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# Trade Partner Diversification and Growth: How Trade Links Matter

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# Trade Partner Diversification and Growth: How Trade Links Matter*

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**Abstract**

We analyze the effects of a country's export connections on its income growth using Trade Partner Diversification (TPD) measures that capture the country's relative importance in the international trade network. On top of the standard trade openness measures, TPD measures are shown to enter growth regressions positively and significantly, where one standard deviation increase in TPD is associated with a 1 to 1.5 percentage point increase in the annual growth rate. Threshold analyses show that TPD measures are positively and significantly correlated with growth in countries that have low financial depth, high inflation, low levels of human capital, or high trade openness.

**Keywords:** *Trade; Economic Growth; Export Networks; Thresholds; Cross-Country Analysis; Trade Partner Diversification*

**JEL Classification:** *F13, G20, O19*

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# 1 Introduction

Trade openness can support growth by providing access into large markets, low-cost intermediate inputs, and higher technologies. Empirical analyses of Frankel and Romer (1999), Irwin and Terviö (2002), and Wacziarg and Welch (2008) provide evidence for a robust, statistically significant, and positive effect of international trade on income growth. Nevertheless, measures for a country's trade openness and trade volume usually do not differentiate between trade partners so that two countries with the same trade volume but trading with different sets of countries are identical in the eyes of these measures.[1] We investigate in this paper whether and in what ways a country's connectivity in international trade matters in addition to its trade openness (measured by residual openness, to be defined below); hence, we ask: Does the way a country is connected within the web of international trade explain this country's per capita income growth above and beyond what can solely be explained by conventional measures of trade openness, and moreover, how does this connectivity correlate with growth in countries at different stages of economic and financial development?

We measure a country's connectivity by evaluating the overall position of this country in the web of international trade. This requires paying attention not only to trade partners of this country but also to trade partners of its trade partners, because a country's connectivity depends on quantity as well as quality of its trade partners. Although a country may have fewer trade partners than some other countries, it may still be deemed better connected than others if its trade partners are better connected than those of other countries. Similarly, between two countries that have the same number of trade partners, the one that has better connected trade partners is also deemed better connected than the other country. We employ conventional network centrality measures to capture the connectivity of a country and will refer to these centrality measures as *trade partner diversification (TPD)* measures throughout this paper.

[1] In order to have a better idea about the progress of such measures over time, consider Kali et al. (2007) who show that the share of total trade in the GDP for the average economy went from 58.3 percent in 1970 to 88.5 percent in 2003, while the average number of trading partners more than doubled as it went from 46.4 to 93.9 in that same period.

Using a cross-country panel data set for 83 countries, we first analyze whether TPD has any role in explaining growth, given the degree of trade openness together with other control variables. Such an investigation requires a measure for TPD, for which we consider three alternative definitions, all obtained by using international bilateral trade data. The baseline regression analysis, which is robust to endogeneity concerns, shows that TPD enters growth equations positively and significantly on top of the control variables, including the financial system (measured by financial depth), price stability (measured by inflation), human capital (measured by secondary education level), government size (measured by government expenditure as a percentage of GDP), per capita income level, and trade openness (measured by residual openness). Therefore, on average across all countries in the sample, there is a positive role of TPD on growth. A country's measures of TPD increase as this country gains access to more and/or better export markets—better in the sense that these export markets are well connected with the rest of the world.

Herzer (2013) finds, in addition to a positive and significant effect of trade on income, a large heterogeneity in this effect across countries. In order to take into account that countries having different macroeconomic conditions may be affected asymmetrically by their respective positions in the web of international trade regarding their growth, we investigate nonlinear effects of countries' positions in the international trade network using a threshold analysis. In particular, this methodology enables us to observe how coefficients of network measures change continuously over the whole range of other explanatory variables so that we do not need to consider discrete categories or interaction terms and we are able to prevent any potential problems of over-representation and biases created as a result thereof.

In our threshold investigation, we consider alternative sets of countries distinguished with respect to their financial system (measured by financial depth), price stability (measured by inflation), human capital (measured by secondary education level), government size (measured by government expenditure as a percentage of GDP), per capita income level, and trade openness (measured by residual openness). Our threshold analysis results show that TPD is positively and significantly correlated with the growth of countries that lack a developed financial system, price stability, or advanced human capital, after controlling for the degree of trade openness. Therefore, a plausible interpretation is that the TPD provides channels to hedge against a lack of financial development or human capital as well as against macroeconomic volatility borne by high inflation. This result is important especially for developing economies where, on average, financial depth is low, inflation is high, and human capital is low. Developing (or underdeveloped) countries that experience higher growth rates than their counterparts are those that are well connected to export markets or have export partners that are themselves well connected. Moreover, TPD positively and significantly correlates with the growth rate in countries that have large trade openness, which implies the importance of TPD in creating channels for a country to avoid vulnerability borne by the vulnerability of its trading partners. Finally, TPD correlates positively and significantly with growth irrespective of government size or per capita income level.

The rest of this paper is organized as follows: the next section provides a brief discussion of the underlying mechanisms and a review of the related literature. Section 3 introduces the measures of TPD. Section 4 introduces the trade data and presents descriptive statistics of the TPD measures. Results obtained from growth regressions and threshold analysis are shown and discussed in Section 5. We draw our conclusions in the last section.

## 2 How Trade Partner Diversification Works and Relations to the Existing Literature

Our paper follows the line of literature investigating the relationship between international trade and growth, using trade network indicators for the role and strength of a country in international trade. Kali and Reyes (2007) and Kali, Méndes, and Reyes (2007) provide the first set of very intriguing results, using network measures. Kali and Reyes (2007) use degree centrality and importance measures to capture a country's international economic integration in addition to its trade openness. They use rankings of countries according to these measures in their regression analysis and show that a country's ranking in either of these network measures is significantly correlated with its growth rate even after controlling for conventional measures of trade openness: e.g., a 10-unit increase in a country's rank in degree centrality is correlated with a 1.11 percentage point increase in income of that country. Moreover, they argue that the network position of a country substitutes for physical capital by making up for the lack of technology and at the same time complements human capital. Kali, Méndez, and Reyes (2007) investigate how degree centrality (what they refer to as the number of trading partners) and trade concentration (as measured by the Herfindahl-Hirschmann Index) correlate with growth in rich and poor countries. They find that the number of trading partners and trade concentration are positively correlated with growth across all countries; however, the former turns out to be more important for rich countries whereas the latter is more important for poor countries.

A related line of research has mainly focused on the relationship between economic growth and the diversification of goods exported. Kali et al. (2013) provide a powerful analysis using network density and proximity measures linking all internationally traded products and products traded by a country. They unravel interesting characteristics of the growth acceleration process: interactions of agglomeration externalities and proximity of products are shown to determine the likelihood of higher growth. Their findings also support those of Cadot et al. (2011) who show that a country travels along diversification cones as its income grows.[2] This line of literature focuses on sector-specific links and hence offers insights for possible effects of industry/goods-specific shocks on growth. However, as shown by Costello (1993) and Karadimitropoulou and León-Ledesma (2013) from a business cycle perspective through variance decomposition analyses, fluctuations in growth rates are dominated by country-specific shocks rather than industry/goods-specific shocks. Thus, our analysis using measures of TPD bridges an important gap between network structure of international trade and economic growth by focusing on country-specific rather than sector-specific links, which constitute an important transmission mechanism of global shocks to country-specific growth rates.

In our analysis, we employ degree centrality of a country in the international network,

[2]See Cadot et al. (2013) for an excellent survey on diversification of export goods and growth.

as Kali and Reyes (2007) and Kali, Méndez, and Reyes (2007) do,[3] and in addition, we employ measures of closeness centrality and eigenvector centrality. Whereas Kali and Reyes (2007) use rank of a country according to its degree centrality and importance, we prefer using numerical values of centrality measures in our regression and threshold analyses. Similar to these two papers, we show that network measures are positively and significantly correlated with growth even after controlling for trade openness. In addition to it, we show that this canonical finding still holds after controlling for finance, inflation, and government spending of countries. We further advance this line of literature by providing an investigation of *nonlinear relationships* between a country's position in the international trade network and its growth rate, using *threshold analysis* with respect to various explanatory variables of the growth equation.

In the theoretical literature, the positive effects of trade on growth are well established. One channel through which these positive effects work is the transmission and creation of knowledge, as shown in studies by Romer (1990), Grossman and Helpmann (1993), and Rivera-Batiz and Romer (1991). In particular, countries that are involved in trade are exposed to new ideas, designs, and technologies, together with innovative managerial decisions. Accordingly, when a country has a larger trade network, such knowledge spillovers would increase, where size of a country's trade network is measured by the number of direct or indirect (more than one geodesic distance apart) trade partners. While the direct partnership would have an impact on growth through the trade of final goods, the indirect partnership would have an impact through the trade of intermediate goods or re-exports.

Another channel for an exporting country is by getting exposed to different potential buyers because different buyers may have alternative consumer tastes, government regulations, or climate. Accordingly, an exporter country would invest more in local research and development strategies, such as innovation, brand recognition, and patent registrations. As an exporting country gets involved in a larger trade network, such destination-specific requirements, either for final goods or intermediate goods, would result in a wider range of

[3]Kali et al. (2007) cover years between 1980 and 2000 in their empirical analysis, and Kali and Reyes (2007) focus on the period from 1987 to 1998.

research and development, which, in turn, would positively affect the overall productivity of the exporter country. Another channel is through the competition in the destination markets (see Vickers and Yarrow, 1991; Bourbakri and Cosset, 1998). As an exporter country gets involved in a larger trade network, the complexity of the competition would increase for both direct trade partnerships (through final goods) and indirect trade partnerships (through intermediate goods).

The magnitudes of the above-mentioned channels are, however, subject to the changes in the macroeconomic environment or shocks, especially exchange rate fluctuations between the exporting country and (both direct and indirect) trade partners. Accordingly, this paper is also connected to the literature based on strategic hedging for exchange rate volatility through diversification (see Hitt et al., 2006; Hoskisson and Hitt, 1990; Ito, 1997; Meyer, 2006). In particular, consider two extreme countries with the same level of trade openness, the first with only one direct trade partner and the second with many direct and indirect trade partners. The export of the first country would highly depend on economic volatilities (mostly reflected in the exchange rates) in the unique destination country. Hence, in the case of a crisis in the destination country, the first country would need additional resources in order to cope with such a reduction in its exports. If the first country has a developed financial system, low inflation (i.e., low uncertainty in its domestic economy), or high human capital, the economic loss due to the reduction in exports can be compensated by additional credits (due to the developed financial system) that can be provided without any uncertainty (due to the low inflation) in order to sustain and promote economic growth. However, if the first country does not have such characteristics, its growth would be affected adversely in this case. Consider the second country in the example above having a similar problem in one of the countries that it is exporting to (i.e., one of the direct trade partners) or that its trading partner is exporting to (i.e., one of the indirect trade partners). Even without any developed financial system, low inflation, or high human capital, the second country would be affected much less by the economic volatility in any of its trade partners.

