+12
Japan	3.85E+12	4.41E+12	4.85E+12	5.33E+12	4.71E+12	4.32E+12	3.91E+12	4.43E+12	4.73E+12	4.16E+12
Luxembourg	1.62E+10	1.67E+10	1.85E+10	2.18E+10	2.17E+10	1.95E+10	2.04E+10	2.23E+10	2.14E+10	2.11E+10
Malta	3020000000	2710000000	3000000000	3600000000	3670000000	3630000000	3810000000	3910000000	3960000000	3920000000
Netherlands	3.58E+11	3.49E+11	3.74E+11	4.47E+11	4.46E+11	4.12E+11	4.32E+11	4.42E+11	4.13E+11	4.27E+11
Poland	9.25E+10	9.42E+10	1.09E+11	1.39E+11	1.57E+11	1.58E+11	1.73E+11	1.68E+11	1.72E+11	1.91E+11
Portugal	1.08E+11	9.5E+10	9.97E+10	1.18E+11	1.23E+11	1.17E+11	1.24E+11	1.27E+11	1.18E+11	1.22E+11
Rep. of Korea	3.56E+11	3.92E+11	4.59E+11	5.59E+11	6.03E+11	5.6E+11	3.76E+11	4.86E+11	5.62E+11	5.33E+11
Romania	2.51E+10	2.64E+10	3.01E+10	3.77E+10	3.72E+10	3.58E+10	4.2E+10	3.62E+10	3.74E+10	4.07E+10
Slovakia	1.54E+10	1.65E+10	2.01E+10	2.57E+10	2.78E+10	2.77E+10	2.98E+10	3.04E+10	2.91E+10	3.07E+10
Spain	6.29E+11	5.24E+11	5.29E+11	6.13E+11	6.41E+11	5.89E+11	6.17E+11	6.33E+11	5.95E+11	6.26E+11
Sweden	2.8E+11	2.1E+11	2.26E+11	2.64E+11	2.88E+11	2.64E+11	2.67E+11	2.71E+11	2.6E+11	2.4E+11
United Kingdom	1.18E+12	1.06E+12	1.14E+12	1.24E+12	1.31E+12	1.45E+12	1.54E+12	1.57E+12	1.55E+12	1.54E+12
United States	6.54E+12	6.88E+12	7.31E+12	7.66E+12	8.1E+12	8.61E+12	9.09E+12	9.66E+12	1.03E+13	1.06E+13

Source:
World Bank, World Development Indicators (2016). GDP.
Retrieved from http://data.worldbank.org

Table A22: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
3.94E+11	4.66E+11	6.13E+11	6.93E+11	7.47E+11	8.53E+11	1.05E+12	9.27E+11	1.14E+12	1.39E+12	1.54E+12	1.56E+12
2.13E+11	2.61E+11	3E+11	3.15E+11	3.34E+11	3.86E+11	4.28E+11	3.98E+11	3.9E+11	4.29E+11	4.07E+11	4.29E+11
2.59E+11	3.19E+11	3.71E+11	3.87E+11	4.1E+11	4.72E+11	5.19E+11	4.85E+11	4.84E+11	5.27E+11	4.98E+11	5.21E+11
1.64E+10	2.11E+10	2.61E+10	2.98E+10	3.43E+10	4.48E+10	5.47E+10	5.18E+10	4.99E+10	5.69E+10	5.36E+10	5.56E+10
1.46E+12	1.65E+12	1.94E+12	2.27E+12	2.73E+12	3.52E+12	4.56E+12	5.06E+12	6.04E+12	7.49E+12	8.46E+12	9.49E+12
1.13E+10	1.44E+10	1.72E+10	1.83E+10	1.99E+10	2.37E+10	2.75E+10	2.56E+10	2.52E+10	2.71E+10	2.49E+10	2.41E+10
8.17E+10	9.93E+10	1.19E+11	1.36E+11	1.55E+11	1.89E+11	2.35E+11	2.06E+11	2.07E+11	2.27E+11	2.06E+11	2.08E+11
1.79E+11	2.18E+11	2.51E+11	2.65E+11	2.83E+11	3.2E+11	3.53E+11	3.2E+11	3.2E+11	3.41E+11	3.25E+11	3.39E+11
1.4E+11	1.71E+11	1.97E+11	2.04E+11	2.17E+11	2.55E+11	2.84E+11	2.51E+11	2.48E+11	2.74E+11	2.57E+11	2.7E+11
1.5E+12	1.85E+12	2.12E+12	2.2E+12	2.33E+12	2.66E+12	2.92E+12	2.69E+12	2.65E+12	2.86E+12	2.68E+12	2.81E+12
2.08E+12	2.51E+12	2.82E+12	2.86E+12	3E+12	3.44E+12	3.75E+12	3.42E+12	3.42E+12	3.76E+12	3.54E+12	3.75E+12
1.54E+11	2.02E+11	2.41E+11	2.48E+11	2.73E+11	3.18E+11	3.54E+11	3.3E+11	2.99E+11	2.88E+11	2.46E+11	2.4E+11
6.75E+10	8.5E+10	1.04E+11	1.13E+11	1.15E+11	1.39E+11	1.57E+11	1.3E+11	1.3E+11	1.4E+11	1.27E+11	1.34E+11
5.24E+11	6.18E+11	7.22E+11	8.34E+11	9.49E+11	1.24E+12	1.22E+12	1.37E+12	1.71E+12	1.82E+12	1.82E+12	1.86E+12
1.96E+11	2.35E+11	2.57E+11	2.86E+11	3.65E+11	4.32E+11	5.1E+11	5.4E+11	7.55E+11	8.93E+11	9.18E+11	9.13E+11
1.28E+11	1.65E+11	1.94E+11	2.11E+11	2.32E+11	2.7E+11	2.75E+11	2.35E+11	2.2E+11	2.42E+11	2.25E+11	2.38E+11
1.27E+12	1.57E+12	1.8E+12	1.85E+12	1.94E+12	2.2E+12	2.39E+12	2.19E+12	2.13E+12	2.28E+12	2.07E+12	2.13E+12
3.98E+12	4.3E+12	4.66E+12	4.57E+12	4.36E+12	4.36E+12	4.85E+12	5.04E+12	5.5E+12	5.91E+12	5.96E+12	4.91E+12
2.33E+10	2.92E+10	3.43E+10	3.7E+10	4.19E+10	5.03E+10	5.51E+10	5.04E+10	5.24E+10	5.87E+10	5.6E+10	6.18E+10
4300000000	5120000000	5640000000	5990000000	6370000000	7470000000	8550000000	8100000000	8160000000	9300000000	8880000000	9640000000
4.65E+11	5.72E+11	6.51E+11	6.79E+11	7.27E+11	8.39E+11	9.36E+11	8.58E+11	8.36E+11	8.94E+11	8.29E+11	8.64E+11
1.99E+11	2.18E+11	2.54E+11	3.04E+11	3.43E+11	4.29E+11	5.3E+11	4.36E+11	4.79E+11	5.29E+11	5E+11	5.24E+11
1.34E+11	1.65E+11	1.89E+11	1.97E+11	2.09E+11	2.4E+11	2.62E+11	2.44E+11	2.38E+11	2.45E+11	2.16E+11	2.26E+11
6.09E+11	6.81E+11	7.65E+11	8.98E+11	1.01E+12	1.12E+12	1E+12	9.02E+11	1.09E+12	1.2E+12	1.22E+12	1.31E+12
4.62E+10	5.99E+10	7.62E+10	9.97E+10	1.24E+11	1.72E+11	2.08E+11	1.67E+11	1.68E+11	1.85E+11	1.72E+11	1.92E+11
3.51E+10	4.67E+10	5.72E+10	6.25E+10	7.04E+10	8.61E+10	1E+11	8.87E+10	8.93E+10	9.79E+10	9.3E+10	9.8E+10
7.05E+11	9.07E+11	1.07E+12	1.16E+12	1.26E+12	1.48E+12	1.63E+12	1.5E+12	1.43E+12	1.49E+12	1.34E+12	1.37E+12
2.64E+11	3.31E+11	3.82E+11	3.89E+11	4.2E+11	4.88E+11	5.14E+11	4.3E+11	4.88E+11	5.63E+11	5.44E+11	5.79E+11
1.68E+12	1.94E+12	2.3E+12	2.42E+12	2.59E+12	2.97E+12	2.79E+12	2.31E+12	2.4E+12	2.59E+12	2.63E+12	2.71E+12
1.1E+13	1.15E+13	1.23E+13	1.31E+13	1.39E+13	1.45E+13	1.47E+13	1.44E+13	1.5E+13	1.55E+13	1.62E+13	1.67E+13

Table A23: Oil Import Value as a Component of Gross Domestic Product

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.00424615	0.00522436	0.00486068	0.0051087	0.00685786	0.00639908	0.00521303	0.0077635	0.01081928	0.0112963
Austria	0.00528205	0.00474737	0.00477833	0.00429167	0.00527426	0.00608491	0.00393578	0.00458986	0.00821429	0.00761421
Belgium	0.03080508	0.02628319	0.01873984	0.01134483	0.01562278	0.01709804	0.01137931	0.01530769	0.02806723	0.02722689
Bulgaria	0.00933749	0.00274024	0.02463918	0.00022364	0.09089109	0.06883929	0.03	0.04296296	0.06045802	0.00082062
China	0.00404706	0.00523702	0.00279359	0.00322404	0.00396051	0.00569937	0.00317476	0.00425688	0.01231405	0.00879699
Cyprus	0.01534009	0.01295818	0.01386272	0.01009082	0.01131131	0.01536842	0.01068627	0.01451923	0.02376636	0.01864078
Czech Republic	0.0242029	0.01496296	0.01419831	0.01352941	0.01571856	0.01449675	0.00933735	0.0098609	0.01837398	0.01587537
Denmark	0.00464052	0.00444056	0.00385897	0.00372432	0.00427128	0.00425287	0.00281356	0.00338202	0.00707317	0.00343636
Finland	0.01176991	0.01209406	0.0123301	0.00902985	0.01189394	0.01110236	0.00813433	0.01081481	0.01920635	0.0155814
France	0.00632624	0.00623308	0.00627143	0.00596894	0.0078882	0.00849315	0.00575497	0.00693333	0.01284672	0.01115942
Germany	0.00669811	0.00613527	0.0058371	0.00505792	0.00644	0.00653153	0.0046875	0.00609091	0.01123077	0.00984615
Greece	0.01482759	0.0153211	0.0125641	0.00970803	0.01376712	0.01104895	0.011875	0.00706294	0.02292308	0.02463235
Hungary	0.02020779	0.01694236	0.01374419	0.01469697	0.01649462	0.01460722	0.01117284	0.01371429	0.02266949	0.01774674
India	0.01392491	0.01200704	0.00987988	0.0093733	0.01305	0.01004728	0.0086014	0.02027837	0.03291405	0.02611336
Indonesia	0.00748201	0.0058038	0.0060452	0.00653465	0.00669604	0.00680556	0.01111111	0.01135714	0.01527273	0.0180625
Ireland	0.00516071	0.00460952	0.00473776	0.00401734	0.00429513	0.00513285	0.0036515	0.00309017	0.00547094	0.00504587
Italy	0.00715152	0.00779245	0.0078	0.0077094	0.00862595	0.00887097	0.00622835	0.007776	0.015	0.01275862
Japan	0.00768831	0.00630385	0.00560825	0.00555347	0.0070276	0.00800926	0.00565217	0.00598194	0.00942918	0.00932692
Luxembourg	1.8196E-06	1.7255E-06	1.5219E-06	1.2612E-06	1.6917E-06	1.8719E-06	1.2187E-06	1.4931E-06	4.5555E-06	1.2137E-06
Malta	1.4643E-06	1.6189E-06	1.4507E-06	1.0528E-07	2.2469E-06	5.0193E-07	5.294E-07	2.0223E-06	2.4899E-07	1.956E-07
Netherlands	0.02148045	0.01862464	0.0171123	0.01709172	0.02100897	0.0206068	0.01324074	0.01719457	0.02953995	0.02529274
Poland	0.01632432	0.01592357	0.01321101	0.01136691	0.01261146	0.0128481	0.00797688	0.01083333	0.02011628	0.01518325
Portugal	0.01425926	0.014	0.01584754	0.01440678	0.01341463	0.01461538	0.00983871	0.01291339	0.02059322	0.01819672
Rep. of Korea	0.02682584	0.02334184	0.01934641	0.01932021	0.0238806	0.03178571	0.02978723	0.03045267	0.04483986	0.04015009
Romania	0.03227092	0.03155303	0.02976744	0.02785146	0.02795699	0.02340782	0.01311905	0.01320442	0.02200535	0.0234398
Slovakia	0.01402597	4.226E-05	0.02482587	0.02424125	0.02741007	0.02462094	0.01644295	0.02115132	0.0347079	0.0285342
Spain	0.01135135	0.01061069	0.01115312	0.01013051	0.01227769	0.01235993	0.00850891	0.01028436	0.0194958	0.01587859
Sweden	0.00835714	0.01042857	0.00933628	0.00799242	0.01052083	0.01151515	0.00707865	0.00911439	0.01653846	0.01470833
United Kingdom	0.00516949	0.00577358	0.00435965	0.00412097	0.00480916	0.00411724	0.00233766	0.00234395	0.00503226	0.00458442
United States	0.00629969	0.0059593	0.00559508	0.00593995	0.00658025	0.00666667	0.00447745	0.00552795	0.0091165	0.00748113