In light of the above example, an expected result of a cross-country analysis (as we also run in this paper) would be that trade networks compensate for low levels of financial depth, high levels of inflation, and low levels of human capital. The existing literature also supports this expectation. For instance, Aghion et al. (2009) show that exchange rate volatility can stunt growth of a country when its financial development is low. Similarly, Gylfason (1999) suggests that inflation hurts growth through lower ratios of exports to output;[4] and Kali and Reyes (2007) show that a country's integration to the international economy may complement its human capital, however, significance of such complementarity depends on the particular integration measure being employed in their analysis.

Accordingly, a country's TPD in international trade can be used as a proxy for two important macroeconomic characteristics of this country: first, a country that enjoys a high quantity and/or high quality of trading partners may find it easier to substitute for financial development by hedging, diversifying, and pooling risk arising from exchange rate volatility because exchange rate risk is distributed among its trading partners.[5] Moreover, high and variable inflation may create considerable uncertainty about future prices, interest rates, and exchange rates, which, in turn, increases the overall risk of business among trade partners due to the possibility of a devaluation and vulnerability to speculative attacks.[6] TPDs of trade partners show how such risks are distributed among trade partners because the possibility of a bilateral depreciation (with respect to one currency) is much higher than the possibility of a multilateral depreciation (with respect to a basket of currencies consisting of the currencies of the trade partners). Second, good connectivity can compensate for international shocks that may arise due to having higher degrees

[4]These effects are also subject to firm-level strategies, such as sequential export entry (see Albornoz et al., 2013). In particular, many firms enter new international markets to increase their sales through exports by accepting to pay high sunk costs. However, such costs are worthwhile to pay when they expand their exports to alternative countries through the trade network. Therefore, if the first destination market that is being entered (i.e., the central/hub country through direct trade partnership) is already involved in a good trade network due to its trade partners (i.e., if the source country has a good indirect trade partnership), the exporting firm/country would benefit more from it.

[5]Bailliu et al. (2003) have shown that exchange rate risk is reduced when exports are diversified across markets. See Levine (1997) for the relationship between finance and trade.

[6]See Rousseau and Wachtel (2002) for a discussion on the channels through which inflation may negatively affect growth.

of trade openness.[7] As shown by Svaleryd and Vlachos (2002), trade openness increases income volatility, and thus better diversification of risk is needed. A country with a high score of TPD is likely to find it easier to achieve such diversification.

# 3 Measuring Trade Partner Diversification

In this section, we explain how TPD measures are obtained, we discuss their various aspects, and we provide interpretations with the help of a simple example. The collection of bilateral trade links between countries yields the basic structure of the web of international trade. Links between pairs of countries at time $t$ are captured by the adjacency matrix $\mathbf{A(t)}$ where an element $a(t)_{ij}$ is defined as follows:

$$a(t)_{ij} = \begin{cases} 1, \text{ if there is export of goods from country } i \text{ to country } j \\ 0, \text{ if there is no export of goods from country } i \text{ to country } j \end{cases}$$

We employ *export degree*, *export closeness*, and *export eigenvector (centrality)* to measure a country's TPD. Suppose there are $n$ countries at time $t$ in the international trade network. The fraction of country $i$'s existing export links to the total number of countries (excluding itself) is the *export degree* of country $i$, and we denote it by $ED(t)_i$ such that

$$ED(t)_i = \frac{1}{n-1} \sum_j a(t)_{ij}$$

Export degree takes on values from zero to one: $ED(t)_i = 1$, if country $i$ is exporting to every possible country in the international trade network at time $t$, and $ED(t)_i = 0$, if country $i$ does not export anywhere.

The distance between any two countries $i$ and $j$ in the international trade network is the *geodesic distance* measured by the length of the shortest path connecting the two countries; if country $i$ is exporting to country $j$, then the distance from $i$ to $j$ is one. If country $i$ does not export to country $h$ but it exports to country $j$, and country $j$ exports

[7] See Rodrik (1998) who has emphasized the role of international fluctuations (imported through trade openness) in growth.

to country $h$, then the distance from country $i$ to country $h$ is two.[8] Such linkages are especially important in order to consider the effects of intermediate-input trade, which is mostly discussed in the literature under the title of "Trade in Value-Added and Global Value Chains," which is also given utmost consideration by World Trade Organization.[9] All such bilateral distances in the international trade network at time $t$ are collected in the distance matrix $\mathbf{D(t)}$ where an element $d(t)_{ij}$ is the distance from country $i$ to country $j$ following export links in the international trade network. *Export closeness* of country $i$ at time $t$ is calculated by

$$EC(t)_i = \frac{n-1}{\sum_j d(t)_{ij}}$$

and it takes on values from zero to one, increasing as a country gets *closer* to the rest of the world. *Export closeness* adds valuable information on top of what we already know from the *export degree* of a country. Not only do we care whether there is direct trade between country $i$ and the rest of the world, we also care for the geodesic distance from country $i$ to countries that are not its direct trade partners. Thus, *export closeness* gives a country credit for having access to the export market of a country that itself has access to other export markets that the former country does not have.

The third measure we employ in our analysis is the *export eigenvector* of countries in the international trade network, as developed by Bonacich (1987). The export eigenvector captures the idea that the centrality of a country must be proportional to the centrality of countries where it exports to. This is also referred to as the *prestige* or *influence* (Newman,

[8]If countries $i$ and $j$ are not connected by any collection of edges, then the distance is assumed to be infinite, but it remains a practical issue as to how big "infinity" should be. For our empirical analysis we take the infinite distance to be the equivalent of a geodesic of 10. It is important to emphasize that this specific value does not affect our growth regression results in the next section. We check its robustness by using two alternative distances to capture infinity, namely 5 and 100. Comparing coefficient estimates using 5, 10, and 100 we find that these are qualitatively the same and quantitatively very similar. Details of estimations using 5 and 100 as the infinite geodesic distance are available upon request.

[9]The related theoretical and empirical studies are surveyed in a recent study Johnson (2014) who shows that intermediate inputs (i.e., the part of exports that has not been produced in the source country) range between 10 percent (Russia) and 50 percent (Taiwan). Please see https://www.wto.org/ for more details.

2010). According to this measure, not only the total number of direct links is important but also the *prestige* of those links counts; for a high score of the export eigenvector, a country should be connected to countries that are also well connected and thus have high *prestige*. Countries that are exporting to trade partners that have a high score of the export eigenvector (hence high *prestige*) are in a better position to diversify and minimize country-specific risks affecting international trade because their trade partners are in a better position to do so as well.

Next, we provide a simple example for the international trade network, where we apply these three centrality measures and discuss what they capture. We further show how these measures evolve as new trade links are established. Suppose the world consists of eight countries and exports flow between these countries as depicted in Figure 1.

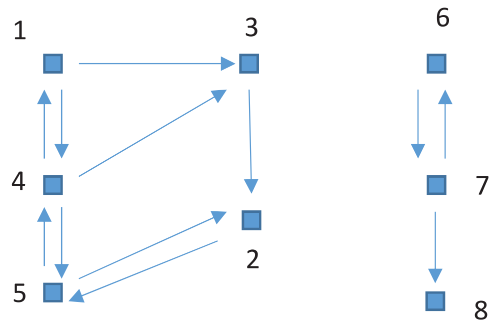


Figure 1: Export flows between eight countries

The direction of an arrow from one country to another shows the direction of export flow between these countries, e.g., country 1 is exporting to countries 3 and 4, but country 1 imports only from country 4. There are two blocks that are not interconnected: countries 1 to 5 make up one block and countries 6, 7, and 8 make up the other. Since these two blocks are not interconnected, the distance between them is *infinite*. We calculate our *TPD* measures for these eight countries and present the results in Table 1.

Table 1: Network centralities as TPD measures

| Country | Export Degree | Export Closeness | Export Eigenvector |
|---|---|---|---|
| 1 | 0.29 | 0.194 | 0.45 |
| 2 | 0.14 | 0.179 | 0.29 |
| 3 | 0.14 | 0.175 | 0.16 |
| 4 | 0.43 | 0.2 | 0.64 |
| 5 | 0.29 | 0.194 | 0.52 |
| 6 | 0.14 | 0.132 | 0 |
| 7 | 0.29 | 0.135 | 0 |
| 8 | 0 | 0.1 | 0 |

*Export degree* captures the overall export market access of a country: country 4 exports to 43% of all countries, while country 8 is not exporting anywhere. Countries 1, 5, and 7 have the same export degree, but according to the *export closeness*, country 7 is *further away* from the rest of the world than countries 1 and 5. This follows from the positioning of country 7; it exports to countries that are not connected to any other country besides country 7.

*Export eigenvector* is increasing in a country's export degree and the connectivity of its trade partners. Countries 2 and 3 have an identical export degree and very close export closeness. When it comes to the export eigenvector, country 2 has a better measure, which reveals that countries that import from country 2 are themselves exporting either to a lot of countries or to key exporters. Although countries 1 and 5 have the same export degree and closeness, country 5 is a more important player in the international trade network than country 1 according to the export eigenvector measure. Countries 6, 7, and 8 have a zero export eigenvector because they are not connected to any important exporter.[10]

[10]It is possible to avoid obtaining a zero export eigenvector by assuming a base *prestige* for each country. This is especially helpful if the network consists of many small components. This is not observed in international trade data so that a strictly positive base *prestige* would not have a meaningful effect on our empirical analysis.

Next, we illustrate how new export links change our TPD measures. Suppose that country 2 starts exporting to country 8, and after a while country 8 starts exporting to country 2. These new export links are depicted in Figure 2 panels (a) and (b).