Notes:

Oil import value divided by GDP

Table A23: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.00997462	0.01023605	0.0106199	0.01213564	0.01405622	0.01500586	0.01495238	0.01089536	0.01342105	0.01546763	0.01448052	0.0125
0.00723005	0.00662835	0.00716667	0.00977778	0.01122754	0.01085492	0.01411215	0.00856784	0.01035897	0.01440559	0.01562654	0.01522145
0.0257529	0.02623824	0.0258221	0.03229974	0.03756098	0.0375	0.04701349	0.02948454	0.04152893	0.0516129	0.05823293	0.0547025
0.00512833	0.00416673	0.02203065	0.04161074	0.06122449	0.08214286	0.08957952	0.05250965	0.06172345	0.07065026	0.0886194	0.0807554
0.00876712	0.012	0.01747423	0.02101322	0.02432234	0.02269886	0.02828947	0.01764822	0.02235099	0.02630174	0.02612293	0.0231823
0.01778761	0.01222222	0.00547185	0.11912568	0.07135678	0.06118143	0.01210909	0.00263	0.00258657	7.155E-08	7.6707E-09	0
0.0249694	0.01299094	0.01403361	0.02088235	0.0236129	0.01873016	0.02578723	0.01563107	0.02140097	0.0245815	0.02854369	0.02600962
0.00367598	0.00369266	0.00442231	0.00418868	0.00473498	0.00403125	0.00467422	0.0050625	0.005	0.00677419	0.00883077	0.01085546
0.0155	0.0148538	0.01675127	0.01985294	0.02709677	0.02505882	0.02901408	0.02083665	0.02645161	0.03452555	0.03583658	0.03459259
0.0098	0.00994595	0.01160377	0.01518182	0.01712446	0.01609023	0.02047945	0.01182156	0.01332075	0.01835664	0.01776119	0.01622776
0.00908654	0.00928287	0.01099291	0.01524476	0.0174	0.0159593	0.02109333	0.01269006	0.01538012	0.01885638	0.02169492	0.02018667
0.0211039	0.02049505	0.01929461	0.02778226	0.03058608	0.02619497	0.03672316	0.02239394	0.03712375	0.04305556	0.06707317	0.06708333
0.01237037	0.01170588	0.01153846	0.01938053	0.02513043	0.02143885	0.02828025	0.02015385	0.02269231	0.03321429	0.03464567	0.03350746
0.0278626	0.02928803	0.03407202	0.04172662	0.05015806	0.04362903	0.07098361	0.04737226	0.05181287	0.06703297	0.08186813	0.07956989
0.01642857	0.01714894	0.02268482	0.02377622	0.02150685	0.02097222	0.01980392	0.01362963	0.01129801	0.01254199	0.01176471	0.01489595
0.00210938	0.00170909	0.00323711	0.00597156	0.00659483	0.00725926	0.00767273	0.00561702	0.00822727	0.00991736	0.01071111	0.01046218
0.01125984	0.01152866	0.01311111	0.01816216	0.02056701	0.02059091	0.02460251	0.0152968	0.02164319	0.02539474	0.02748792	0.02183099
0.00917085	0.01067442	0.01201717	0.01746171	0.02270642	0.02385321	0.03195876	0.01587302	0.01927273	0.02402707	0.02567114	0.02973523
2.9621E-06	6.0949E-07	2.5359E-06	4.4499E-06	1.0891E-06	5.1155E-07	1.0546E-06	2.2941E-06	1.9238E-06	1.0515E-06	1.1685E-06	6.4804E-07
8.7674E-08	6.1133E-07	1.5317E-06	4.872E-06	1.0675E-05	6.5596E-06	1.3392E-07	6.4691E-08	6.0049E-06	3.8806E-06	6.3626E-08	5.2427E-07
0.02172043	0.02132867	0.02549923	0.034757	0.0394773	0.03516091	0.04487179	0.03018648	0.04294258	0.050783	0.0641737	0.06041667
0.01467337	0.01573394	0.01661417	0.02023026	0.02475219	0.02331002	0.02811321	0.01933486	0.0256785	0.03402647	0.0392	0.03435115
0.01552239	0.01648485	0.01962963	0.02502538	0.03028708	0.02691667	0.03389313	0.01938525	0.02794118	0.0344898	0.04425926	0.04141593
0.03152709	0.0339207	0.03908497	0.04743875	0.05534653	0.05383929	0.0859	0.05631929	0.06302752	0.08416667	0.08852459	0.07580153
0.02316017	0.01819699	0.02519685	0.032999	0.03185484	0.02581395	0.02860577	0.01862275	0.02	0.02389189	0.02424419	0.02182292
0.02638177	0.02312634	0.02465035	0.02976	0.03707386	0.03495935	0.0402	0.0270575	0.03404255	0.04749745	0.04548387	0.04622449
0.01446809	0.01323043	0.01485981	0.01913793	0.02166667	0.01993243	0.02521472	0.0152	0.02104895	0.02738255	0.03447761	0.03306569
0.01291667	0.01335347	0.01473822	0.01940874	0.02109524	0.01866803	0.02587549	0.01702326	0.02151639	0.02575488	0.03125	0.02210708
0.00452381	0.00502577	0.00678261	0.00892562	0.01111969	0.00791246	0.01369176	0.01004329	0.01254167	0.01752896	0.01821293	0.01479705
0.00750909	0.00930435	0.01162602	0.01450382	0.01676259	0.01744828	0.02469388	0.01395833	0.0178	0.02212903	0.01987654	0.01670659

Table A24: Oil Import Value as a Component of Gross Domestic Product (modified)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.96435568	0.95614414	0.95919703	0.95711508	0.94243176	0.94628293	0.95623922	0.93482937	0.90917763	0.90517329
Austria	0.95565984	0.96014824	0.95988837	0.96397362	0.95572524	0.94892029	0.96696111	0.96147043	0.93104522	0.93608252
Belgium	0.74140686	0.77936592	0.84268852	0.9047659	0.86885468	0.85647059	0.90447643	0.87149965	0.76438979	0.77144399
Bulgaria	0.92161651	0.97699708	0.79316656	0.99812269	0.23701517	0.42212893	0.74816514	0.6393476	0.49248547	0.99311132
China	0.96602698	0.95603786	0.97654919	0.97293578	0.96675351	0.95215663	0.97334951	0.96426563	0.89662977	0.92615369
Cyprus	0.87122771	0.89122259	0.88362947	0.91529268	0.90504725	0.87098986	0.91029412	0.87811838	0.80049336	0.84352009
Czech Republic	0.79682888	0.87439348	0.88081233	0.88642742	0.8680506	0.87830707	0.92161766	0.91722275	0.84575968	0.86673427
Denmark	0.96104515	0.96272374	0.96760586	0.96873618	0.96414479	0.96429927	0.97638159	0.97160963	0.9406243	0.97115346
Finland	0.90119753	0.89847643	0.89649506	0.92419896	0.90015638	0.90680127	0.93171642	0.90921509	0.83877239	0.86920205
France	0.9468944	0.94767642	0.94735452	0.94989373	0.93378255	0.92870429	0.95168996	0.94179817	0.89215831	0.9063223
Germany	0.94377272	0.94849754	0.95100046	0.95754136	0.94593945	0.94517109	0.9606508	0.94886989	0.90572336	0.91734651
Greece	0.8755299	0.87138709	0.8945307	0.91850599	0.88443195	0.90724963	0.90031537	0.94071021	0.80757234	0.79322383
Hungary	0.83036578	0.85777747	0.88462449	0.87662636	0.86153596	0.87737977	0.90620965	0.88487549	0.80970106	0.85102506
India	0.88310737	0.89920694	0.91706339	0.9213159	0.89045183	0.91565814	0.9277956	0.82977329	0.72370319	0.78079152
Indonesia	0.93719226	0.95128005	0.94925362	0.94514488	0.94379016	0.9428708	0.90672783	0.90466252	0.87179316	0.84837443
Ireland	0.95667841	0.96130537	0.96022888	0.96627645	0.96394459	0.95691231	0.96934751	0.97405956	0.9540742	0.95764245
Italy	0.93996664	0.93458629	0.93452294	0.93528346	0.92758947	0.9255327	0.94771617	0.9347244	0.87408257	0.89289782
Japan	0.9354605	0.94708232	0.95292159	0.95338141	0.94100684	0.93276631	0.95255285	0.94978462	0.92084683	0.92170519
Luxembourg	0.99998473	0.99998552	0.99998722	0.99998941	0.9999858	0.99998429	0.99998977	0.99998747	0.99996176	0.99998981
Malta	0.99998771	0.99998641	0.99998782	0.99999912	0.99998114	0.99999579	0.99999556	0.99998302	0.99999791	0.99999836
Netherlands	0.81968249	0.84365553	0.85635088	0.85652361	0.82364031	0.82701634	0.88885066	0.85566026	0.75202701	0.78768021
Poland	0.86296553	0.86632969	0.88910024	0.90458056	0.89413312	0.89214667	0.93303813	0.90905963	0.83113399	0.87254431
Portugal	0.88030071	0.88247706	0.86696788	0.87906235	0.88739092	0.87731122	0.917409	0.89159864	0.82713031	0.84724771
Rep. of Korea	0.77481059	0.80405706	0.83759669	0.83781655	0.79953444	0.73317497	0.7499512	0.74436516	0.62359202	0.66296022
Romania	0.72910194	0.73512823	0.75011735	0.76620106	0.76531518	0.80350315	0.88987221	0.88915556	0.81527621	0.80323468
Slovakia	0.88225903	0.99964525	0.79159934	0.79650698	0.76990628	0.79331964	0.86196971	0.82244538	0.70864466	0.76046977
Spain	0.90471113	0.91092864	0.90637519	0.91495952	0.89693498	0.89624461	0.92857196	0.91366799	0.83634261	0.86670721
Sweden	0.929846	0.9124574	0.92162661	0.93290763	0.91168291	0.90333611	0.94057829	0.92348929	0.86116796	0.87653096
United Kingdom	0.95660473	0.95153367	0.96340295	0.96540656	0.95962953	0.96543784	0.9803765	0.98032373	0.95775673	0.96151614
United States	0.94711725	0.94997466	0.95303217	0.95013714	0.94476215	0.9440367	0.96241409	0.95359565	0.92347154	0.93719967

Notes:

Normalized and inverted for model

Table A24: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.9162681	0.91407351	0.91085128	0.89812741	0.88200508	0.87403336	0.87448231	0.90853894	0.88733704	0.87015709	0.87844335	0.89506881
0.9393074	0.94435833	0.93983945	0.91792049	0.90575043	0.9088784	0.88153563	0.92807731	0.91304164	0.8790723	0.86882312	0.87222365
0.78381743	0.77974318	0.78323648	0.72885997	0.68469456	0.68520642	0.6053455	0.7524922	0.65138562	0.56673572	0.51116392	0.54080015
0.95695027	0.96502241	0.8150638	0.65069885	0.4860513	0.31045216	0.24802509	0.55920796	0.48186281	0.40692669	0.25608483	0.3220992
0.92640442	0.89926606	0.85331268	0.82360466	0.79582619	0.80945449	0.76252414	0.85185209	0.81237469	0.7792102	0.78071117	0.80539631
0.85068198	0.89740061	0.95406659	0	0.4009958	0.48641273	0.89835029	0.9779225	0.97828702	0.9999994	0.99999994	1
0.79039448	0.89094764	0.8821949	0.82470318	0.80178159	0.84276977	0.78352918	0.86878507	0.82034969	0.79365073	0.76039013	0.7816624
0.96914202	0.96900198	0.96287693	0.96483815	0.96025221	0.96615969	0.96076227	0.95750287	0.95802752	0.94313406	0.92587015	0.90887391
0.86988532	0.87530983	0.85938155	0.83334458	0.77253625	0.78964382	0.7564414	0.82508681	0.77795206	0.71017545	0.69917003	0.70961264
0.91773394	0.9165088	0.90259218	0.8725563	0.85624877	0.86493068	0.82808533	0.90076396	0.88817899	0.84590524	0.85090374	0.86377616
0.92372309	0.922075	0.90772009	0.87202797	0.85393578	0.86602971	0.82293211	0.89347336	0.87089168	0.84171018	0.81788213	0.83054312
0.82284344	0.8279544	0.83803152	0.76678196	0.74324529	0.78010646	0.69172757	0.81201418	0.68836489	0.63857034	0.43695458	0.43686927
0.89615698	0.90173502	0.90314044	0.83731022	0.78904268	0.82003168	0.76260153	0.83081863	0.80950953	0.72118283	0.70916709	0.71872176
0.76610757	0.7541418	0.71398257	0.64972609	0.57894839	0.63375629	0.40412844	0.60233376	0.56505714	0.43729207	0.31275834	0.3320509
0.86209043	0.85604333	0.80957234	0.8004106	0.81946085	0.82394878	0.83375607	0.88558614	0.90515888	0.89471629	0.90124123	0.87495604
0.98229286	0.98565304	0.97282607	0.94987173	0.94463975	0.93906218	0.93559133	0.95284794	0.9309362	0.91674881	0.91008563	0.91217524
0.9054793	0.9032227	0.88993884	0.84753781	0.82735033	0.82714971	0.79347434	0.87159105	0.81831632	0.786824	0.76925276	0.81673989
0.92301531	0.91039364	0.89912194	0.85341778	0.80939104	0.79976433	0.73172231	0.86675404	0.83821518	0.79830485	0.78450373	0.75038771
0.99997513	0.99999488	0.99997871	0.99996264	0.99999086	0.99999571	0.99999115	0.99998074	0.99998385	0.99999117	0.9999019	0.99999456
0.99999926	0.99999487	0.99998714	0.9999591	0.99991039	0.99994494	0.99999888	0.99999946	0.99994959	0.99996742	0.9999947	0.9999956
0.81766795	0.82095657	0.78594681	0.70823256	0.66860795	0.70484194	0.62332392	0.74659973	0.63951868	0.57370236	0.46129414	0.49283257
0.87682449	0.86792147	0.8605324	0.83017715	0.79221788	0.80432412	0.76400381	0.83769359	0.78444198	0.714365	0.67093578	0.71163947
0.86969738	0.86161802	0.83521916	0.78992456	0.74575523	0.77404817	0.71548428	0.83727064	0.76544792	0.71047557	0.62846585	0.65233417
0.73534596	0.7152528	0.67190142	0.60177561	0.53539377	0.54804636	0.27891284	0.52722797	0.47091575	0.2934633	0.25688073	0.36368443
0.80558203	0.84724541	0.78848515	0.72299007	0.7325947	0.78330489	0.759869	0.84367137	0.83211009	0.79943962	0.79648229	0.81680763
0.77853838	0.80586606	0.79307275	0.75017982	0.68878362	0.7065339	0.66254128	0.77286596	0.71422994	0.6012829	0.61818585	0.61196873
0.87854773	0.88893722	0.87525937	0.83934673	0.81811927	0.83267729	0.78833512	0.87240367	0.82330468	0.77013731	0.71057784	0.72243019
0.8915711	0.88790432	0.87628008	0.83707342	0.82291612	0.84329128	0.78278835	0.85709836	0.81938073	0.78380074	0.73767202	0.81442221
0.9620249	0.95781117	0.94306342	0.92507393	0.9066558	0.93357891	0.88506461	0.91569165	0.89471904	0.85285325	0.84711166	0.87578625
0.93696497	0.92189469	0.90240546	0.87824778	0.85928652	0.85353053	0.79270736	0.88282683	0.85057798	0.81423794	0.83314645	0.85975663

Table A25: Military Expenditures

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	14963	15531	15704	15212	15026	15292	16041	16829	16780	17449
Austria	3522	3556	3572	3540	3508	3516	3525	3598	3683	3431
Belgium	6717	6378	6343	6214	6097	6020	6018	6097	6096	5828
Bulgaria	1459	1102	944	930	763	712	824	934	963	1066
China	28426	26222	25256	26213	27837	29858	32715	39800	43230	52179
Cyprus	1122	504	530	475	713	904	807	499	533	629
Czech Republic	2594.80952	2626	2712	2601	2579	2440	2650	2874	2963	2850
Denmark	4711	4724	4605	4556	4571	4629	4680	4652	4500	4778
Finland	2964	2881	2833	2549	2823	3036	3102	2703	2848	2715
France	67789	67038	67382	64047	62510	62725	61091	61607	60897	60711
Germany	64288	57793	53898	53011	51977	50087	50248	51272	50448	49619
Greece	6689	6529	6641	6784	7190	7661	8349	8741	9224	9021
Hungary	1999	1722	1705	1284	1208	1485	1327	1516	1674	1838
India	16548	18690	18773	19336	19687	21793	22737	26424	27266	28215
Indonesia	2699	2591	2863	3013	3372	4432	2899	2203	2265	2014
Ireland	1079	1087	1112	1121	1181	1253	1263	1307	1341	1455
Italy	36240	36434	35533	32452	35770	37506	38744	40263	42956	42250
Japan	44534.5177	44354.7846	44340	45074	45896	46279	46331	46084	46315	47156
Luxembourg	206	188	207	202	209	225	242	245	251	314
Malta	45.5	48.4	52	51.9	55.6	54	49.5	47.9	46.6	49.7
Netherlands	13245	12172	11738	11404	11470	11350	11309	11860	11393	11692
Poland	4978	5456	5447	5481	5767	6310	6546	6437	6248	6438
Portugal	4078	3948	3841	4125	3977	4064	3974	4182	4307	4480
Rep. of Korea	18142	18979	19528	21347	21648	22179	21404	20831	22111	22743
Romania	3650	2204	2628	2562	2490	2792	2536	2288	2178	2285
Slovakia	1110.7619	1118	1154	2043	2030	1634	1277	1116	1160	1306
Spain	18392	17921	18106	18250	17674	17501	18367	20184	20860	20629
Sweden	7351	7329	7313	7330	7425	7054	7255	7530	7688	7295
United Kingdom	61097	58306	56702	53183	52865	51200	51485	51421	52766	54901
United States	514822	487764	460072	433220	409656	407537	398332	399314	414768	418135
World	1222000	1180000	1144000	1092000	1070000	1083000	1069000	1093000	1132000	1158000

Source:

Stockholm International Peace Research Institute, Military Expenditure Database, 2015

Retrieved from: http://www.sipri.org

Notes:

Military expenditure by country in constant 2014 US dollars (millions)

Data for the Czech Republic and Slovakia interpolated for 1992

Table A25: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
18195	18527	19291	19969	21040	22331	23145	24877	25184	24835	23965	23757
3371	3511	3517	3441	3305	3930	3809	3557	3536	3456	3411	3278
5651	5712	5594	5390	5348	5771	6291	5926	5675	5476	5415	5244
1076	1096	1072	1096	1087	1263	1058	1005	956	810	829	886
60642	65496	72415	79809	92586	103716	113527	137401	144383	155898	169321	182930
430	416	432	470	461	437	439	479	497	461	421	379
3045	3308	3174	3470	3206	3092	2636	2713	2463	2218	2060	1971
4720	4582	4608	4391	4801	4630	4808	4520	4813	4486	4626	4243
2768	3215	3409	3499	3562	3356	3613	3793	3713	3772	3814	3823
61963	63826	65573	64235	64525	64773	64124	68451	65322	63725	62844	62686
49753	49073	47570	46830	45749	45789	47104	48885	49418	48004	49149	46312
8849	7581	8335	9013	9371	9363	10409	10913	8387	6752	5972	5577
2007	2166	2005	1985	1780	1813	1685	1502	1347	1365	1299	1228
28128	28756	33403	35548	35718	36151	41003	48277	48470	48940	48766	48406
2435	3279	3660	3179	3228	3882	3621	3784	4444	5095	5850	7865
1397	1339	1360	1377	1366	1376	1425	1407	1341	1271	1204	1197
43406	43758	43897	42227	40867	39600	41049	39897	38772	38047	35342	33948
47576	47435	47245	47155	46558	45954	45515	46364	46527	47161	46584	46380
280	296	311	315	308	320	239	237	298	258	251	260
49.1	50.7	53.5	67.5	54.8	54.9	56.3	61.3	62.9	55.6	52.4	53.9
11679	11846	11935	11957	12514	12682	12463	12732	12196	11786	11075	10317
6549	6808	7117	7608	8101	9158	8315	8768	9175	9302	9383	9304
4605	4443	4719	5002	4859	4651	4669	5106	5036	4810	4272	4707
23370	24165	25226	27283	28266	29546	31479	33458	33730	34201	35070	36175
2272	2344	2520	2666	2748	2635	2904	2469	2274	2353	2289	2463
1324	1404	1304	1413	1434	1450	1486	1420	1243	1067	1067	966
19121	19406	20285	20537	21210	21998	21877	21001	21138	19499	19721	17205
7101	7049	6634	6720	6616	6789	6038	5922	6409	6026	6152	6188
58458	62661	63392	63922	64334	66370	69332	70679	69192	66271	63446	60766
469486	534351	582400	610176	619653	635921	682967	737747	757992	748646	706082	650081
1230000	1308000	1384000	1443000	1491000	1548000	1634000	1745000	1774000	1779000	1774000	1746000

Table A26: Gross National Income

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	3.14E+11	3.03E+11	3.14E+11	3.55E+11	3.87E+11	4.21E+11	3.87E+11	3.77E+11	4.03E+11	3.68E+11
Austria	1.95E+11	1.9E+11	2.03E+11	2.39E+11	2.37E+11	2.12E+11	2.16E+11	2.15E+11	1.94E+11	1.94E+11
Belgium	2.37E+11	2.3E+11	2.52E+11	2.96E+11	2.88E+11	2.61E+11	2.67E+11	2.66E+11	2.44E+11	2.42E+11
Bulgaria	1.02E+10	1.06E+10	9500000000	1.26E+10	9710000000	1.08E+10	1.43E+10	1.33E+10	1.28E+10	1.42E+10
China	4.25E+11	4.42E+11	5.61E+11	7.2E+11	8.48E+11	9.47E+11	1.01E+12	1.07E+12	1.19E+12	1.31E+12
Cyprus	7000000000	6690000000	7510000000	9410000000	9510000000	8980000000	1.05E+10	9840000000	9070000000	9590000000
Czech Republic	3.43E+10	4.05E+10	4.74E+10	5.91E+10	6.59E+10	6.08E+10	6.55E+10	6.36E+10	6.03E+10	6.55E+10
Denmark	1.49E+11	1.41E+11	1.54E+11	1.83E+11	1.85E+11	1.71E+11	1.75E+11	1.76E+11	1.61E+11	1.62E+11
Finland	1.08E+11	8.5E+10	9.92E+10	1.3E+11	1.29E+11	1.25E+11	1.31E+11	1.34E+11	1.25E+11	1.29E+11
France	1.42E+12	1.34E+12	1.41E+12	1.62E+12	1.63E+12	1.48E+12	1.53E+12	1.53E+12	1.39E+12	1.41E+12
Germany	2.14E+12	2.08E+12	2.21E+12	2.59E+12	2.5E+12	2.21E+12	2.23E+12	2.18E+12	1.94E+12	1.93E+12
Greece	1.19E+11	1.11E+11	1.19E+11	1.4E+11	1.48E+11	1.44E+11	1.45E+11	1.41E+11	1.31E+11	1.37E+11
Hungary	3.5143E+10	3.95E+10	4.24E+10	4.49E+10	4.5E+10	4.48E+10	4.61E+10	4.63E+10	4.49E+10	5.1E+10
India	2.89E+11	2.8E+11	3.29E+11	3.63E+11	3.96E+11	4.2E+11	4.25E+11	4.63E+11	4.72E+11	4.9E+11
Indonesia	1.22E+11	1.52E+11	1.72E+11	1.96E+11	2.21E+11	2.09E+11	9.01E+10	1.29E+11	1.5E+11	1.43E+11
Ireland	5.15E+10	4.85E+10	5.31E+10	6.32E+10	6.97E+10	7.49E+10	8.08E+10	8.61E+10	8.7E+10	9.32E+10
Italy	1.29E+12	1.05E+12	1.08E+12	1.16E+12	1.3E+12	1.23E+12	1.26E+12	1.25E+12	1.14E+12	1.16E+12
Japan	3.89E+12	4.45E+12	4.89E+12	5.38E+12	4.76E+12	4.38E+12	3.97E+12	4.49E+12	4.79E+12	4.23E+12
Luxembourg	1.41E+10	1.42E+10	1.53E+10	1.85E+10	1.85E+10	1.72E+10	1.72E+10	1.84E+10	1.71E+10	1.73E+10
Malta	3170000000	2810000000	3060000000	3640000000	3680000000	3640000000	3740000000	3950000000	3860000000	3960000000
Netherlands	3.56E+11	3.49E+11	3.77E+11	4.53E+11	4.53E+11	4.17E+11	4.32E+11	4.49E+11	4.21E+11	4.26E+11
Poland	8.94E+10	9.17E+10	1.09E+11	1.39E+11	1.58E+11	1.58E+11	1.74E+11	1.69E+11	1.73E+11	1.93E+11
Portugal	1.08E+11	9.57E+10	1E+11	1.19E+11	1.23E+11	1.17E+11	1.23E+11	1.27E+11	1.16E+11	1.19E+11
Rep. of Korea	3.56E+11	3.91E+11	4.58E+11	5.57E+11	6.01E+11	5.57E+11	3.71E+11	4.81E+11	5.58E+11	5.29E+11
Romania	2.5E+10	2.62E+10	2.99E+10	3.74E+10	3.69E+10	3.55E+10	4.15E+10	3.57E+10	3.72E+10	4.05E+10
Slovakia	1.4658E+10	1.8405E+10	2.2153E+10	2.59E+10	2.8E+10	2.77E+10	2.98E+10	3.02E+10	2.9E+10	3.07E+10
Spain	6.24E+11	5.21E+11	5.2E+11	6.1E+11	6.34E+11	5.84E+11	6.12E+11	6.3E+11	5.93E+11	6.19E+11
Sweden	2.72E+11	2.03E+11	2.21E+11	2.6E+11	2.84E+11	2.61E+11	2.65E+11	2.7E+11	2.6E+11	2.4E+11
United Kingdom	1.14E+12	1.02E+12	1.12E+12	1.21E+12	1.28E+12	1.43E+12	1.55E+12	1.56E+12	1.57E+12	1.55E+12
United States	6.46E+12	6.76E+12	7.2E+12	7.6E+12	8.08E+12	8.62E+12	9.17E+12	9.73E+12	1.04E+13	1.08E+13
World	2.52E+13	2.56E+13	2.75E+13	3.05E+13	3.12E+13	3.12E+13	3.11E+13	3.22E+13	3.33E+13	3.32E+13

Source:

World Bank, World Development Indicators (2016). GNI (current US dollars).