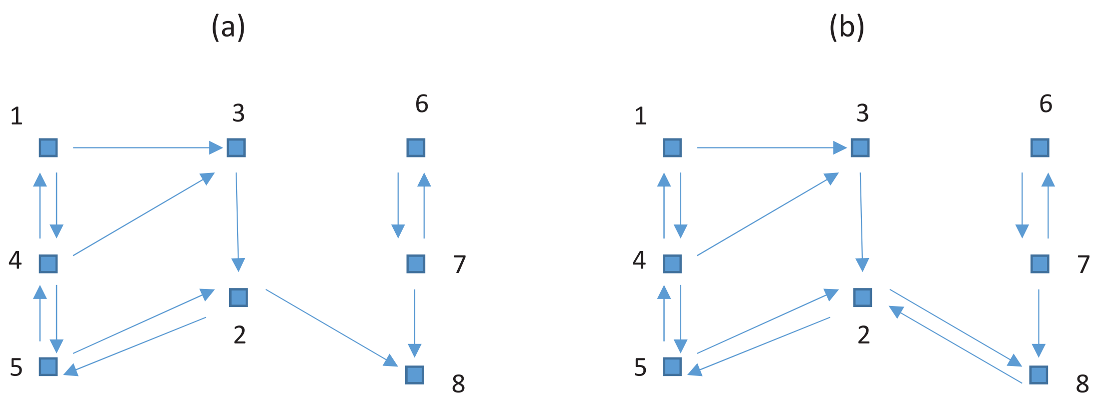


Figure 2: Export flows between eight countries, including exports from country 2 to country 8

Table 2: Revised TPD measures

| Country | Export Degree (a) | Export Degree (b) | Export Closeness (a) | Export Closeness (b) | Export Eigenvector (a) | Export Eigenvector (b) |
|---|---|---|---|---|---|---|
| 1 | 0.29 | 0.29 | 0.24 | 0.24 | 0.45 | 0.41 |
| 2 | 0.29 | 0.29 | 0.23 | 0.23 | 0.29 | 0.37 |
| 3 | 0.14 | 0.14 | 0.218 | 0.219 | 0.16 | 0.19 |
| 4 | 0.43 | 0.43 | 0.25 | 0.25 | 0.64 | 0.58 |
| 5 | 0.29 | 0.29 | 0.25 | 0.25 | 0.52 | 0.5 |
| 6 | 0.14 | 0.14 | 0.132 | 0.26 | 0 | 0.07 |
| 7 | 0.29 | 0.29 | 0.134 | 0.33 | 0 | 0.14 |
| 8 | 0 | 0.14 | 0.1 | 0.21 | 0 | 0.19 |

Table 2 lists our revised TPD measures for each country based on their position in the international trade network. Each measure has two columns (a) and (b), corresponding to networks depicted in panels (a) and (b), respectively, of Figure 2. When country 2 starts exporting to country 8, this directly affects the export degree of country 2. Moreover, closeness of most countries is being affected positively. It is worth mentioning that the new export link does not affect the eigenvector measure of any country. This is simply because the exporter, country 2 in this case, is not getting any *prestige* from exporting to country 8 because country 8 itself has no *prestige*.

When country 8 starts exporting to country 2, this leads to several curious changes in eigenvector centralities: country 2's import demand generates *prestige* for country 8. Since country 8 now has *prestige*, i.e., a non-zero export eigenvector, this also leads to non-zero export eigenvectors for countries 6 and 7. Changes in the export eigenvector are very sensitive to the case that a low *prestige* country starts exporting, especially to a *prestigious* trade partner or equivalently if this trade partner is a member of a large trading block.

# 4 Trade Data and International Trade Networks

Our trade data set contains bilateral trade flows between 83 countries from 1965 to 2004; this is a subset of the trade data set of Rose and Spiegel (2011) that covers the annual real FOB exports.[11] The list of countries is given in the note under Table 3. In this section, we describe how the TPD measures evolve over time for a selected group of countries. It is not the aim of this paper to provide a full discussion of the international trade network[12]. Our aim for this section is to provide insight to how the TPD measures evolve over time for different countries because patterns of these measures are important for the subsequent econometric analysis and interpretation of our results in the next section. Arribas et al. (2009) document an overall increasing trend in direct trade connections between countries and also find that *indirect or higher order* connections reveal distinct and varying patterns

[11] We focus on this subset to be consistent with our growth data set, which we document below.

[12] See De Benedictis and Tajoli (2011) for a recent and detailed description of the international trade network with implications on trade structure. Also see Serrano and Boguña (2003) for an analysis of complex network properties observed in the international trade network.

across countries. In the context of our analysis, export degree captures direct export links between countries, whereas export closeness and export eigenvector are measures that capture the strength and influence of such indirect connections.

In this section, we briefly describe the positions of the United States, Brazil, and Israel in the international trade network based on their export connections. Being a rich and large country, the US has been one of the most important players in world trade. Brazil and Israel are developing countries that differ by the characteristics of their trade in goods; Brazil has long been an exporter of raw materials and agricultural products, whereas Israeli exports rely on capital-intensive manufactures. A common pattern for export degree and export closeness is that both display an increasing trend over time for most countries in our data set. The export eigenvector reveals an interesting pattern. As discussed in the previous section, well-connected countries lose network *prestige* measured in the export eigenvector as the rest of the trade network establishes further links to outsiders. This trend is obvious for the US. Since Brazil and Israel rose later in world trade, their trade network centrality measures reveal different patterns.

The US is one of the most important players in international trade, and this importance clearly manifests itself in its TPD measures shown in Figure 3. The US was exporting to about 75% of the countries that are contained in our data for 1965, and to more than 95% of countries in 2004. Connecting to different trade partners and hence establishing more links necessarily cuts down the overall distance of the US to other countries, which leads to a higher centrality measure over years. The decrease in the export eigenvector of the US in the 1980s captures the fact that the world trade network kept growing in this decade and export markets of the US lost their relative importance and *prestige*, which in turn led to the US losing its importance and *prestige* in the international trade network measured by the export eigenvector.

Trade network measures for Brazil reveal an even more interesting story, as shown in Figure 4. Brazil's export markets made up 40% of countries that were actively trading in 1965, and in 2004, Brazil's exports reached about 90% of countries. Although the trend of the degree centrality measure has been increasing and is thus similar to that of the US in that respect, its relative change from 40% to more than 90% is impressive. The increase