Retrieved from http://data.worldbank.org

Notes:

Data for Slovakia interpolated for 1992-1994

Data for Hungary interpolated in 1992

Table A26: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
3.83E+11	4.53E+11	5.95E+11	6.67E+11	7.18E+11	8.15E+11	1.01E+12	8.94E+11	1.1E+12	1.33E+12	1.49E+12	1.52E+12
2.12E+11	2.6E+11	2.99E+11	3.14E+11	3.35E+11	3.86E+11	4.31E+11	3.97E+11	3.94E+11	4.3E+11	4.08E+11	4.3E+11
2.63E+11	3.25E+11	3.76E+11	3.92E+11	4.15E+11	4.78E+11	5.31E+11	4.85E+11	4.98E+11	5.32E+11	5.09E+11	5.29E+11
1.67E+10	2.14E+10	2.64E+10	2.99E+10	3.35E+10	4.15E+10	5.21E+10	5.01E+10	4.86E+10	5.47E+10	5.22E+10	5.35E+10
1.45E+12	1.64E+12	1.94E+12	2.25E+12	2.72E+12	3.53E+12	4.59E+12	5.05E+12	6.01E+12	7.42E+12	8.44E+12	9.41E+12
1.08E+10	1.39E+10	1.62E+10	1.73E+10	1.91E+10	2.34E+10	2.68E+10	2.53E+10	2.45E+10	2.72E+10	2.42E+10	2.32E+10
7.89E+10	9.6E+10	1.13E+11	1.3E+11	1.46E+11	1.77E+11	2.2E+11	1.91E+11	1.91E+11	2.1E+11	1.93E+11	1.96E+11
1.77E+11	2.17E+11	2.52E+11	2.67E+11	2.86E+11	3.21E+11	3.57E+11	3.23E+11	3.25E+11	3.49E+11	3.3E+11	3.48E+11
1.4E+11	1.7E+11	1.98E+11	2.05E+11	2.19E+11	2.56E+11	2.84E+11	2.55E+11	2.51E+11	2.75E+11	2.58E+11	2.7E+11
1.52E+12	1.87E+12	2.16E+12	2.24E+12	2.37E+12	2.72E+12	2.99E+12	2.74E+12	2.7E+12	2.93E+12	2.72E+12	2.85E+12
2.05E+12	2.48E+12	2.84E+12	2.89E+12	3.05E+12	3.49E+12	3.79E+12	3.49E+12	3.48E+12	3.85E+12	3.62E+12	3.83E+12
1.54E+11	2.01E+11	2.37E+11	2.48E+11	2.68E+11	3.1E+11	3.43E+11	3.22E+11	2.93E+11	2.81E+11	2.51E+11	2.42E+11
6.41E+10	8.12E+10	9.82E+10	1.06E+11	1.09E+11	1.3E+11	1.47E+11	1.24E+11	1.24E+11	1.33E+11	1.22E+11	1.31E+11
5.21E+11	6.14E+11	7.17E+11	8.28E+11	9.42E+11	1.23E+12	1.22E+12	1.36E+12	1.69E+12	1.8E+12	1.8E+12	1.84E+12
1.72E+11	2.26E+11	2.45E+11	2.72E+11	3.49E+11	4.14E+11	4.92E+11	5.21E+11	7.34E+11	8.66E+11	8.91E+11	8.85E+11
1.07E+11	1.42E+11	1.67E+11	1.84E+11	2.04E+11	2.34E+11	2.39E+11	1.98E+11	1.87E+11	1.99E+11	1.86E+11	2.03E+11
1.26E+12	1.56E+12	1.8E+12	1.86E+12	1.95E+12	2.21E+12	2.37E+12	2.18E+12	2.12E+12	2.27E+12	2.07E+12	2.13E+12
4.04E+12	4.37E+12	4.74E+12	4.68E+12	4.48E+12	4.5E+12	5.01E+12	5.17E+12	5.64E+12	6.09E+12	6.14E+12	5.1E+12
1.87E+10	2.27E+10	2.82E+10	3.1E+10	2.9E+10	3.8E+10	4.12E+10	3.4E+10	3.89E+10	4.09E+10	3.89E+10	4.05E+10
4320000000	5090000000	5570000000	5720000000	6130000000	7170000000	8450000000	7660000000	7980000000	8830000000	8300000000	8950000000
4.66E+11	5.8E+11	6.62E+11	6.81E+11	7.42E+11	8.52E+11	9.19E+11	8.59E+11	8.43E+11	9.1E+11	8.46E+11	8.81E+11
2.01E+11	2.18E+11	2.46E+11	2.99E+11	3.36E+11	4.16E+11	5.2E+11	4.24E+11	4.64E+11	5.12E+11	4.85E+11	5.08E+11
1.32E+11	1.63E+11	1.86E+11	1.94E+11	2.02E+11	2.33E+11	2.52E+11	2.35E+11	2.3E+11	2.4E+11	2.11E+11	2.23E+11
6.07E+11	6.78E+11	7.63E+11	8.91E+11	1.01E+12	1.12E+12	1E+12	9E+11	1.1E+12	1.21E+12	1.23E+12	1.31E+12
4.57E+10	5.85E+10	7.31E+10	9.68E+10	1.19E+11	1.66E+11	2.03E+11	1.65E+11	1.65E+11	1.82E+11	1.69E+11	1.87E+11
3.49E+10	4.44E+10	5.5E+10	6.08E+10	6.83E+10	8.35E+10	9.82E+10	8.87E+10	8.93E+10	9.46E+10	9.15E+10	9.71E+10
6.97E+11	9E+11	1.06E+12	1.14E+12	1.24E+12	1.44E+12	1.59E+12	1.47E+12	1.41E+12	1.46E+12	1.33E+12	1.36E+12
2.65E+11	3.37E+11	3.84E+11	3.94E+11	4.3E+11	5.05E+11	5.35E+11	4.41E+11	5.03E+11	5.8E+11	5.62E+11	5.96E+11
1.71E+12	1.98E+12	2.34E+12	2.48E+12	2.62E+12	3E+12	2.8E+12	2.32E+12	2.43E+12	2.63E+12	2.63E+12	2.69E+12
1.11E+13	1.16E+13	1.24E+13	1.32E+13	1.41E+13	1.46E+13	1.48E+13	1.45E+13	1.51E+13	1.58E+13	1.66E+13	1.71E+13
3.44E+13	3.86E+13	4.36E+13	4.72E+13	5.13E+13	5.76E+13	6.29E+13	5.98E+13	6.57E+13	7.29E+13	7.46E+13	7.65E+13

Table A27: Land Area

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300
Austria	82580	82580	82580	82580	82580	82580	82580	82580	82580	82580
Belgium	30280	30280	30280	30280	30280	30280	30280	30280	30280	30280
Bulgaria	110630	110630	110630	110630	110630	110630	110630	110630	110630	110630
China	9388250	9388250	9388250	9388240	9388230	9388230	9388230	9388230	9388220	9388214
Cyprus	9240	9240	9240	9240	9240	9240	9240	9240	9240	9240
Czech Republic	77270	77270	77270	77270	77270	77270	77270	77270	77270	77270
Denmark	42430	42430	42430	42430	42430	42430	42430	42430	42430	42430
Finland	304590	304590	304590	304590	304590	304590	304590	304590	304590	304590
France	547566	547566	547566	547566	547566	547566	547566	547566	547566	547566
Germany	349130	349120	349110	349100	349090	349050	349020	348980	348950	348900
Greece	128900	128900	128900	128900	128900	128900	128900	128900	128900	128900
Hungary	89870	89860	89860	89860	89860	89800	89800	89800	89620	89620
India	2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190
Indonesia	1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570
Ireland	68890	68890	68890	68890	68890	68890	68890	68890	68890	68890
Italy	294110	294110	294110	294110	294110	294110	294110	294110	294110	294110
Japan	364600	364600	364600	364600	364500	364500	364500	364500	364500	364500
Luxembourg	2590	2590	2590	2590	2590	2590	2590	2590	2590	2590
Malta	320	320	320	320	320	320	320	320	320	320
Netherlands	33760	33760	33760	33760	33760	33760	33760	33760	33760	33760
Poland	306290	306290	306290	306290	306290	306290	306290	306290	306290	306290
Portugal	91500	91500	91500	91500	91500	91500	91500	91500	91500	91500
Rep. of Korea	96460	96460	96460	96460	96460	96460	96460	96460	96460	96740
Romania	229460	229460	229510	229490	229520	229530	229590	229600	229710	229710
Slovakia	48100	48100	48100	48100	48100	48100	48100	48100	48100	48100
Spain	499440	499440	499440	499440	499440	499440	499440	499440	499000	498520
Sweden	410340	410340	410340	410340	410340	410340	410340	410340	410340	410340
United Kingdom	241930	241930	241930	241930	241930	241930	241930	241930	241930	241930
United States	9158960	9158960	9158960	9158960	9158960	9158960	9158960	9158960	9161920	9161920
World	130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000

Source:

World Bank, World Development Indicators (2016). Land Area (square kilometers).

Retrieved from http://data.worldbank.org

Data for Belgium and Luxembourg from 1992-1999 filled with 2000-2013 data

Table A27: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300	7682300
82580	82580	82580	82580	82580	82578	82578	82571	82561	82554	82540	82531
30280	30280	30280	30280	30280	30280	30280	30280	30280	30280	30280	30280
108800	108770	108760	108640	108630	108610	108610	108560	108560	108560	108560	108560
9388213	9388213	9388213	9388212	9388211	9388211	9388211	9388211	9388211	9388211	9388211	9388211
9240	9240	9240	9240	9240	9240	9240	9240	9240	9240	9240	9240
77270	77270	77260	77260	77250	77250	77250	77250	77240	77240	77230	77230
42430	42430	42430	42430	42430	42430	42430	42430	42430	42430	42430	42430
304590	304590	304590	304590	304110	304090	303900	303900	303900	303890	303890	303890
547566	547566	547566	547556	547556	547556	547557	547557	547557	547557	547561	547557
348860	348810	348770	348760	348720	348670	348630	348610	348570	348560	348540	348540
128900	128900	128900	128900	128900	128900	128900	128900	128900	128900	128900	128900
89620	89620	89620	89610	89610	89610	89610	90530	90530	90530	90530	90530
2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190	2973190
1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570	1811570
68890	68890	68890	68890	68890	68890	68890	68890	68890	68890	68890	68890
294110	294140	294140	294140	294140	294140	294140	294140	294140	294140	294140	294140
364500	364500	364500	364500	364500	364500	364500	364500	364550	364555	364560	364560
2590	2590	2590	2590	2590	2590	2590	2590	2590	2590	2590	2590
320	320	320	320	320	320	320	320	320	320	320	320
33760	33760	33760	33760	33760	33760	33760	33730	33730	33720	33720	33670
306290	306240	306330	306330	306320	306320	306300	306280	306280	306230	306220	306210
91500	91500	91500	91470	91470	91470	91470	91590	91590	91590	91590	91600
96790	96800	96820	96850	96880	96920	97030	97100	97230	97230	97350	97466
229870	229950	230000	229980	229980	229890	229900	230060	230050	230170	230020	230030
48100	48110	48100	48100	48100	48100	48100	48090	48091	48088	48088	48088
499040	499210	499180	499090	498980	499110	498800	498660	500010	499880	500210	500210
410340	410340	410340	410340	410340	410340	410340	410340	410340	410340	407340	407340
241930	241930	241930	241930	241930	241930	241930	241930	241930	241930	241930	241930
9161920	9161920	9161920	9161920	9161920	9161920	9147420	9147420	9147420	9147420	9147420	9147420
130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000	130000000