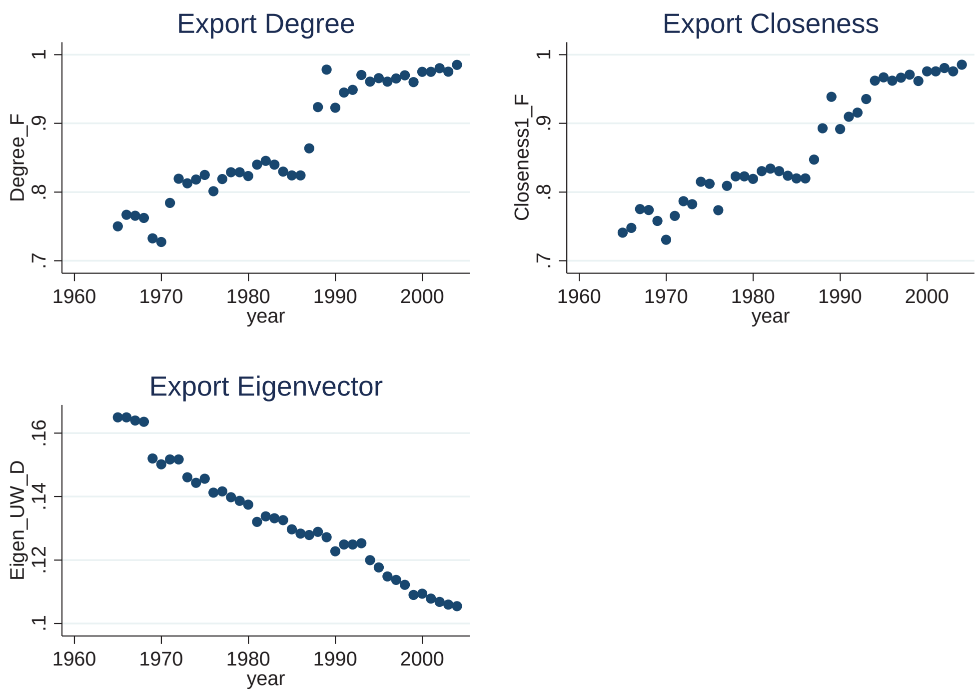


Figure 3: Trade Network Centralities for the United States, 1965-2004

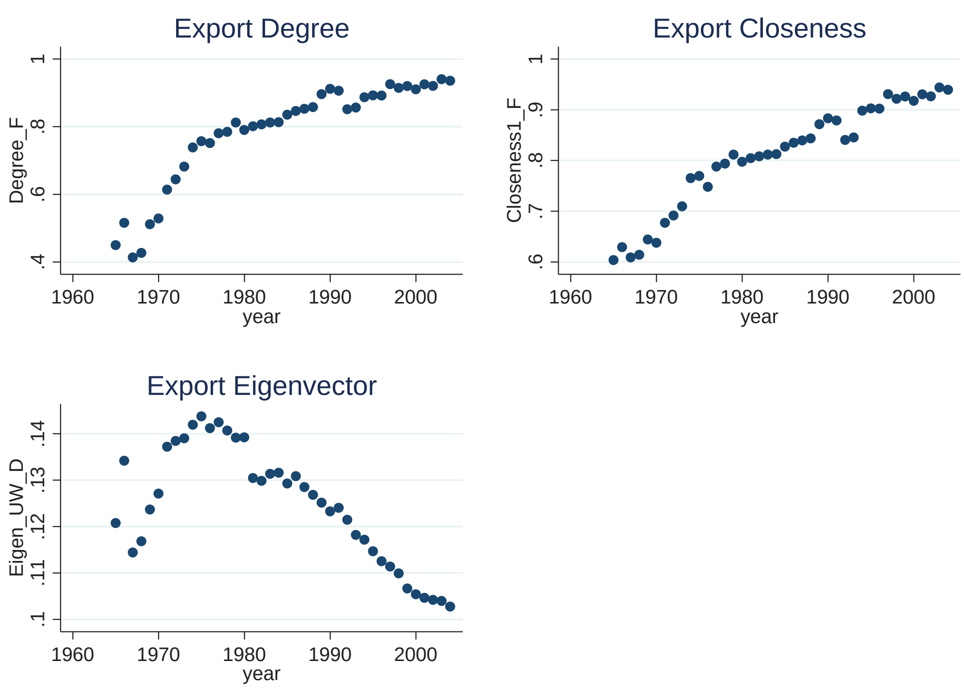


Figure 4: Trade Network Centralities for Brazil, 1965-2004

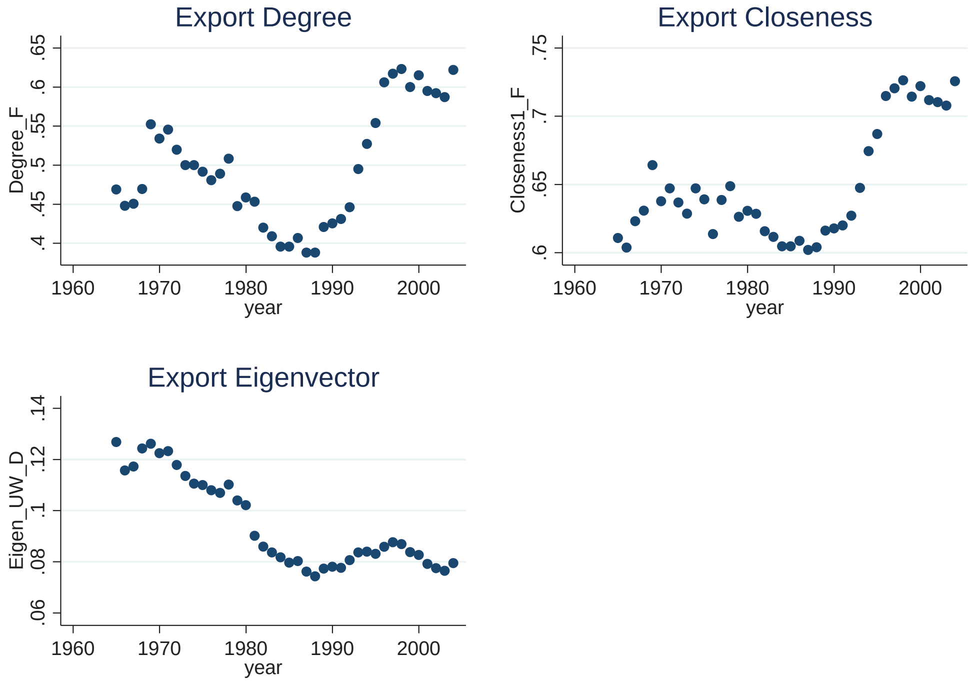


Figure 5: Trade Network Centralities for Israel, 1965-2004

in Brazil's export eigenvector during the 1960s and 1970s shows that Brazil gained access to *prestigious* markets in these years.

Export market access of Israeli goods experienced a downward trend from 1970 until the late 1980s, as revealed by the degree centrality (see Figure 5). During the same period, the export eigenvector for Israel decreased as well. The decrease in the export eigenvector turned out to be strong because the downward trend is fed by two factors simultaneously: first, the world trade network is becoming more dense over time, and this creates downward pressure on a country's export eigenvector, even if a country keeps its share of access to the world's export markets from previous periods. Second, even if the world trade network remained stable except for one country that loses its existing export links, this country is bound to lose its *prestige* as captured by the export eigenvector.[13] In

[13]One possibility to see whether a country's export eigenvector is declining due to an expanded world trade or a reduction in trading relationships is to take a closer look at the co-movements of the TPD measures in our dataset. In 1,056 observations (that is 33% of all observations) the decrease in export eigenvector is accompanied by a decrease in export degree and closeness as well, and in 516 (16%) we

the Israeli case, the world trade network grows more dense (most countries establish new export links and their export degree increases), and the export degree of Israel decreases at the same time; thus, the two forces mentioned above work in the same direction and lead to an even stronger decrease in its export eigenvector.

# 5 Growth Data and Baseline Growth Regressions

An almost standard empirical framework has emerged since Barro (1991) and Levine and Renelt (1992) introduced cross-country regression as an empirical representation of the Solow growth model because new growth theories suggest that trade policy affects growth through its impact on technological change (i.e., Solow's residual).[14] The growth data set was constructed for 83 countries covering the period 1965-2004 as a panel of country observations from the World Bank's World Development Indicators and International Monetary Fund's Direction of Trade CD-ROM. The list of countries is the same as the one that we have for the trade data, which can be found in the note under Table 3.

We present descriptive statistics of variables in our analysis and their correlations in Table 3. As is evident, TPD measures are positively correlated with per capita income growth and with each other; however, they are not correlated (either negatively or positively) with trade openness. A possible explanation for the low correlation between trade openness and TPD measures is the following: since TPD measures are based on unweighted trade networks and don't depend on the volume or scale of exports whereas trade openness does, it is possible that two countries have similar positions in the international trade network and yet their trade volumes are completely different. Hence TPD measures are expected to have significant effects on growth on top of the trade openness measure, which is also positively correlated with per capita income growth. Nevertheless, these are just descriptive statistics, and next we employ a formal econometric analysis to show the effects of TPD measures.

Following Barro (1991) and Levine and Renelt (1992), the baseline growth equations

observe that the export eigenvector decreases whereas export degree and closeness increase.

[14]See, for example, Grossman and Helpman (1993) and Harrison (1996).

Table 3: Descriptive Statistics, 1965-2004, 83 Countries

| Variable | Per capita income growth (%) | Trade Openness | Finance (M3, % GDP) | Inflation (%) | Log of initial SEC (%) | Gov't (% GDP) | Log of initial GDP | Export Degree | Export Closeness | Export Eigenvector |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 1.78 | 53.68 | 45.59 | 12.75 | 3.65 | 14.44 | 7.65 | 48.85 | 65.84 | 8.56 |
| Maximum | 11.66 | 113.20 | 184.03 | 86.25 | 4.96 | 40.59 | 10.73 | 97.81 | 97.85 | 16.70 |
| Minimum | -9.27 | 8.92 | 4.15 | 0.49 | 0.00 | 4.36 | 4.97 | 0.00 | 10.00 | 0.00 |
| Standard deviation | 2.68 | 10.43 | 28.48 | 13.48 | 0.84 | 5.26 | 1.48 | 25.78 | 14.09 | 3.49 |
| Coefficient of Variation | 1.51 | 0.19 | 0.62 | 1.06 | 0.23 | 0.36 | 0.19 | 0.53 | 0.21 | 0.41 |
| *Correlations* | | | | | | | | | | |
| Per capita income growth (%) | 1.00 | | | | | | | | | |
| Trade Openness | 0.16 | 1.00 | | | | | | | | |
| Finance (M3, % GDP) | 0.25 | 0.05 | 1.00 | | | | | | | |
| Inflation (%) | -0.20 | 0.05 | -0.25 | 1.00 | | | | | | |
| Log of initial SEC (%) | 0.19 | 0.00 | 0.53 | 0.01 | 1.00 | | | | | |
| Government (% GDP) | -0.04 | -0.01 | 0.33 | -0.16 | 0.33 | 1.00 | | | | |
| Log of initial GDP | 0.18 | 0.00 | 0.52 | -0.11 | 0.71 | 0.43 | 1.00 | | | |
| Export Degree | 0.25 | 0.03 | 0.54 | -0.16 | 0.60 | 0.27 | 0.61 | 1.00 | | |
| Export Closeness | 0.21 | 0.04 | 0.49 | -0.16 | 0.55 | 0.24 | 0.55 | 0.95 | 1.00 | |
| Export Eigenvector | 0.34 | 0.00 | 0.43 | -0.10 | 0.49 | 0.23 | 0.59 | 0.88 | 0.80 | 1.00 |

*Source*: Authors' analysis based on data sources discussed in the text.

*Notes*: The list of 83 countries is as follows: Algeria, Argentina, Australia, Austria, Bangladesh, Barbados, Belgium, Bolivia, Brazil, Cameroon, Canada, Central African Republic, Chile, Colombia, Costa Rica, Cote d'Ivoire, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Finland, France, Gambia, Ghana, Greece, Guatemala, Guyana, Haiti, Honduras, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea Rep., Luxembourg, Malawi, Malaysia, Malta, Mauritius, Mexico, Morocco, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Rwanda, Senegal, Sierra Leone, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Thailand, Togo, Trinidad and Tobago, Turkey, United Kingdom, United States, Uruguay, Venezuela, Zimbabwe.

include a standard set of explanatory variables that provide robust and widely accepted proxies for growth determinants. The dependent variable is the growth rate of real per capita income averaged over 5-year periods from 1965 to 2004. On top of the TPD measures[15], the baseline regression analysis includes standard explanatory variables, such as log initial per capita GDP, log initial secondary enrollment rate (SEC), the ratio of liquid liabilities (i.e., M3) to GDP, inflation rate, trade openness, and government size. In order to consider the effects of trade policies (rather than the volume of trade that is endogenous to within-country variations in per capita GDP), consistent with earlier studies, such as by Balassa (1985), Leamer (1988), Syrquin and Chenery (1989), and Edwards (1992), who have considered the deviation of actual from predicted trade flows in their growth regressions, we measure trade openness as residual openness that is obtained as residual from the regression where exports plus imports over GDP are regressed on per capita income, country-fixed effects, and time-fixed effects.[16]

As discussed in detail by Kali et al. (2007), although income growth may affect the change in trade network, there is no reason to believe that growth affects the level of trade network. Nevertheless, we use two-stage least squares (TSLS) to control for any potential endogeneity, where initial values of the corresponding variables (i.e., trade network, finance, inflation, trade openness, and government size) are used as instruments in the first stage for each 5-year period. The usage of initial values as instruments is based on the assumption that they are exogenous, since they are predetermined. However, since such an assumption may not be valid as discussed in studies such as by Brock and Durlauf (2001), we support our investigation with state-of-the-art tests of under-identification, weak-identification, and weak-instrument-robust inference. Moreover, since ordinary least squares (OLS) is more efficient when variables are exogenous, we also perform a standard endogeneity test.

Time-fixed effects for 5-year periods are also included to control for shocks with common growth effects across countries. For robustness, country-fixed effects are also consid-

[15]TPD measures in raw form take values between zero and one. We scale these measures by 100 when we use them in our regression analysis.

[16]We also considered the raw trade openness measure of exports plus imports over GDP; the results were virtually the same. Such results are available upon request.

ered in order to capture any country-specific characteristics that are constant over time, such as their geographic location or historical experience/institutions.[17]

Accordingly, regression results are shown in Table 4 where country-fixed effects are excluded in the benchmark case. As is evident, all TPD measures are positive and significant at the 1% level, with or without the trade openness measure included in the regressions. All other control variables have their expected signs, although inflation is the only variable that is insignificant at any considered level. We present regression results without TPD measures in column (1), and as can be seen, signs and significances of other explanatory variables do not change when TPD measures are included in the analysis. When country-fixed effects are also included for robustness, as shown in Table 5, all TPD measures are again positive and significant at the 1% level, although some of the control variables have changed their estimated signs and/or significance. In sum, robust to the inclusion of country-fixed effects, trade openness, and other control variables, TPD measures are significant and positive in all considered cases.

When we perform endogeneity tests by using the null hypothesis that variables are exogenous, we obtain the results (in terms of $p$-values) given in Table 4 and Table 5, which are mixed. Since OLS is more efficient when variables are exogenous, in order to give the reader a better insight, we also replicated the results in Table 4 and Table 5 by using OLS in Appendix Table A.1 and Table A.2, respectively. As is evident, the estimated coefficients are virtually the same qualitatively and very similar quantitatively when OLS is used instead of TSLS.

We run further state-of-the-art tests of under-identification, weak-identification, and weak-instrument-robust inference in order to test the validity of our instruments and document their results in Appendix Table A.3 and Table A.4. Regarding under-identification, we use the Kleibergen-Paap *rk* LM test. The null hypothesis that the estimated equation is under-identified is rejected for all the TSLS regressions that we have run at the 1

[17] In order to make a comparison with the existing literature, Kali et al. (2007) have also considered IV regressions where they have instrumented trade networks with country-specific measures, such as physical access to international waters or tropical climate. Since these are mostly time-invariant country-specific variables, our methodology involving country-fixed effects is comparable to the one in Kali et al. (2007).

Table 4: Instrumental variables growth regressions, 1965-2004, 83 Countries

| | Dependent Variable: Growth of Per Capita Income (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Export Degree | | 0.0215*** | | | 0.0203*** | | |
| | | (0.00622) | | | (0.00612) | | |
| Export Closeness | | | 0.0396*** | | | 0.0367*** | |
| | | | (0.0111) | | | (0.0109) | |
| Export Eigenvector | | | | 0.161*** | | | 0.159*** |
| | | | | (0.0449) | | | (0.0441) |
| Trade Openness | 0.0326** | | | | 0.0327** | 0.0324** | 0.0343** |
| | (0.0117) | | | | (0.0115) | (0.0115) | (0.0115) |
| Finance (M3, % GDP) | 0.0208*** | 0.0181*** | 0.0184*** | 0.0186*** | 0.0170*** | 0.0174*** | 0.0172*** |
| | (0.00490) | (0.00504) | (0.00502) | (0.00499) | (0.00497) | (0.00494) | (0.00491) |
| Inflation (%) | -0.0168 | -0.00847 | -0.00883 | -0.0106 | -0.0132 | -0.0136 | -0.0154 |
| | (0.0109) | (0.0111) | (0.0111) | (0.0110) | (0.0109) | (0.0109) | (0.0107) |
| Government (% GDP) | -0.0728** | -0.0667** | -0.0667** | -0.0649** | -0.0685** | -0.0685** | -0.0666** |
| | (0.0243) | (0.0244) | (0.0244) | (0.0243) | (0.0240) | (0.0240) | (0.0239) |
| Log of initial GDP | -0.191 | -0.330** | -0.327** | -0.307* | -0.321** | -0.316** | -0.304* |
| | (0.117) | (0.124) | (0.123) | (0.121) | (0.122) | (0.121) | (0.119) |
| Log of initial SEC (%) | 0.999*** | 0.839*** | 0.880*** | 0.770*** | 0.872*** | 0.912*** | 0.799*** |
| | (0.211) | (0.216) | (0.214) | (0.219) | (0.213) | (0.211) | (0.215) |
| F-test (Endogeneity) | 0.0821 | 0.0395 | 0.0463 | 0.0318 | 0.1122 | 0.1381 | 0.0957 |
| *R*-bar Squared | 0.265 | 0.259 | 0.259 | 0.266 | 0.282 | 0.281 | 0.290 |

*Source*: Authors' analysis based on data sources discussed in the text.

*Notes*: +, *, ** and *** indicate significance at the 10%, 5%, 1% and 0.1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Network measures are five-year averages; their initial values in each five-year period are used as instruments for the corresponding five-year averages. All equations also include time fixed effects that are not shown. Estimation is by two-stage least squares. The sample size in each equation is 464. Endogeneity (p-value) shows p-values of the regression-based endogeneity test results regarding the null hypothesis that variables are exogenous.

Table 5: Instrumental variables growth regressions with country-fixed effects, 1965-2004, 83 Countries

| | Dependent Variable: Growth of Per Capita Income (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Export Degree | | 0.0585*** | | | 0.0518*** | | |
| | | (0.0142) | | | (0.0139) | | |
| Export Closeness | | | 0.100*** | | | 0.0893*** | |
| | | | (0.0203) | | | (0.0199) | |
| Export Eigenvector | | | | 0.293*** | | | 0.280** |
| | | | | (0.0887) | | | (0.0859) |
| Trade Openness | 0.0351*** | | | | 0.0344*** | 0.0340*** | 0.0373*** |
| | (0.00952) | | | | (0.00941) | (0.00938) | (0.00937) |
| Finance (M3, % GDP) | -0.0159 | -0.00897 | -0.0131 | -0.00716 | -0.0143 | -0.0179+ | -0.0129 |
| | (0.0108) | (0.0108) | (0.0108) | (0.0109) | (0.0107) | (0.0106) | (0.0107) |
| Inflation (%) | -0.0120 | -0.00533 | -0.00678 | -0.00408 | -0.0146 | -0.0158 | -0.0145 |
| | (0.0139) | (0.0142) | (0.0142) | (0.0142) | (0.0137) | (0.0137) | (0.0137) |
| Government (% GDP) | -0.0914* | -0.0808+ | -0.0956* | -0.0640 | -0.0863* | -0.0994* | -0.0703+ |
| | (0.0423) | (0.0430) | (0.0427) | (0.0439) | (0.0418) | (0.0415) | (0.0425) |
| Log of initial GDP | -2.564*** | -3.503*** | -3.326*** | -2.863*** | -3.346*** | -3.193*** | -2.790*** |
| | (0.522) | (0.567) | (0.544) | (0.535) | (0.554) | (0.531) | (0.520) |
| Log of initial SEC (%) | -0.993** | -1.118** | -1.124** | -1.314*** | -1.052** | -1.058** | -1.239*** |
| | (0.371) | (0.377) | (0.375) | (0.387) | (0.366) | (0.365) | (0.375) |
| Endogeneity (p-value) | 0.2207 | 0.1566 | 0.0655 | 0.2424 | 0.3630 | 0.2525 | 0.4747 |
| *R*-bar Squared | 0.420 | 0.403 | 0.409 | 0.399 | 0.434 | 0.439 | 0.434 |

*Source*: Authors' analysis based on data sources discussed in the text.

*Notes*: +, *, ** and *** indicate significance at the 10%, 5%, 1% and 0.1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Network measures are five-year averages; their initial values in each five-year period are used as instruments for the corresponding five-year averages. All equations also include country fixed effects and time fixed effects that are not shown. Estimation is by two-stage least squares. The sample size in each equation is 464. Endogeneity (p-value) shows p-values of the regression-based endogeneity test results regarding the null hypothesis that variables are exogenous.

percent significance level.

Regarding weak-identification, we use the Cragg-Donald Wald $F$-test and the Kleibergen-Paap Wald $rk$ $F$-test; both have the null hypothesis that the estimated equation is weakly identified. The corresponding test statistic is based on the rejection rate $r$ that is to be tolerated if the true rejection rate is the standard 5 percent. In this context, weak instruments are defined as instruments that lead to a rejection rate of $r$ when the true rejection rate is 5 percent. The results are given in Appendix Table A.3 and Table A.4, which we compare against the critical value tables in Stock and Yogo (2005). The rejection rate $r$ of 10 percent (with a critical value lower than 16.87) for all the TSLS regressions that we have run at the 5 percent significance level implies that our estimations do not suffer from a weak identification problem.

Regarding weak-instrument-robust inference, we employ the Anderson-Rubin Wald test (based on both $F$-statistic and chi-square statistic) in order to check whether the estimated coefficients of the endogenous variables are compatible with the our sample, independent of the strength of our instruments. The corresponding null hypothesis is that the estimated coefficients of the endogenous variables are jointly equal to zero. We reject the null hypothesis for all the TSLS regressions that we have run at the 1 percent significance level, independent of the statistic considered, and we conclude that our estimated coefficients are compatible with the data used, independent of the strength of instruments used. Hence the empirical results in Tables 4-5 are robust to the consideration of any endogeneity problem, since all the employed statistical tests suggest evidence for the validity of the instruments used in TSLS regressions.

In order to gain a better understanding of the correlation between TPD measures and income growth rate, consider Table 6 where we document the magnitude of the change in a country's annual growth rate associated with one standard deviation increase in a given network measure. Using network measure coefficients of Table 4 between columns (2) and (4), we find that one standard deviation increase in a network measure is associated with a 0.56 percentage point increase in the annual growth rate, which corresponds to 0.21 of one unit standard deviation in the growth rate. Coefficients of network measures after controlling for trade openness (shown in columns (5) to (8) of Table 4) reveal that one standard deviation increase in network measures is associated with about a 0.52 - 0.56 percentage point increase in the annual growth rate, corresponding to about 0.2 of one unit standard deviation in the growth rate. Inclusion of country-fixed effects leads to higher coefficient estimates for network measures (shown in Table 5), and the associated increase in the annual growth rate with one standard deviation increase in network measures turns out to be about 1 to 1.5 percentage points, corresponding to 0.37 to 0.56 of one unit standard deviation in the growth rate. One standard deviation increase in trade openness, on the other hand, is associated with about a 0.34 - 0.39 percentage point increase in the annual growth rate. This shows the importance of having access to well-connected export markets and improving a country's trade networks is not being captured by trade openness measure.