Table A28: Total Population

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	17495000	17667000	17855000	18072000	18311000	18517000	18711000	18926000	19153000	19413000
Austria	7840709	7905633	7936118	7948278	7959017	7968041	7976789	7992324	8011566	8042293
Belgium	10045158	10084475	10115603	10136811	10156637	10181245	10203008	10226419	10251250	10286570
Bulgaria	8540164	8472313	8443591	8406067	8362826	8312068	8256786	8210624	8170172	8020282
China	1160000000	1180000000	1190000000	1200000000	1220000000	1230000000	1240000000	1250000000	1260000000	1270000000
Cyprus	800660	818814	837166	855389	873246	890733	908040	925491	943287	961482
Czech Republic	10319123	10329855	10333587	10327253	10315241	10304131	10294373	10283860	10255063	10216605
Denmark	5171370	5188628	5206180	5233373	5263074	5284991	5304219	5321799	5339616	5358783
Finland	5041992	5066447	5088333	5107790	5124573	5139835	5153498	5165474	5176209	5188008
France	58851216	59106766	59327194	59541900	59753098	59964845	60186291	60496715	60912498	61357431
Germany	80624598	81156363	81438348	81678051	81914831	82034771	82047195	82100243	82211508	82349925
Greece	10399061	10460415	10512922	10562153	10608800	10661259	10720509	10761698	10805808	10862132
Hungary	10369341	10357523	10343355	10328965	10311238	10290486	10266570	10237530	10210971	10187576
India	906000000	924000000	943000000	961000000	979000000	998000000	1020000000	1030000000	1050000000	1070000000
Indonesia	188000000	191000000	194000000	197000000	200000000	203000000	206000000	209000000	212000000	214000000
Ireland	3558430	3576261	3590386	3608841	3637510	3674171	3712696	3754786	3805174	3866243
Italy	56797087	56831821	56843400	56844303	56860281	56890372	56906744	56916317	56942108	56974100
Japan	124000000	125000000	125000000	125000000	126000000	126000000	126000000	127000000	127000000	127000000
Luxembourg	392175	397475	402925	408625	414225	419450	424700	430475	436300	441525
Malta	361260	364704	367941	370433	372687	375236	377516	379360	381363	393028
Netherlands	15184166	15290368	15382838	15459006	15530498	15610650	15707209	15812088	15925513	16046180
Poland	38363667	38461408	38542652	38594998	38624370	38649660	38663481	38660271	38258629	38248076
Portugal	9952494	9964675	9991525	10026176	10063945	10108977	10160196	10217828	10289898	10362722
Rep. of Korea	43747962	44194628	44641540	45092991	45524681	45953580	46286503	46616677	47008111	47357362
Romania	22794284	22763280	22730211	22684270	22619004	22553978	22507344	22472040	22442971	22131970
Slovakia	5305016	5325305	5346331	5361999	5373361	5383291	5390516	5396020	5388720	5378867
Spain	39067745	39189400	39294967	39387017	39478186	39582413	39721108	39926268	40263216	40756001
Sweden	8668067	8718561	8780745	8826939	8840998	8846062	8850974	8857874	8872109	8895960
United Kingdom	57580402	57718614	57865745	58019030	58166950	58316954	58487141	58682466	58892514	59119673
United States	257000000	260000000	263000000	266000000	269000000	273000000	276000000	279000000	282000000	285000000
World	5450000000	5540000000	5620000000	5710000000	5790000000	5870000000	5950000000	6030000000	6120000000	6200000000

Source:
World Bank, World Development Indicators (2016). Population (total).
Retrieved from http://data.worldbank.org

Table A28: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
19651400	19895400	20127400	20394800	20697900	20827600	21249200	21691700	22031750	22340024	22728254	23117353
8081957	8121423	8171966	8227829	8268641	8295487	8321496	8343323	8363404	8391643	8429991	8479375
10332785	10376133	10421137	10478617	10547958	10625700	10709973	10796493	10895586	11047744	11128246	11182817
7868468	7823557	7781161	7739900	7699020	7545338	7492561	7444443	7395599	7348328	7305888	7265115
1280000000	1290000000	1300000000	1300000000	1310000000	1320000000	1320000000	1330000000	1340000000	1340000000	1350000000	1360000000
979883	998150	1015827	1032586	1048293	1063040	1077010	1090486	1103685	1116644	1129303	1141652
10196916	10193998	10197101	10211216	10238905	10298828	10384603	10443936	10474410	10496088	10510785	10514272
5375931	5390574	5404523	5419432	5437272	5461438	5493621	5523095	5547683	5570572	5591572	5614932
5200598	5213014	5228172	5246096	5266268	5288720	5313399	5338871	5363352	5388272	5413971	5438972
61805267	62244884	62704897	63179356	63621376	64016229	64374990	64707044	65027512	65342776	65659790	65972097
82488495	82534176	82516260	82469422	82376451	82266372	82110097	81902307	81776930	81797673	80425823	82132753
10902022	10928070	10955141	10987314	11020362	11048473	11077841	11107017	11121341	11104899	11045011	10965211
10158608	10129552	10107146	10087065	10071370	10055780	10038188	10022650	10000023	9971727	9920362	9893082
1090000000	1110000000	1130000000	1140000000	1160000000	1180000000	1200000000	1210000000	1230000000	1250000000	1260000000	1280000000
217000000	220000000	223000000	226000000	229000000	232000000	235000000	238000000	242000000	245000000	248000000	251000000
3931947	3996521	4070262	4159914	4273591	4398942	4489544	4535375	4560155	4576794	4586897	4598294
57059007	57313203	57685327	57969484	58143979	58438310	58826731	59095365	59277417	59379449	59539717	60233948
127000000	128000000	128000000	128000000	128000000	128000000	128000000	128000000	128000000	128000000	128000000	127000000
446175	451630	458095	465158	472637	479993	488650	497783	506953	518347	530946	543360
395969	398582	401268	403834	405308	406724	409379	412477	414508	416268	419455	423374
16148929	16225302	16281779	16319868	16346101	16381696	16445593	16530388	16615394	16693074	16754962	16804432
38230364	38204570	38182222	38165445	38141267	38120560	38125759	38151603	38042794	38063255	38063164	38040196
10419631	10458821	10483861	10503330	10522288	10542964	10558177	10568247	10573100	10557560	10514844	10457295
47622179	47859311	48039415	48138077	48371946	48597652	48948698	49182038	49410366	49779440	50004441	50219669
21730496	21574326	21451748	21319685	21193760	20882982	20537875	20367487	20246871	20147528	20058035	19983693
5376912	5373374	5372280	5372807	5373054	5374622	5379233	5386406	5391428	5398384	5407579	5413393
41431558	42187645	42921895	43653155	44397319	45226803	45954106	46362946	46576897	46742697	46773055	46620045
8924958	8958229	8993531	9029572	9080505	9148092	9219637	9298515	9378126	9449213	9519374	9600379
59370479	59647577	59987905	60401206	60846820	61322463	61806995	62276270	62766365	63258918	63700300	64128226
288000000	290000000	293000000	296000000	298000000	301000000	304000000	307000000	309000000	312000000	314000000	316000000
6270000000	6350000000	6430000000	6510000000	6590000000	6680000000	6760000000	6840000000	6920000000	7010000000	7090000000	7180000000

Table A29: Final Power Score

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	3.72382346	3.74264028	3.75208569	3.77996945	3.83836035	3.91587944	3.90460022	3.88145164	3.86916793	3.81769538
Austria	0.77714681	0.76443697	0.76852477	0.8060957	0.79197207	0.73584889	0.74871638	0.72994698	0.67010097	0.65149519
Belgium	1.06263495	1.02773816	1.04830953	1.0932995	1.0614964	0.99384711	1.0125751	0.9869012	0.91109789	0.88453303
Bulgaria	0.1871805	0.16920733	0.15648924	0.1617564	0.1447987	0.1424733	0.15666457	0.15825913	0.15520592	0.1613707
China	12.1771745	12.1396339	12.2971642	12.5865707	12.9772007	13.2533915	13.5593006	13.9600237	14.1982998	14.8696858
Cyprus	0.08699588	0.05319236	0.05642647	0.05692983	0.07214074	0.08226327	0.08029174	0.05829405	0.05705499	0.06300738
Czech Republic	0.31522827	0.33579631	0.35405442	0.36807188	0.38069553	0.35844037	0.38315515	0.3836355	0.37088842	0.3703429
Denmark	0.69369892	0.67617882	0.68344835	0.71957449	0.72127593	0.69122462	0.70759053	0.68843222	0.62730235	0.64006332
Finland	0.55635429	0.49270657	0.513858	0.54768742	0.55913131	0.56126932	0.58123754	0.54895436	0.52426985	0.52133263
France	7.9552158	7.77307888	7.83715467	7.93904685	7.86201329	7.50449863	7.56717585	7.40019418	6.8413475	6.79676958
Germany	9.75126885	9.25963129	9.07102721	9.4638527	9.14142094	8.3607898	8.46306428	8.18407776	7.39215808	7.2642969
Greece	0.77638981	0.75392256	0.77089502	0.81488463	0.85834109	0.87287579	0.92460898	0.91761686	0.89739603	0.88589394
Hungary	0.28849135	0.28551338	0.28653637	0.2598689	0.25382201	0.26860035	0.26211892	0.26794428	0.26707126	0.28597566
India	7.9709734	8.10702207	8.24704965	8.34630388	8.47126891	8.6685473	8.80564249	9.02641289	9.0320271	9.12333266
Indonesia	2.0843485	2.15594045	2.19896875	2.22689345	2.29823129	2.33666285	1.99249918	2.02129055	2.05288175	2.01813839
Ireland	0.23453684	0.22689643	0.23248853	0.24531067	0.26111962	0.27570238	0.29043344	0.29640054	0.29153889	0.30936406
Italy	5.81258077	5.21015428	5.10143175	4.92396918	5.40919865	5.33544707	5.51139727	5.43384286	5.19763707	5.14339709
Japan	13.5724995	14.9400548	15.2733485	15.3345344	13.8493542	13.0167535	12.1988931	12.9024301	13.102393	11.9850288
Luxembourg	0.05160272	0.05065628	0.05220778	0.05581881	0.05560054	0.05364854	0.05500567	0.05608255	0.0520568	0.05585399
Malta	0.01316011	0.01232859	0.01271287	0.01336932	0.01355505	0.01331474	0.01330113	0.0132788	0.01263133	0.01300817
Netherlands	1.76591079	1.697194	1.6978671	1.78528046	1.78065676	1.68700508	1.72796672	1.74906221	1.60920536	1.62346245
Poland	0.82126065	0.85700298	0.88880667	0.94228289	0.9978199	1.02404558	1.07636038	1.03476281	1.00122489	1.04235995
Portugal	0.59252416	0.55568706	0.54898199	0.59393225	0.59200887	0.58103557	0.59187986	0.59796256	0.56539032	0.57604687
Rep. of Korea	2.2238475	2.38113471	2.53780952	2.8086952	2.91979439	2.84113752	2.41415556	2.54885592	2.70006495	2.65099002
Romania	0.46351516	0.38854802	0.4192978	0.42942671	0.42305641	0.43465165	0.43207518	0.39656313	0.38388143	0.39076303
Slovakia	0.14415544	0.15546909	0.16499625	0.22497243	0.22957687	0.20267567	0.18605055	0.17275749	0.16805738	0.17808566
Spain	3.02118408	2.73311488	2.67686204	2.80548853	2.81122418	2.67801325	2.80791773	2.88422546	2.76293859	2.77753815
Sweden	1.27884436	1.10038726	1.1192188	1.17254747	1.2255679	1.14736678	1.17530847	1.17247355	1.1268269	1.05494781
United Kingdom	6.76324973	6.35969171	6.4247104	6.29236584	6.42571572	6.60048606	6.92309651	6.75262178	6.63348008	6.65301017
United States	49.0965704	49.0742864	48.1736245	46.9614119	46.685794	47.4044293	48.3930996	48.3915076	49.1328339	49.6404663

Table A29: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
3.80272059	3.80093327	3.91318648	3.93890769	3.94834306	3.97875173	4.0893903	4.02259677	4.13854228	4.22300049	4.30882373	4.3088641
0.65770338	0.69180664	0.69013698	0.66578072	0.64612171	0.6785784	0.67442257	0.64031095	0.59413507	0.58381459	0.5535935	0.56041745
0.87867369	0.9146761	0.90617167	0.86410862	0.83955233	0.86256304	0.88004346	0.82746902	0.77884059	0.75201748	0.71844842	0.72091189
0.16041286	0.16177993	0.16022971	0.16035412	0.15893428	0.16792528	0.16318027	0.15836312	0.14870158	0.14315501	0.13998671	0.14201718
15.3090319	15.3495837	15.6010366	15.9288055	16.7079697	17.5463748	18.4128387	19.7679143	20.3862739	21.4067928	22.6597088	23.906231
0.05181507	0.05281863	0.0532152	0.05380546	0.05310555	0.05357714	0.05399586	0.05418852	0.0512233	0.04982888	0.04512617	0.04235842
0.39197053	0.4077312	0.39834541	0.41602501	0.40468038	0.40922123	0.41173611	0.38728458	0.35662933	0.34487695	0.3191085	0.31467917
0.63830948	0.64749778	0.64618313	0.6186118	0.62471782	0.60905702	0.61251156	0.5705682	0.54825612	0.52463627	0.50591861	0.50222333
0.52709298	0.56293798	0.57216533	0.55616372	0.5484817	0.54518949	0.55253938	0.53313117	0.49798517	0.49638122	0.47726665	0.48443694
6.7731428	6.9499618	6.92684045	6.59539976	6.42721698	6.39752427	6.24311982	6.12549118	5.64815133	5.51862674	5.24150725	5.32384548
7.19749439	7.30710798	7.1511287	6.75716517	6.51526439	6.51122908	6.4330604	6.24688994	5.87161659	5.79804944	5.5495315	5.57667178
0.86908014	0.82395818	0.85372167	0.85599343	0.85607514	0.85020965	0.87589956	0.86307795	0.69911556	0.59585539	0.53371326	0.50779467
0.3099912	0.32679234	0.32210813	0.31605061	0.29515868	0.30169767	0.2970252	0.26767772	0.24782701	0.24340963	0.22769513	0.23019105
9.09138918	9.11522441	9.32565188	9.41134076	9.45105288	9.63108169	9.64548295	10.0196011	10.2235731	10.1863258	10.1273912	10.1565376
2.08345846	2.17681431	2.17146284	2.15274993	2.22069974	2.26853989	2.29248051	2.34973958	2.54201288	2.61239119	2.64655539	2.70132633
0.32165009	0.35214033	0.35962676	0.3624687	0.36546544	0.3697075	0.35125356	0.31425569	0.27977615	0.26904148	0.25069519	0.26162259
5.17324602	5.30085297	5.24125578	4.95025126	4.7309104	4.63032557	4.55220264	4.31797361	3.96919572	3.85946177	3.53335722	3.50748724
11.1767367	10.7305593	10.2804949	9.53759615	8.64460433	7.91958719	7.89163829	8.25220835	8.18150596	8.03872539	7.93292555	6.89842704
0.05445257	0.05732704	0.06113888	0.06138419	0.05451311	0.06082198	0.05649194	0.05004851	0.05377722	0.05020009	0.04735605	0.04840824
0.01322049	0.01354946	0.01325613	0.01334741	0.01254864	0.01277456	0.01335372	0.01297368	0.0125399	0.01222001	0.01144062	0.01190518
1.63061821	1.69932738	1.68019777	1.60649784	1.61513525	1.62267961	1.57226827	1.53326107	1.40241162	1.36188515	1.25964799	1.24833331
1.02627502	1.00257609	0.99545359	1.04777208	1.07033349	1.14464881	1.15692396	1.07212018	1.07740597	1.0763222	1.04350479	1.05306959
0.58426309	0.58633595	0.58952603	0.58233827	0.55644459	0.54604084	0.53310016	0.53204282	0.497051	0.47341681	0.42202207	0.44609604
2.721016	2.67868632	2.65565547	2.7902665	2.84590488	2.83608839	2.61046021	2.54616306	2.64669157	2.64983257	2.67717659	2.78100197
0.38617684	0.39271879	0.40334192	0.42802549	0.44368728	0.46876204	0.49385888	0.43651964	0.40939976	0.40943662	0.39032948	0.40876335
0.1803159	0.18878616	0.18709437	0.19100024	0.19238812	0.19824249	0.20356702	0.19171572	0.17562696	0.16449639	0.1596209	0.15896512
2.7353662	2.89295693	2.94841797	2.91047009	2.91230554	2.96769919	2.93228468	2.79492828	2.57767538	2.41631357	2.27783408	2.18680904
1.05110727	1.09355445	1.05855095	1.01841124	1.00576989	1.02773255	0.96406316	0.868415	0.90163952	0.90637415	0.88262651	0.90467952
6.86007464	6.98856398	7.00455882	6.82733151	6.65116332	6.69856767	6.16319808	5.65217137	5.43035504	5.25141285	5.09612198	5.02417539
50.8383343	51.1410776	50.8823265	50.6990544	49.8865029	48.1361331	47.3956113	48.1917648	47.6413342	46.3330413	45.1908845	43.536217

Table A30: Total Cost for Crude (per barrel)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	12.8589874	12.6173292	13.4846525	13.6978201	18.5726867	18.1242684	12.8336524	17.0525175	30.2520955	26.6023779
Austria	16.4184745	14.8387819	15.4785991	16.8243803	19.5543251	18.7303638	12.6091748	15.8257259	27.8482149	23.7754042
Belgium	30.0496409	25.9349907	19.6546617	15.3130864	17.1274747	16.4176227	10.8386979	15.2279525	24.3459858	24.6580932
Bulgaria	2.41867641	0.6895456	4.71752755	0.05036165	18.3941127	16.6885488	10.8569121	14.2364923	20.698457	0.27375333
China	20.53628	20.3462029	17.1094984	18.484265	20.2964562	20.8229233	15.4835624	17.073991	29.0709372	23.6078388
Cyprus	19.4325379	14.9398228	15.5771663	17.2138643	20.7850447	19.2634055	13.9013637	17.4502363	28.0561764	22.780919
Czech Republic	18.6110417	13.5548169	13.2980701	15.3961364	18.9764438	17.2970318	12.243511	14.3893774	26.9942528	24.2616575
Denmark	16.9550992	15.6018606	14.1801074	13.7667537	15.4673919	16.6247855	11.2276175	13.4036251	27.8272278	17.2989869
Finland	20.6113104	17.610633	17.121294	22.7411666	23.1837092	20.9298428	12.829439	17.5616383	27.6645393	23.181192
France	15.8586396	14.2270718	15.6745363	16.5064529	20.4023786	18.7991872	12.913567	16.9696873	27.755266	24.3022956
Germany	19.3791034	17.0554893	16.2392507	17.3274785	20.8202176	19.3261383	12.8225548	17.307032	28.3861633	24.4452071
Greece	14.345396	15.867352	13.4384008	10.3137888	14.8031839	11.5600023	12.1356152	7.94818942	20.027817	22.8116991
Hungary	18.7428516	15.374979	14.6491503	15.0695596	18.8412827	16.1276846	12.0375297	15.5505539	24.427706	22.8766351
India	21.8865507	15.4003955	16.0542295	17.2451604	21.1639915	17.3117283	13.081129	29.6749632	32.2356393	22.3912887
Indonesia	21.9730281	16.3265913	18.6953042	19.3665452	21.2154937	20.4347846	15.9778227	18.9008619	31.9153011	25.7907661
Ireland	18.9342501	16.7096565	15.3981426	16.1625202	19.7653664	19.1302417	13.7311374	14.0048696	23.9978069	20.4571322
Italy	14.2489151	12.8262494	13.3519856	14.7968442	18.5852571	16.8241689	11.6067753	14.9535408	25.4435317	21.8979158
Japan	18.5908745	17.1216269	15.8222768	17.4778126	19.8220493	20.0198805	13.6795996	16.7108807	28.0610293	24.6759018
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	18.1716448	15.5863748	14.8384988	16.6481066	19.9444693	18.2108216	12.0689706	16.7885412	26.2424173	23.0323291
Poland	15.737838	14.7732492	14.7210459	15.3462627	18.1019315	18.3793833	11.6629305	15.182511	26.1950302	22.3268963
Portugal	17.9011873	15.4015847	15.1170883	16.6279951	18.2454449	16.8806232	11.6918062	15.6288905	26.1513315	22.7577266
Rep. of Korea	18.9763543	16.3361506	15.1592743	16.8243401	19.606735	19.9347269	13.2403077	16.6751974	27.9168033	24.4445164
Romania	16.8041515	15.0461324	15.1179701	17.1727102	19.9082237	18.6106262	12.6229766	15.3175943	23.5480683	18.6726024
Slovakia	6.47308544	0.02116528	14.3482961	15.8204602	19.6086625	17.7347071	12.3720487	16.4681047	26.0328357	21.8718603
Spain	17.8303813	14.1598551	14.7244947	15.1865747	19.5680772	17.4832711	11.8362107	15.0913599	27.1361814	23.7402642
Sweden	18.0456122	16.0277341	15.5828848	15.3345547	20.8876996	19.947498	12.6675326	16.7585103	27.3511379	23.4622413
United Kingdom	14.1146794	13.2646135	12.4156305	14.5862716	16.8066538	16.2558666	10.3326512	12.2306897	22.3646406	18.9241668
United States	17.0989233	15.2655721	14.8019192	16.143964	17.9554078	17.7271832	11.9796436	15.6021526	26.5645322	21.4467792

Notes:

Luxembourg, Malta, negligible imports, amount counts as zero

Cyprus from 2005-2013

Table A30: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
24.3505875	31.7817865	42.8348916	57.6556433	70.7677918	78.4910844	107.829327	67.2305987	86.3200525	117.561157	119.701153	115.619374
23.9100279	28.8349111	38.2998911	51.5892358	61.2366148	70.9916585	97.7787069	57.4382497	74.5688663	102.093304	112.48581	112.763315
24.610692	28.9547578	34.2402719	48.0345775	60.2471009	66.4708275	90.7637628	56.9836969	77.3660521	115.370482	117.005628	126.214651
1.85825422	2.28236081	13.4043024	25.7214993	37.5692043	70.6346976	91.5035828	59.5242612	70.3190949	95.3161837	101.665778	95.3355006
25.0581703	30.0128809	37.9393152	50.3089558	62.6400043	67.0312321	99.0344806	59.907463	77.9791763	106.717167	111.596828	106.181954
25.562564	24.8293506	52.983145	0	0	0	0	0	0	0	0	0
45.1557938	27.4449447	35.2214553	49.7054101	63.8889326	66.7617739	102.22235	61.1961929	78.5322103	110.570184	114.106464	112.932297
22.3439851	30.2022274	39.1825855	53.1915871	66.0751066	83.9699414	89.1937033	61.4278463	78.4398879	102.509737	89.9998746	101.235056
24.5936241	28.0537385	36.0686492	50.4755266	64.4250128	69.7591439	92.7873477	60.7910703	79.0433136	112.410558	110.616533	108.455091
24.6690031	28.9888774	38.8904759	53.3149974	65.5829421	71.6690112	96.8403655	59.4563842	74.0603603	109.8966	112.554992	110.796605
24.1288799	29.6074036	38.0752453	52.397145	64.3409684	69.571605	101.785329	60.0011481	76.5164534	106.256602	111.408154	113.395409
21.5969606	26.7493322	29.3865606	46.4048233	50.6800326	49.7574419	82.4001844	49.154388	70.6766142	91.8722755	97.9566045	93.9678826
22.276533	25.115167	29.2319223	45.2413917	55.7408062	56.7328062	88.005357	62.8269418	66.7832729	102.404316	103.941485	106.637965
24.7783369	27.6870584	35.2313169	49.1804414	60.4715934	61.3977471	92.7810254	55.823169	74.3147542	99.7429695	110.271767	105.419257
27.1095174	29.7798522	39.3792766	44.7474413	69.8729067	83.1733783	106.830326	53.9316122	59.1413287	79.5098094	75.5441966	92.0658873
10.6404242	11.5136265	28.8363687	51.3001048	63.7962468	77.4796031	87.8910879	65.7954824	79.0401324	104.688002	104.636412	102.691262
21.6392299	26.7214363	34.1643034	47.3588546	57.5678582	63.6027773	88.8391226	55.0871891	72.6842451	100.000446	101.854921	94.5432295
24.3182859	28.9667625	36.2111548	50.7805331	63.8239013	67.8613014	100.821105	58.8310973	77.2116396	106.846541	112.651128	108.142149
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
23.3208936	27.1619811	35.4711202	48.9552235	61.2381033	60.7795815	88.7738433	53.7273644	73.1043849	98.3031769	114.438043	118.691102
22.5495484	27.0664881	32.4778234	46.2751591	56.4089961	63.016275	94.0694701	54.0406652	72.2682492	101.07871	108.813175	105.789464
22.1110756	26.255639	36.2379119	46.6157956	58.4262697	64.4370134	94.3189461	57.0952229	78.5972429	106.61957	115.957386	90.7603655
24.1094916	28.5962021	35.5626563	49.2696705	62.7626972	68.3166309	99.7318551	59.212161	78.3472812	108.722591	115.282595	109.782856
22.9450334	28.5600813	36.0217625	47.5885839	55.499421	71.2293704	93.7330063	58.3756569	75.9035765	107.634187	108.847145	110.79975
22.6021572	26.2918168	32.6089582	46.3010927	62.529235	67.3577586	93.9139627	57.3552811	76.2209905	105.670845	107.742606	105.51116
24.537608	28.2517951	36.7142593	50.5557823	61.9241435	68.786207	92.8388048	56.2160967	73.2489031	99.7052382	102.709989	101.407391
25.0587672	29.2445212	36.5161258	50.111561	61.1262525	67.4773741	84.2842639	51.327874	70.5594892	102.378137	110.100505	99.1599687
18.3026616	25.0221192	34.010154	50.7251283	67.3031011	55.9120718	87.2731188	57.6500442	73.7220708	105.328832	107.383235	89.9770492
22.7654934	27.5520296	35.2829091	46.1156106	55.2480684	59.9794087	87.3937113	52.6590295	68.9636655	90.2499658	89.9124798	84.3300346