The time it takes to reach one standard deviation increase in export degree takes on average 22 years, but the variation across countries is also large, e.g. Malawi and New Zealand reach this milestone in 1971 whereas Greece and Guyana reach it in 1980, Turkey in 1982, Chile and Ghana in 1992, Rwanda reaches it in 2002. One standard deviation increase in export closeness and eigenvector take on average 23 years and 11 years, respectively. While 61 countries in our sample have been able to increase their export degree or export closeness by at least one standard deviation during the sample period, 23 countries were able to increase their export eigenvector by at least one standard deviation.

**Threshold Analysis.** It is important to note that all of the results shown so far represent on-average effects across countries. However, we would also like to know how different country characteristics would change the effects of trade networks on growth across countries, which we achieve next. This is in line with Herzer (2013) who shows that effects of trade on income have a large heterogeneity across countries. Therefore, a given level of connectivity in the international trade network may also have very different effects on countries that have very different underlying macroeconomic conditions. Accordingly, in order to have a systematic explanation of such heterogeneity, we would like to know for which countries larger and/or better trade networks are associated with higher income

Table 6: Change in Growth in Response to One Standard Deviation Increase in Trade Network Measures

| | By how many percentage points does the annual growth rate change when controlled for: | | | |
|---|---|---|---|---|
| | ALL: Finance (M3), Inflation, Human Capital (SEC), Gov. spending, initial GDP | ALL and trade openness | ALL and country fixed effects | ALL, country fixed effects and trade openness |
| Export Degree | 0.567 | 0.516 | 1.495 | 1.341 |
| Export Closeness | 0.564 | 0.521 | 1.409 | 1.254 |
| Export Eigenvector | 0.562 | 0.555 | 1.023 | 0.977 |

*Source*: Standard deviations of *export degree, export closeness,* and *export eigenvector* are reported in table 3. These are multiplied by estimated coefficients taken from regression results in tables 4 and 5.

growth. For example, in the related literature, Aghion et al. (2009) show that exchange rate volatility can stunt growth of a country when its financial development is low. Since macroeconomic volatilities, especially exchange rate volatility, constitute an important channel through which trade networks may affect income growth (as discussed in Section 2 in detail), one would expect superior trade network connections to be more important for a country where financial development is low. Similarly, Gylfason (1999) suggests that inflation adversely affects growth through lower ratios of exports to output; therefore, one would expect trade networks to be more important for countries experiencing high inflation. Finally, since trade openness increases income volatility according to Svaleryd and Vlachos (2002), one would expect trade networks to be more important for countries with high trade openness because high trade openness comes with an increased risk of being exposed to external shocks, and being connected to larger and/or better export markets may provide good diversification of risk.

Accordingly, in order to account for the heterogeneity across countries regarding the effects of trade networks on income growth, we consider thresholds of the right-hand side variables in the growth regressions. Following Yilmazkuday (2011), rolling-window TSLS regressions are employed with a constant window size of 200 after ordering the data according to the threshold variable.[18] For instance, if the inflation thresholds were

[18]Earlier studies that have also used rolling-window regressions in the context of long-run growth

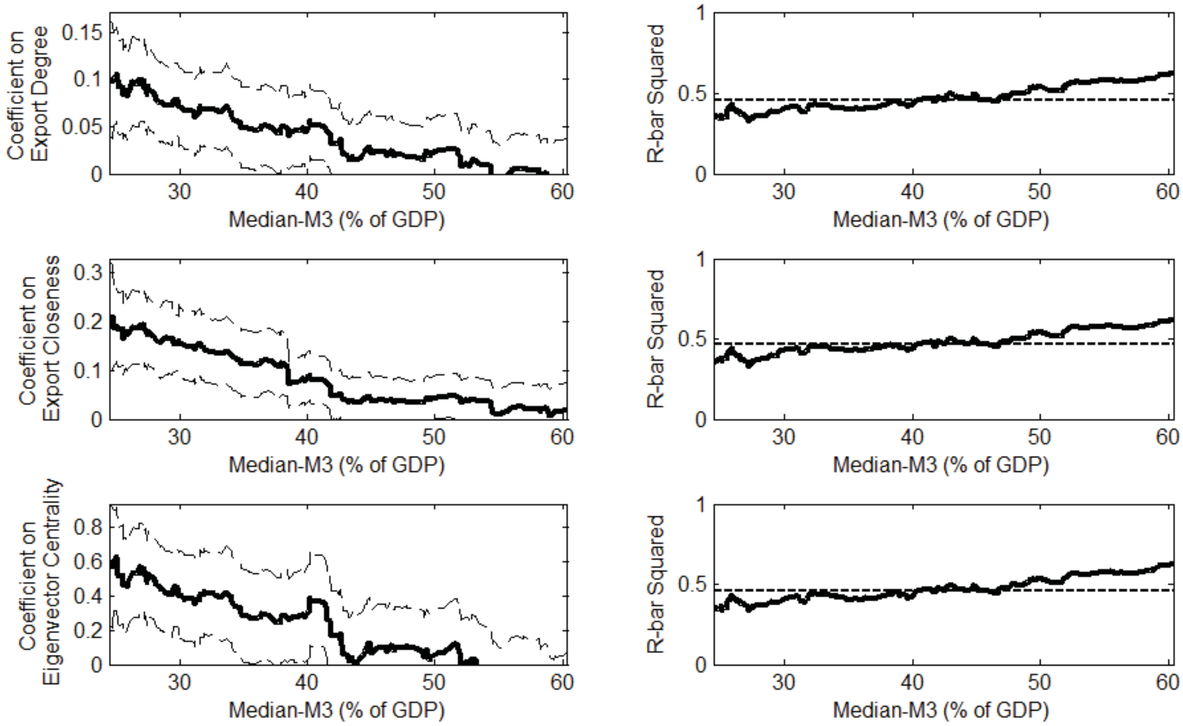


Figure 6: Effects of Trade Partner Diversification on Growth: Thresholds in Finance

of interest, all the observations (i.e., the pooled sample of 5-year average data from all countries) are sorted in the order of the lowest to the highest inflation rates; the first regression is run with the first 200 observations of the sorted data set, the second regression by moving the 200 window toward higher inflation rates by one observation, and so on. The selection of a constant window size is important for comparison of coefficient estimates across the windows, while the selection of a window size of 200 is important to ensure a fair distribution across the power of regressions and the degree of nonlinearity.[19]

For a consistent inference across linear and nonlinear frameworks, the rolling-window

are Rousseau and Wachtel (2002,2011) and Yilmazkuday (2013). The use of rolling windows is well established and has been considered in a variety of other contexts, including international and monetary economics, exchange rates, and inflation modeling as well as returns predictability (e.g., Cushman, 1988; Guidolin et al., 2013; Meese and Rogoff, 1988; and Swanson, 1988), while Giacommi and White (2006) provide general support for the use of rolling-window regressions.

[19]It is important to emphasize that having a rolling-window regression corresponds to having different residual characteristics across different windows of 200 observations. This is to our benefit since it results in cluster-robust standard errors, where clusters depend on the level of the variable of interest. Moreover, the main advantage of using rolling-window regressions is allowing the data to speak, whereas other methods such as using interaction terms have the underlying assumptions of linearity (of the derivatives) regarding the effects of TPD measures on long-run growth.

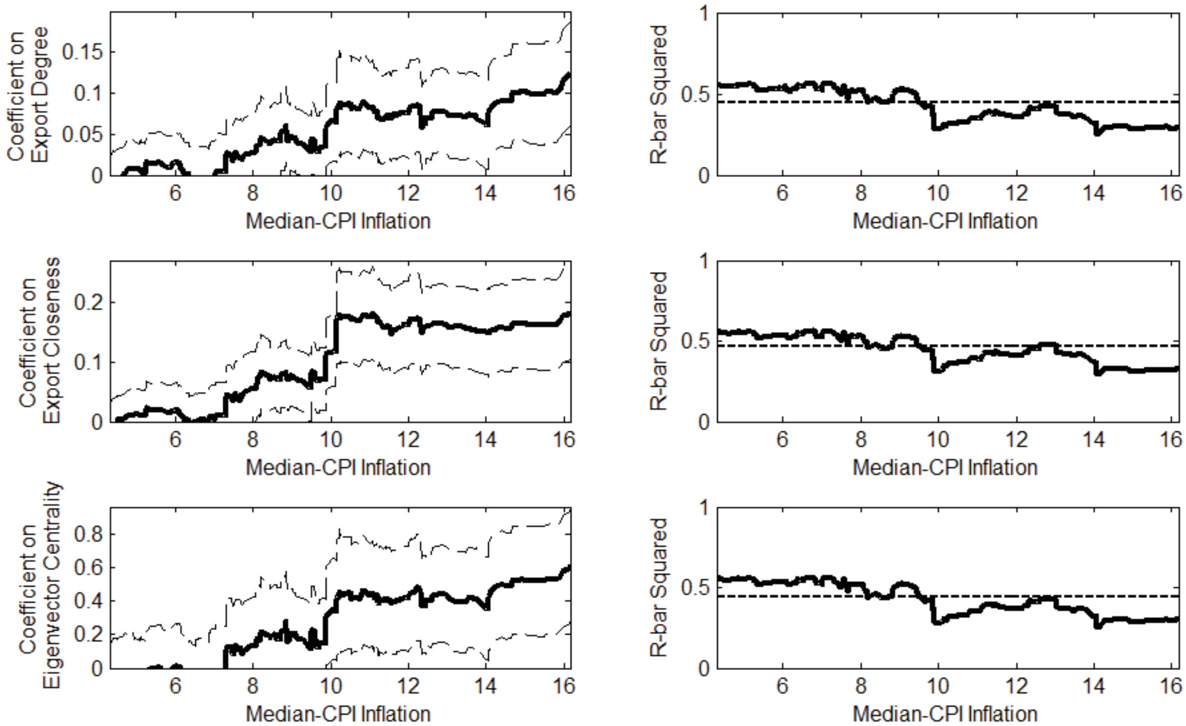


Figure 7: Effects of Trade Partner Diversification on Growth: Thresholds in Inflation

regressions use the specifications in columns 4-6 of Table 5. The rolling-window regression results are given in Figures 6 to 11, where the x-axes show the median of the threshold variable in 200 sample windows (i.e., the variable according to which all the observations have been sorted). The y-axes of the figures in the left panel show the coefficient estimates of the TPD measures. The bold solid lines show the coefficient estimates, and the dashed lines the 10-percent confidence intervals. The dashed lines in the right panels of figures 6 to 11 show the mean of R-bar squared values. As is evident in Figures 6 to 9, the coefficient estimates of the TPD measures are positive and significant in subsets of countries where financial development is low, inflation is high, human capital is low, and trade openness is high.[20] Hence, positive effects of TPD are more evident for such countries because from two countries that have, e.g., very similar low levels of financial development, the one with better TPD (that is, the one with access to more/better export markets) has a significantly higher growth rate than the other one. A brief look in our data reveals that many countries with low financial development and high TPD maintain this combination over time, i.e.

[20]We observe several changes in the estimated coefficients based on the threshold variable; it is simply implied that certain country characteristics play important roles in the determination of TPD effects on long-run growth, supporting our nonlinear investigation.

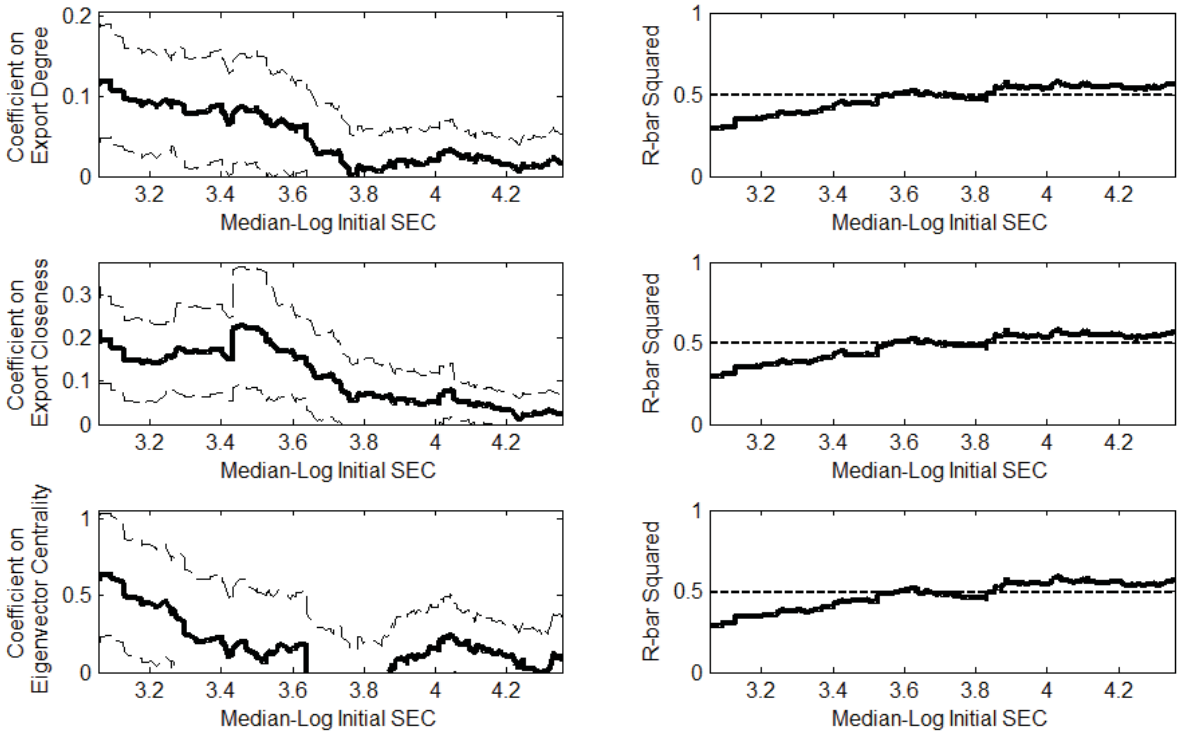


Figure 8: Effects of Trade Partner Diversification on Growth: Thresholds in Human Capital

the relationship of low financial development and high TPD seems to stay the same over time. This points out that high TPD substitutes for low financial development rather than supporting a country's financial development growth. Figures 10 and 11 reveal that such effects are relatively stable across alternative levels of government size and level of income (log-initial GDP).

The rolling-window regression results have important implications for the stages of economic development. Correlation between a country's position in the international trade network is positively and significantly correlated with the annual growth rate in countries that display traits of developing or underdeveloped countries (low financial development and human capital) or experience macroeconomic volatility in the domestic economy (high inflation). In particular, Figures 6 to 8 imply that a superior position in the international trade network, which means having many trade partners and/or having trade partners that themselves have superior positions in the trade network, compensates countries in their early stages of development for their low levels of financial depth, high levels of inflation, and low levels of human capital.

The results also yield an important policy implication for countries with high levels of

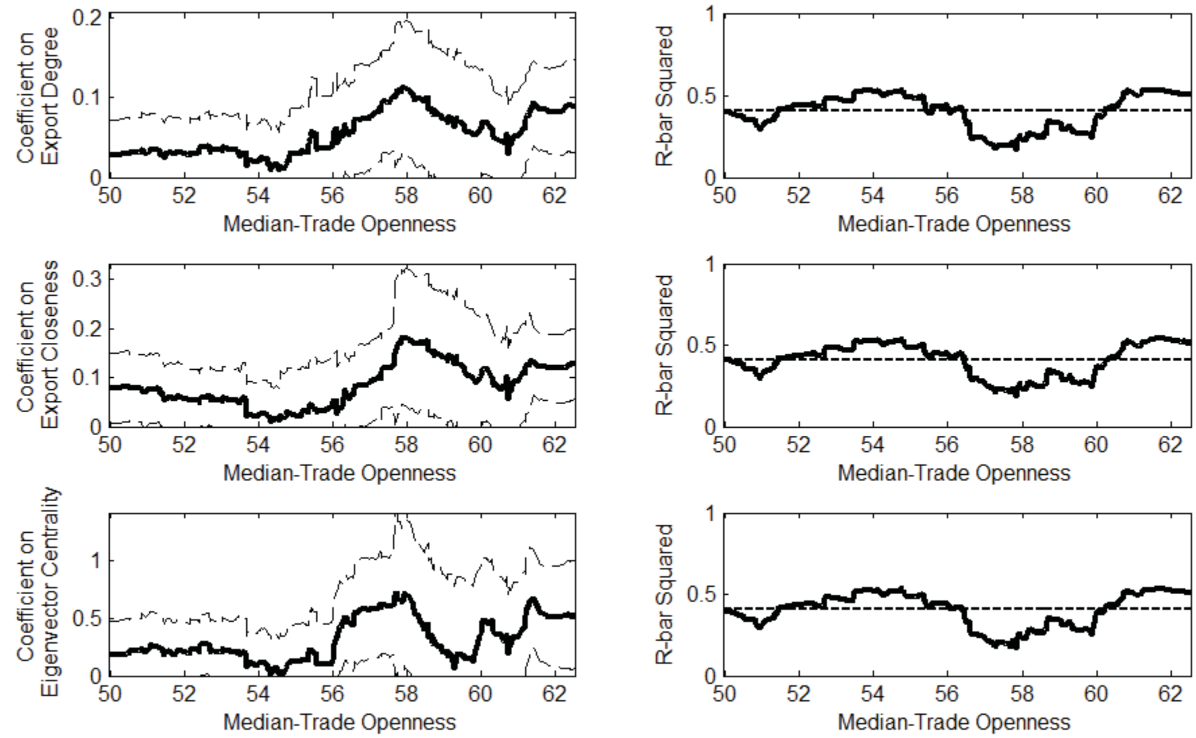


Figure 9: Effects of Trade Partner Diversification on Growth: Thresholds in Trade Openness

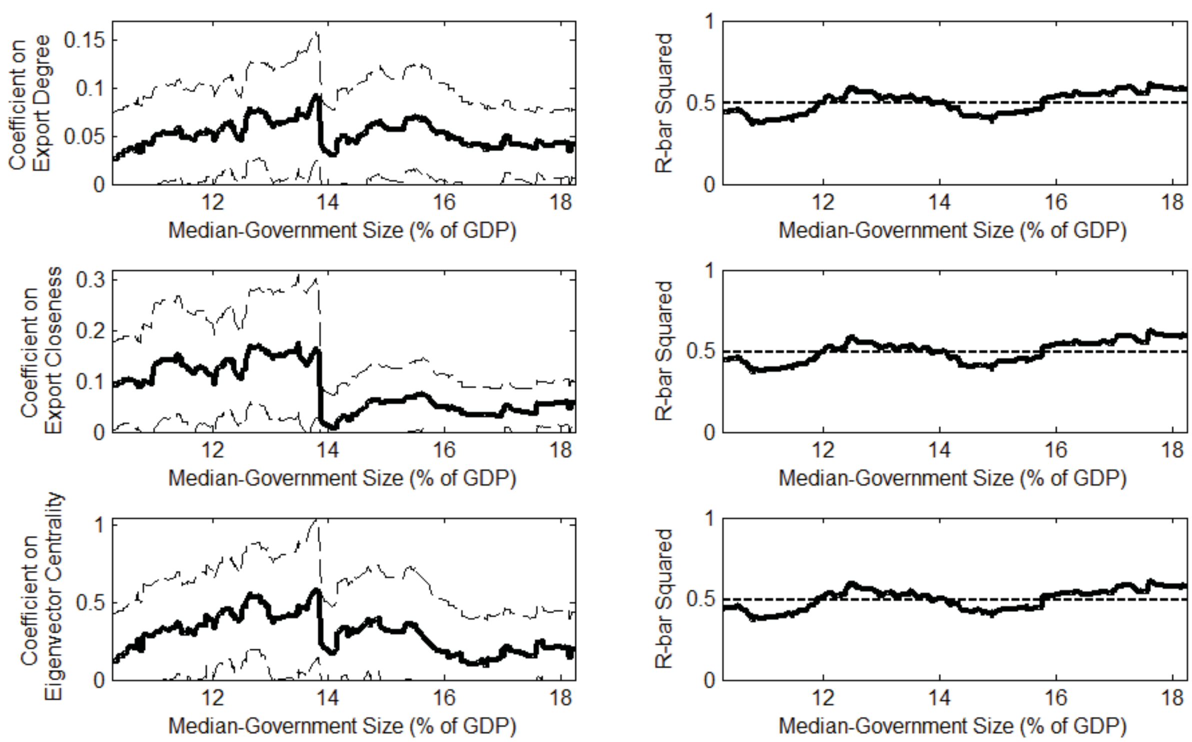


Figure 10: Effects of Trade Partner Diversification on Growth: Thresholds in Government