Table A31: Total Cost for Crude (per barrel, inflation adjusted)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	20.6365537	19.8881382	20.8599704	20.2504808	26.7583109	26.0470337	18.2876234	23.9484496	40.6659772	34.2590581
Austria	23.2539004	20.2811852	20.5476486	21.8426734	24.9273444	23.5686255	15.721428	19.6215501	33.7199917	28.0415636
Belgium	42.7726349	35.9264436	26.5942577	20.4202502	22.3790003	21.1079725	13.8034603	19.1788274	29.9016348	29.5536777
Bulgaria	816.293086	134.613774	469.740387	3.09443483	510.006472	39.94539	21.8980393	27.9942438	36.8947181	0.4545057
China	46.2456395	39.9456016	27.0676836	24.9723322	25.319124	25.2683594	18.9406362	21.182724	35.9229571	28.9622302
Cyprus	32.6639821	23.9496576	23.8507217	25.6848555	30.1162829	26.9402321	19.0176575	23.4897839	36.2645012	28.8749991
Czech Republic	48.1429444	28.9917925	25.8654214	27.4307839	31.0750881	26.0944492	16.6964057	19.2109953	34.685806	29.7735189
Denmark	24.537462	22.3000798	19.8716278	18.8958459	20.7911177	21.8667277	14.4990909	16.8904765	34.0698039	20.6934294
Finland	27.0059951	22.5995229	21.7355295	28.5883145	28.9660333	25.8412135	15.6214155	21.1383967	32.2140826	26.3180481
France	21.0814819	18.5224937	20.0735788	20.769663	25.1672608	22.9096979	15.6440459	20.4487324	32.8866409	28.3333822
Germany	26.2764048	22.1437168	20.520762	21.5248849	25.4950326	23.2287382	15.2690016	20.4923216	33.1231709	27.9696805
Greece	34.7961527	33.6389226	25.6841086	18.0950362	24.0040369	17.7612779	17.7974087	11.3569088	27.7388631	30.563387
Hungary	121.820105	81.6084723	65.414492	52.4476198	53.1277621	38.4367248	25.1269908	29.5008294	42.212929	36.2164847
India	75.167344	49.7275564	47.0357265	45.8380293	51.6203349	39.4015933	26.2938271	56.9871919	59.5183189	39.8729493
Indonesia	147.611754	99.9926585	105.511893	99.8795519	101.33988	91.8862884	45.3605627	44.5342935	72.5018858	52.5450294
Ireland	29.1397786	25.3588849	22.8329138	23.3785168	28.1139141	26.8249939	18.7980041	18.8633346	30.6190512	24.8887964
Italy	22.7695308	19.6179806	19.6314622	20.6717376	24.9717831	22.1529183	14.9887886	18.9962362	31.527911	26.3984822
Japan	18.7250715	17.0293788	15.629518	17.2862293	19.5789376	19.4320606	13.1904579	16.1665998	27.3255086	24.2237176
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	26.5074586	22.1635123	20.5250331	22.5936108	26.5321325	23.7098926	15.4074941	20.9726577	32.040404	26.9973582
Poland	88.2572466	60.5321856	45.2662767	36.8456007	36.2734281	32.0028544	18.1766773	22.0572767	34.5778852	27.937749
Portugal	30.28998	24.4694951	22.8271982	24.1144312	25.6593569	23.237643	15.6691421	20.473854	33.3100173	27.7671444
Rep. of Korea	36.6667046	30.1350784	26.3174947	27.9558187	31.0503857	30.2257156	18.6727004	23.3276053	38.1888366	32.1321281
Romania	6982.29575	1760.2489	747.025336	641.666792	535.823978	196.613545	83.8211337	69.7611141	73.623789	43.4159736
Slovakia	23.0039231	0.05996638	35.8453079	35.9669863	42.1317283	35.9112811	23.4796257	28.2653297	39.8818409	31.2190588
Spain	30.6323361	23.2635956	23.1012328	22.7621167	28.3214297	24.8149991	16.4973208	20.559293	35.7413561	30.1845972
Sweden	23.4908775	19.9374154	18.9667457	18.2042099	24.6803135	23.4480339	14.9108069	19.6370943	31.7201804	26.570796
United Kingdom	20.1657147	18.4878253	16.9688103	19.4196184	21.8340284	20.7495672	12.9826797	15.1649949	27.5141572	22.9972822
United States	26.5721415	23.0429226	21.7752745	23.1014776	24.9619085	24.0816717	16.025115	20.424045	33.6384577	26.4114537

Notes:

Adjusted to 2010 dollars by author

Table A31: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
30.4448486	38.6645713	50.9180627	66.7540771	79.1352174	85.7711978	112.915765	69.1434594	86.3200525	113.801276	113.865652	107.352881
27.7011393	32.9601131	42.8950154	56.4771155	66.0806289	74.9812853	100.056002	58.4799114	74.5688663	98.8635311	106.285336	104.45816
29.0203793	33.6074973	38.9279924	53.1314863	65.4673851	70.9378551	92.7015591	58.2312431	77.3660521	111.434504	109.893331	117.236558
2.91580047	3.5056484	19.3600556	35.3678556	48.1615096	83.5308601	96.3160427	60.9760522	70.3190949	91.4567983	94.7498007	88.0663297
30.9790109	36.6765464	44.6225814	58.1154535	71.3139863	72.8411863	101.622594	61.8984801	77.9791763	101.181925	103.118373	95.5988513
31.5178917	29.3970946	61.3281242	0	0	0	0	0	0	0	0	0
54.4426151	33.0537177	41.2531338	57.1621562	71.6617935	72.7543059	104.745448	62.0582755	78.5322103	108.469775	108.363934	105.731852
26.0952169	34.5504261	44.3096157	59.0829948	72.0320175	89.997545	92.4533591	62.8392922	78.4398879	99.7577205	85.5327554	95.4570412
27.4921397	31.0872787	39.8942174	55.352521	69.5600467	73.4746311	93.9109833	61.5268577	79.0433136	108.696612	104.040057	100.521157
28.2199667	32.4767032	42.6589085	57.4834686	69.539732	74.8787408	98.408275	60.36585	74.0603603	107.617793	108.106828	105.50681
27.2209881	33.0596732	41.8182964	56.6714779	68.5089428	72.4140973	103.230683	60.6634473	76.5164534	104.096393	106.994318	107.288443
27.9224585	33.4045008	35.6640201	54.3895203	57.5607398	54.9228721	87.3277857	51.4710268	70.6766142	88.9116078	93.397499	90.4275535
33.5036394	36.0950503	39.3440623	58.8036474	69.745579	65.7681078	96.1863315	65.8937419	66.7832729	98.5408261	94.6552382	95.4677594
42.2671898	45.4973516	55.7927724	74.7103162	86.5441904	82.6075605	115.210034	62.5176461	74.3147542	91.6268467	92.6690886	79.8783835
49.3675477	50.8795513	63.3265759	65.1497975	89.9404228	100.614	117.722338	56.7009608	59.1413287	75.4682578	68.7615567	78.749369
12.3700303	12.9350472	31.7005899	55.0568424	65.8734066	76.2798732	83.1592438	65.1729504	79.0401324	102.056078	100.307828	97.9507397
25.4600382	30.6200658	38.3004021	52.0518035	61.989401	67.2626811	90.8838363	55.9354729	72.6842451	97.3321819	96.2109922	88.228125
24.1897657	28.7654047	35.9624029	50.5698087	63.4064963	67.3784004	98.7474098	58.4076419	77.2116396	107.150129	113.008994	108.097072
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
26.4657529	30.1871032	38.9394534	52.8571488	65.3558904	63.8361053	90.9759992	54.4126867	73.1043849	96.0544463	109.140266	110.428099
27.6901942	32.9770345	38.2036757	53.310215	64.2681122	70.1214034	100.312873	55.5037895	72.2682492	96.950276	100.784015	96.9804401
26.0545058	29.9547239	40.3917511	50.7940701	61.9632957	66.4732965	94.8427245	57.8960234	78.5972429	102.86202	108.851863	84.9657045
30.8396224	35.337109	42.4223504	57.1978668	71.2645591	75.6535081	105.510675	60.9623912	78.3472812	104.540953	108.470639	101.962345
43.5376905	47.0115818	52.9992979	64.2428833	70.2936825	86.0552535	105.001964	61.9331923	75.9035765	101.745369	99.5724676	97.4739838
31.2237969	33.4587729	38.5853049	53.3417688	68.946507	72.2780662	96.3440585	57.9041838	76.2209905	101.685486	100.070501	96.6444207
30.2700689	33.8237588	42.659456	56.8274341	67.2419897	72.6683002	94.2374966	57.2278391	73.2489031	96.6171605	97.1525703	94.588065
27.7792379	31.8069184	39.5678132	54.0544726	65.0509936	70.2557282	84.8386847	51.9222435	70.5594892	99.4337057	105.992449	95.5024171
21.9660732	29.6266906	39.7344359	58.0724287	75.294624	61.1321324	92.09332	59.5442602	73.7220708	100.808383	99.9541429	81.6659837
27.5977255	32.6588712	40.7321922	51.4909979	59.7601316	63.0784597	88.5111827	53.5226604	68.9636655	87.4881402	85.3938635	78.935725

Table A32: Price Volatility

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.86937542	0.7484155	0.86012387	0.79066092	3.55865982	3.60955362	4.23534373	6.71011822	11.1891769	11.5622234
Austria	3.05137119	2.97271522	1.61958929	0.78074409	2.18984792	2.22169494	4.6029582	5.8736598	8.99928188	9.88843493
Belgium	6.73171548	6.84619125	8.08918858	7.75309669	4.06637878	1.61488899	4.28777001	6.3399396	8.04908724	5.53538227
Bulgaria	649.455927	681.679312	508.402962	400.886282	486.778995	488.486559	244.054216	12.0717776	7.49833936	22.6703433
China	6.22517827	6.30003795	9.58897797	7.48663471	1.22107165	0.19877822	3.18924389	4.28490548	8.49116042	10.85048
Cyprus	0	8.71432445	4.40663019	0.96653486	3.13278057	3.80373903	5.54931267	6.1973505	8.62342182	10.0821096
Czech Republic	18.3043809	19.1511519	11.1387615	2.34586678	2.60483334	4.31247157	7.18934121	5.95631654	8.99470015	10.1935489
Denmark	2.70582238	2.23738223	2.33291711	1.70211694	1.43552685	1.4854409	4.22162339	4.87951119	9.78535648	15.2778509
Finland	4.39129388	4.4064722	2.6352328	3.85838919	3.61525188	1.75126929	6.6723089	7.86838959	8.29633354	8.48586023
France	2.51068048	2.55898819	2.05503664	1.12358464	2.54684102	3.32758038	4.76160744	6.03516922	8.62129747	8.49558355
Germany	4.01189454	4.13268802	2.87782142	1.31353888	2.48713533	3.11822106	5.11301553	6.59152834	8.92708467	8.89216984
Greece	1.27964384	1.15723011	4.55602207	7.77194322	6.74903655	6.07587984	3.13944492	3.23831534	11.411227	9.6032391
Hungary	38.4086531	40.211633	28.2028067	14.5804262	6.82350723	7.68558979	14.0003856	8.84178624	8.54296907	9.35427194
India	24.5577251	25.4397876	14.0658088	1.94476357	3.49000146	9.00052363	12.6632539	21.9005656	16.6122459	11.0882483
Indonesia	45.7490082	47.6190958	26.5691653	5.57578818	3.54633457	5.45695945	27.9896585	23.6759974	14.3969307	23.9622243
Ireland	3.69859736	3.78089377	3.15343244	1.53578706	2.64050019	3.01215882	4.65795504	4.04616017	5.91052354	8.74298565
Italy	3.21823973	3.15155029	1.58251595	0.52687853	2.67016046	3.55945514	4.99149726	5.58578866	8.26956119	8.83055179
Japan	1.87139277	1.69569275	1.54777677	1.52828607	1.97470983	1.21979265	3.19423987	4.60887231	7.06752537	7.13034994
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	4.47932156	4.34394632	2.99121275	1.85352844	3.00354968	3.38038077	5.56231917	6.933781	8.31645494	8.05539604
Poland	26.5866607	27.7250609	21.4954849	11.8432925	4.49642431	2.42137315	9.04837541	8.85338825	8.20060399	9.58037239
Portugal	6.25465229	5.82048487	3.7313909	1.46476497	1.41607934	1.98331976	4.99510738	6.18660639	8.82043758	9.18951806
Rep. of Korea	6.46911981	6.5316263	5.17460498	2.72795383	2.36644549	1.95961854	6.18884262	8.10395999	9.75806807	10.4589699
Romania	4973.47965	5222.04685	3117.63521	559.291056	105.600679	222.526623	226.001422	63.4262157	8.96134722	17.0352452
Slovakia	21.9714127	22.9439568	29.3646492	17.95351	3.14321016	6.19259456	9.32605128	8.60867968	8.20110759	10.1396466
Spain	7.09165556	7.36874046	3.76555166	0.25073943	2.94921447	4.53287175	5.91205441	6.18982519	9.62201761	10.3694109
Sweden	3.79017284	3.55346209	2.26206588	0.86660276	3.61931971	3.85419161	4.88475331	6.6317572	8.40468674	8.61623523
United Kingdom	2.05376126	1.67788935	1.59845221	1.98491163	2.43260906	1.74943555	4.42567435	4.97460139	7.26573876	8.43301867
United States	3.56478979	3.5292189	2.39843351	1.29692561	1.59331703	1.37033387	4.46839677	6.22774337	8.80667134	10.2207083

Notes:

Volatility calculated by as an average of the price change for the previous two years

Started measuring volatility with 1994, since the data set does not have the data necessary to calculate those years

1993 is a simple average of the difference between 1992 and 1993

Data for 1992 is interpolated

Values for Luxembourg, Malta, and select years for Cyprus were adjusted to 0

Table A32: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
5.11056432	6.01696612	10.2366071	14.0447529	14.1085773	9.50856035	16.8902736	35.458436	30.4744491	22.3289084	13.7727998	3.28857374
3.00942621	2.79969903	7.59693803	11.7585012	11.5928067	9.25208485	16.9876863	33.3254032	28.8325225	20.1918099	15.8582348	4.62449057
0.44062777	2.56020825	4.95380659	9.76199448	13.2696963	8.90318442	13.617087	28.11701	26.8025625	26.6016305	17.8048125	4.44220009
19.4507536	1.52557135	8.22212758	15.9311036	14.400727	24.0815023	24.0772665	24.0625866	22.3415166	15.240373	12.2153529	4.98823676
4.48875381	3.85715812	6.82178524	10.7194535	13.3457024	7.36286641	15.1543038	34.2527607	27.902405	19.6417226	12.5695983	4.72798457
5.01619729	2.38184479	17.0259133	0	0	0	0	0	0	0	0	0
14.7906917	23.0289968	14.7941567	12.0542193	15.2043299	7.79607486	16.5418272	37.3391573	29.5805537	23.2057499	15.0217031	1.36896151
9.38908098	6.92849835	9.10719939	12.2662843	13.8612009	15.4572751	10.2106708	16.0349405	22.6073314	18.4592142	17.7713988	12.0746255
3.53506308	2.38461534	6.20103888	12.1326212	14.8329146	9.06105501	12.1754683	26.4102389	24.9502907	23.5848771	17.1549265	4.08772755
2.33333709	2.18507601	7.21947088	12.5033827	13.4404118	8.69763611	14.4342715	30.7859796	25.8684676	23.6259715	17.0232339	1.54452631
2.9510914	3.29368876	7.29865416	11.8059024	13.3453232	7.87130968	17.3608699	36.6919104	29.2101207	21.716473	15.2389322	1.59602492
2.73272624	4.06148541	3.87078081	10.4925098	10.9483598	2.90454361	17.5213907	34.1308362	27.5311731	18.7202905	11.3604424	3.72791837
4.3546448	2.65212809	2.92021149	11.3542986	15.2007583	7.45970138	17.1978475	30.3554067	15.5910603	16.3235421	17.8215705	2.3490545
11.019805	2.81220112	6.76279132	14.6064823	15.375709	7.88525211	18.2695519	42.647431	32.2447481	14.5546003	9.17716719	6.91647348
11.567169	2.34474258	6.97951406	7.1351231	13.3069235	17.7321014	13.8909578	39.0648579	31.7308728	9.38364849	11.5168151	8.34725672
9.1245104	6.54189147	9.66527976	21.0608976	17.0864084	10.6115154	8.64291859	12.432832	15.9267377	18.4415638	12.3820975	2.05266913
3.03393637	3.04923575	6.42018195	10.7158689	11.8444994	7.60543877	14.4472176	29.2847593	25.8485678	20.6983545	12.8845633	4.55202846
1.56787148	2.30479548	5.88631861	10.902202	13.7220467	8.40429585	17.6704567	35.8543886	29.5718828	24.3712435	17.8986771	5.38539302
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
2.78732555	2.12647782	6.23685024	11.3350228	13.2082185	7.00926339	14.3298396	31.8516032	27.6275053	20.8208798	18.0179403	7.18682625
3.44384552	2.76719755	5.25674077	10.1665903	13.0322182	8.40559419	18.0223805	37.5002767	30.7867717	20.7232433	14.2578828	3.8186568
3.62775571	2.8064283	7.16862263	10.4196731	10.7857723	7.8396132	16.4397144	32.6580646	28.8239604	22.4829985	15.1273102	14.9380008
3.6746071	2.89499614	5.791364	10.9303789	14.4211044	9.22782066	17.1230578	37.2027251	30.9665867	21.7892808	15.0616788	5.21899009
15.1647662	1.79780411	4.73080366	8.61565073	8.64719232	10.9061851	17.3541408	31.0077411	28.5195779	19.9060882	14.0073466	2.13569243
4.33376009	1.11985708	3.68075401	9.94149794	15.180601	9.46814871	13.6987758	31.2529335	28.3783407	21.8906509	13.53974	2.52053242
2.82111526	1.81958077	6.19469354	11.5018376	12.2912668	7.92043308	13.4977535	29.2894269	26.5153607	19.6946607	11.9518336	1.54995756
3.17891319	2.6180612	5.89428761	11.1237771	12.7415902	8.1006278	9.89384555	23.7496989	25.7768435	23.7557311	17.7164801	8.52438791
2.774042	4.34591316	8.88418133	14.2228691	17.7800941	15.6923435	22.5618396	31.7551237	23.3634352	20.6320613	13.9702761	9.57119961
4.20663786	3.12370872	6.56723335	9.41606336	9.51396973	5.79373093	14.3755255	30.2106226	25.2147637	16.9827399	10.3093757	4.2762076

Table A33: Price Volatility (modified)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	0.98174314	0.98428329	0.98193742	0.98339614	0.92526823	0.92419946	0.91105788	0.85908767	0.76502754	0.75719358
Austria	0.93592128	0.93757305	0.96598866	0.98360439	0.95401324	0.95334446	0.90333798	0.87665328	0.81101529	0.79234309
Belgium	0.85863413	0.85623014	0.83012723	0.83718515	0.91460614	0.96608737	0.90995693	0.86686141	0.83096935	0.8837571
Bulgaria	0	0	0	0	0	0	0	0.74649295	0.84253505	0.52392331
China	0.8692714	0.86769935	0.79863168	0.84278084	0.97435752	0.99582566	0.93302595	0.91001708	0.82168583	0.77214017
Cyprus	1	0.81699939	0.90746087	0.97970279	0.93421168	0.92012157	0.88346456	0.86985578	0.81890834	0.78827593
Czech Republic	0.61560842	0.59782625	0.76608627	0.95073685	0.94529856	0.9094382	0.849024	0.87491749	0.8111115	0.78593571
Denmark	0.94317779	0.95301502	0.95100879	0.96425558	0.96985397	0.96880578	0.91134601	0.89753038	0.79450774	0.67916548
Finland	0.90778293	0.90746419	0.94466017	0.91897392	0.92407979	0.96322339	0.85988167	0.834764	0.82577719	0.82179713
France	0.94727577	0.94626131	0.95684428	0.97640475	0.9465164	0.93012089	0.90000635	0.87326159	0.81895295	0.82159294
Germany	0.91575031	0.91321365	0.93956582	0.97241571	0.94777022	0.93451743	0.89262679	0.86157806	0.81253143	0.81326464
Greece	0.97312751	0.97569819	0.90432364	0.83678937	0.85827039	0.87240666	0.93407173	0.93199545	0.7603645	0.7983322
Hungary	0.19341917	0.15555664	0.40774171	0.69381139	0.85670651	0.83860279	0.70599223	0.81432269	0.82059785	0.80356051
India	0.48428834	0.46576505	0.70461834	0.95916001	0.92671005	0.81098921	0.73407196	0.54008863	0.65114322	0.76714704
Indonesia	0.03927188	8.9115E-08	0.44204814	0.88290858	0.92552706	0.88540398	0.41221782	0.5028046	0.69766479	0.49679384
Ireland	0.92232954	0.92060132	0.93377799	0.96774851	0.94454956	0.93674473	0.90218305	0.91503073	0.87587914	0.8163975
Italy	0.93241704	0.93381752	0.9667672	0.98893556	0.94392669	0.92525152	0.89517867	0.88269857	0.82633941	0.81455862
Japan	0.9607008	0.96439049	0.96749672	0.96790603	0.95853114	0.97438438	0.93292104	0.90321379	0.85158213	0.85026282
Luxembourg	1	1	1	1	1	1	1	1	1	1
Malta	1	1	1	1	1	1	1	1	1	1
Netherlands	0.90593435	0.90877723	0.9371846	0.96107595	0.93692553	0.92901208	0.88319143	0.85439076	0.82535464	0.83083687
Poland	0.44168074	0.41777436	0.54859531	0.75129113	0.90557519	0.94915122	0.80998433	0.81407905	0.82778751	0.7988124
Portugal	0.86865245	0.87776995	0.92164088	0.96923997	0.97026237	0.95835033	0.89510286	0.87008141	0.81477101	0.80702033
Rep. of Korea	0.86414863	0.862836	0.89133341	0.94271303	0.9503047	0.95884806	0.87003445	0.82981703	0.7950808	0.78036187
Romania	0	0	0	0	0	0	0	0	0.81181192	0.64226025
Slovakia	0.53860084	0.51817744	0.38334305	0.62297671	0.93399266	0.86995566	0.80415314	0.81921793	0.82777693	0.78706765
Spain	0.8510754	0.84525662	0.9209235	0.99473448	0.93806656	0.9048098	0.87584699	0.87001381	0.79793785	0.78224261
Sweden	0.92040646	0.92537738	0.95249667	0.98180136	0.92399437	0.91906207	0.89742029	0.86073325	0.82350177	0.81905926
United Kingdom	0.95687106	0.96476436	0.96643254	0.9583169	0.94891527	0.96326189	0.90706094	0.89553349	0.84741965	0.8229068
United States	0.9251395	0.92588648	0.94963295	0.97276459	0.96654038	0.97122302	0.90616377	0.86921753	0.81506011	0.78536536

Notes:

Normalized and inverted;

For normalization, maximum volatility was reframed to 47.6191 to minimize effect of outliers;

Reframing maximum value effects Bulgaria from 1992-1998 and Romania from 1992-1999

Table A33: Cont.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0.89267827	0.87364385	0.78503149	0.70506051	0.7037202	0.80032045	0.64530464	0.25537366	0.36003727	0.53109344	0.71077152	0.93094003
0.93680212	0.94120638	0.84046448	0.75307175	0.75655133	0.80570643	0.64325898	0.3001673	0.39451769	0.57597246	0.66697744	0.9028858
0.99074683	0.94623569	0.89597018	0.79499834	0.72133668	0.81303333	0.71404149	0.40954344	0.43714681	0.44136637	0.62609935	0.9067139
0.59153462	0.96796304	0.82733551	0.66544719	0.69758507	0.49428901	0.49437796	0.49468624	0.53082867	0.67995252	0.74347787	0.89524714
0.90573627	0.91899977	0.85674267	0.77489172	0.71974056	0.84537998	0.68175997	0.28069282	0.41405014	0.58752428	0.73603873	0.90071243
0.89465997	0.94998131	0.64245621	1	1	1	1	1	1	1	1	1
0.68939582	0.5163916	0.68932305	0.74686167	0.68070942	0.83628261	0.65262201	0.21587856	0.37880906	0.51267979	0.68454458	0.97125184
0.80282952	0.85450169	0.80874902	0.74240831	0.7089151	0.67539758	0.78557615	0.66326662	0.52524656	0.61235693	0.62680104	0.74643314
0.92576376	0.94992313	0.86977833	0.74521524	0.68850914	0.80971805	0.74431545	0.44538559	0.47604447	0.50471813	0.63974694	0.91415782
0.95099998	0.95411345	0.84839128	0.73742925	0.71775166	0.81734984	0.69688063	0.35349514	0.45676278	0.50385514	0.6425248	0.96756498
0.93802715	0.93083261	0.84672843	0.75207632	0.71974852	0.83470268	0.63542213	0.22947073	0.38658814	0.54395457	0.67998278	0.96648351
0.94261281	0.9147089	0.91871369	0.77965754	0.7700847	0.93900465	0.6320512	0.28325323	0.421846	0.60687433	0.76143097	0.9217138
0.90855256	0.94430537	0.93867563	0.76155999	0.68078443	0.84334644	0.6388456	0.36253716	0.67258809	0.65720599	0.62574743	0.95066991
0.76858435	0.94094384	0.85798154	0.69326421	0.67711047	0.83440989	0.61633983	0.10440493	0.32286103	0.69435373	0.8072797	0.85475422
0.75708972	0.95076046	0.85343037	0.85016258	0.72055491	0.62762628	0.70829021	0.17963889	0.33365241	0.8029436	0.75814715	0.8247078
0.80838549	0.86262043	0.79702935	0.55772164	0.64118582	0.77715842	0.81849891	0.73891082	0.66553888	0.61272759	0.73997624	0.956894
0.93628741	0.93596612	0.86517633	0.774967	0.75126579	0.84028596	0.69660876	0.38502073	0.45718067	0.56533503	0.72942447	0.90440751
0.96707474	0.95159935	0.87638745	0.77105401	0.71183734	0.82350998	0.62892082	0.24705867	0.37899115	0.48820445	0.62412819	0.88690687
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
0.94146623	0.95534401	0.86902629	0.76196478	0.72262772	0.85280563	0.6990737	0.33111707	0.41982303	0.56276201	0.62162367	0.84907681
0.92767932	0.94188892	0.88960857	0.78650184	0.72632372	0.82348272	0.62153043	0.21249506	0.35347851	0.56481237	0.70058479	0.9198083
0.92381721	0.94106507	0.84945909	0.78118711	0.77349903	0.8353683	0.65476638	0.3141814	0.3946975	0.52785755	0.68232684	0.68630233
0.92283334	0.93920515	0.87838149	0.7704623	0.69715714	0.80621598	0.64041618	0.21874363	0.34970239	0.54242561	0.68370509	0.89040133
0.68154026	0.96224616	0.90065323	0.81907153	0.81840916	0.77097037	0.63556344	0.34883815	0.40108952	0.58197261	0.70584604	0.95515051
0.90899114	0.97648303	0.92270425	0.79122877	0.68120773	0.8011691	0.71232602	0.34368912	0.4040555	0.54029684	0.71566577	0.94706888
0.94075664	0.96178885	0.86991158	0.75846168	0.74188368	0.83367109	0.71654749	0.38492271	0.44317804	0.58641258	0.74901177	0.96745093
0.9332429	0.94502078	0.8762201	0.76640094	0.7324269	0.829887	0.79222947	0.50125687	0.45868688	0.5011302	0.62795433	0.82098805
0.94174518	0.90873592	0.8134324	0.70132008	0.62661843	0.67046115	0.52620189	0.33314314	0.5093684	0.56672719	0.70662453	0.79900503
0.9116607	0.93440219	0.86208825	0.80226289	0.80020686	0.87833178	0.6981143	0.36557762	0.47049055	0.64336285	0.78350335	0.91019974

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