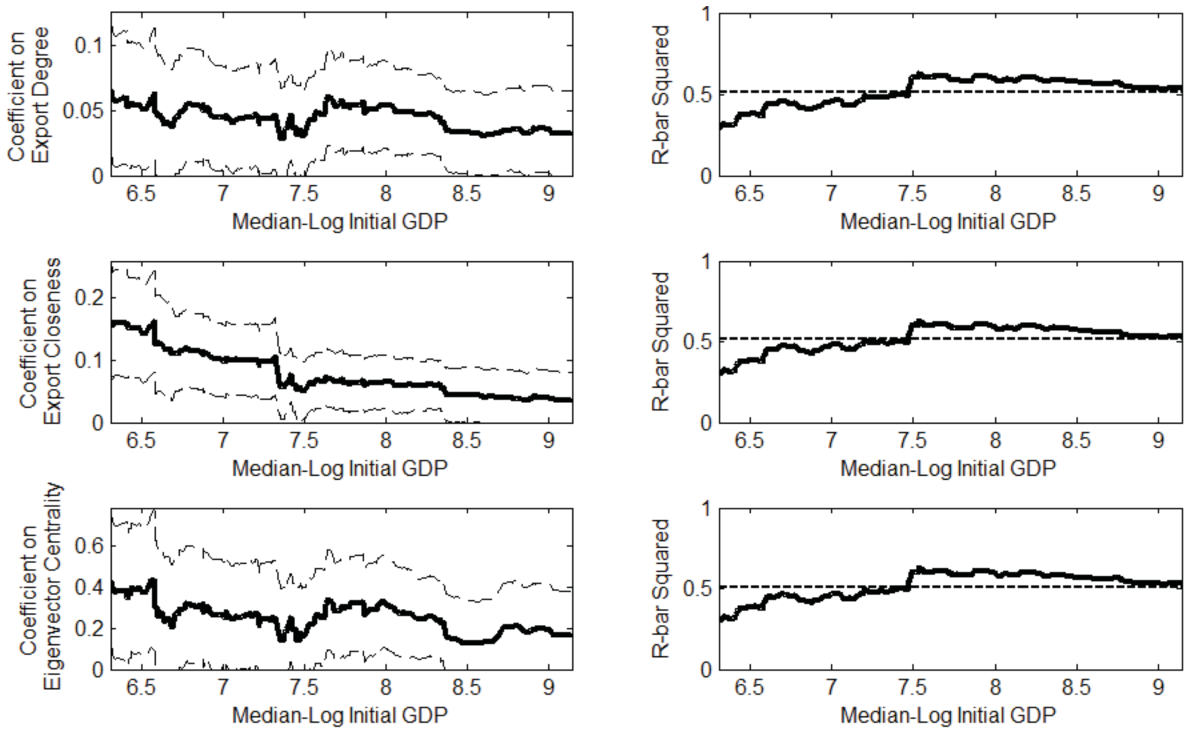


Figure 11: Effects of Trade Partner Diversification on Growth: Thresholds in Initial GDP

trade openness: TPD measures and growth are positively and significantly correlated in countries that are exposed to external shocks due to their high trade openness. Hence, of two similar highly open countries, the one with a superior position in the international trade network has a significantly higher growth rate than the other one. TPD compensates countries that have a high degree of trade openness for their vulnerability to international trade shocks through having access to superior export markets, thereby providing better diversification of risk.

# 6 Conclusion

The relationship between trade and growth has been an important area of ongoing research and policy discussion. We contribute to this literature by showing that a country's position in the international trade network enters per capita income growth regressions positively and significantly on top of trade openness and other standard control variables. In technical terms, when all other country characteristics are controlled for, one standard deviation increase in network measures is associated with about a 1 to 1.5 percentage point increase in the annual growth rate, depending on the trade network measure used; this corresponds to about 0.37 to 0.56 of one unit standard deviation of the growth rate. Moreover, from a welfare perspective, having international trade connections with a larger and/or better connected set of countries is positively and significantly correlated with higher rates of growth, ceteris paribus, and should thus be considered important for achieving higher growth and development levels.

We use network centrality measures to capture the position (and hence the importance) of a country in the web of international trade and call it the TPD of this country. Since the TPD of a country increases based on quantity and quality of its export partners, TPD yields an overall comparison between countries as to how diversified and well connected they are (and their trade partners are) with the rest of the world. The positive and significant effect of TPD on growth can best be understood once its potentially important role in coping with uncertainty borne by country-specific shocks is understood: being linked to diversified and well-connected trade partners provides an important insurance against country-specific shocks that might disturb international trade and thus affect growth.

Using threshold analyses, we also show that countries' position and importance in the international trade network can compensate for their low levels of financial depth, high levels of inflation, and low levels of human capital. This result is especially important for countries in their early stages of development where, on average, financial depth is low, inflation is high, and human capital is low; therefore, gaining access into more and/or better connected export markets turns out to be crucial. The results also show that trade networks are effective for income growth through better diversification of risk, especially for countries that are more vulnerable to external shocks due to their high levels of trade openness.

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Table A.1: OLS growth regressions, 1965-2004, 83 Countries

| | Dependent Variable: Growth of Per Capita Income (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Export Degree | | 0.0202*** | | | 0.0196*** | | |
| | | (0.00580) | | | (0.00572) | | |
| Export Closeness | | | 0.0357*** | | | 0.0339*** | |
| | | | (0.0101) | | | (0.0100) | |
| Export Eigenvector | | | | 0.167*** | | | 0.169*** |
| | | | | (0.0416) | | | (0.0410) |
| Trade Openness | 0.0395*** | | | | 0.0384*** | 0.0378*** | 0.0400*** |
| | (0.0102) | | | | (0.0101) | (0.0101) | (0.0101) |
| Finance (M3, % GDP) | 0.0188*** | 0.0165*** | 0.0170*** | 0.0167*** | 0.0151** | 0.0157** | 0.0151** |
| | (0.00479) | (0.00491) | (0.00488) | (0.00485) | (0.00485) | (0.00482) | (0.00479) |
| Inflation (%) | -0.0337*** | -0.0283** | -0.0287** | -0.0298*** | -0.0308*** | -0.0311*** | -0.0323*** |
| | (0.00879) | (0.00884) | (0.00882) | (0.00877) | (0.00873) | (0.00873) | (0.00865) |
| Government (% GDP) | -0.0829*** | -0.0797*** | -0.0797*** | -0.0775*** | -0.0791*** | -0.0792*** | -0.0767*** |
| | (0.0234) | (0.0235) | (0.0234) | (0.0234) | (0.0231) | (0.0231) | (0.0230) |
| Log of initial GDP | -0.201+ | -0.336** | -0.328** | -0.324** | -0.328** | -0.318** | -0.322** |
| | (0.118) | (0.124) | (0.123) | (0.121) | (0.122) | (0.121) | (0.119) |
| Log of initial SEC (%) | 1.071*** | 0.927*** | 0.968*** | 0.840*** | 0.951*** | 0.992*** | 0.858*** |
| | (0.212) | (0.215) | (0.213) | (0.218) | (0.212) | (0.211) | (0.214) |
| *R*-bar Squared | 0.271 | 0.267 | 0.268 | 0.273 | 0.288 | 0.288 | 0.297 |

*Source*: Authors' analysis based on data sources discussed in the text.

*Notes*: +, *, ** and *** indicate significance at the 10%, 5%, 1% and 0.1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Network measures are five-year averages; their initial values in each five-year period are used as instruments for the corresponding five-year averages. All equations also include time fixed effects that are not shown. Estimation is by OLS. The sample size in each equation is 464.

Table A.2: OLS growth regressions with country-fixed effects, 1965-2004, 83 Countries

| | Dependent Variable: Growth of Per Capita Income (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Export Degree | | 0.0432*** | | | 0.0383** | | |
| | | (0.0118) | | | (0.0116) | | |
| Export Closeness | | | 0.0737*** | | | 0.0660*** | |
| | | | (0.0173) | | | (0.0170) | |
| Export Eigenvector | | | | 0.235** | | | 0.231** |
| | | | | (0.0754) | | | (0.0733) |
| Trade Openness | 0.0435*** | | | | 0.0406*** | 0.0398*** | 0.0433*** |
| | (0.00924) | | | | (0.00916) | (0.00912) | (0.00913) |
| Finance (M3, % GDP) | -0.0125 | -0.00280 | -0.00495 | -0.00110 | -0.0113 | -0.0131 | -0.0101 |
| | (0.0108) | (0.0108) | (0.0107) | (0.0109) | (0.0107) | (0.0106) | (0.0107) |
| Inflation (%) | -0.0251* | -0.0220* | -0.0234* | -0.0212+ | -0.0260* | -0.0271* | -0.0256* |
| | (0.0109) | (0.0110) | (0.0110) | (0.0111) | (0.0108) | (0.0107) | (0.0108) |
| Government (% GDP) | -0.0948* | -0.0908* | -0.100* | -0.0785+ | -0.0899* | -0.0986* | -0.0771+ |
| | (0.0409) | (0.0414) | (0.0412) | (0.0420) | (0.0404) | (0.0402) | (0.0408) |
| Log of initial GDP | -2.698*** | -3.490*** | -3.378*** | -3.034*** | -3.270*** | -3.179*** | -2.875*** |
| | (0.568) | (0.600) | (0.583) | (0.579) | (0.587) | (0.571) | (0.564) |
| Log of initial SEC (%) | -0.894* | -0.966* | -0.966* | -1.127** | -0.946* | -0.947* | -1.110** |
| | (0.405) | (0.410) | (0.407) | (0.418) | (0.400) | (0.398) | (0.406) |
| *R*-bar Squared | 0.424 | 0.411 | 0.418 | 0.405 | 0.439 | 0.445 | 0.437 |

*Source*: Authors' analysis based on data sources discussed in the text.

*Notes*: +, *, ** and *** indicate significance at the 10%, 5%, 1% and 0.1% levels, respectively. Standard errors are in parentheses. Growth rates are five-year averages. Network measures are five-year averages; their initial values in each five-year period are used as instruments for the corresponding five-year averages. All equations also include country fixed effects and time fixed effects that are not shown. Estimation is by OLS. The sample size in each equation is 464.

Table A.3: Validity of Instruments in TSLS regressions in Table 4

| | Table 4 Column (1) | Table 4 Column (2) | Table 4 Column (3) | Table 4 Column (4) | Table 4 Column (5) | Table 4 Column (6) | Table 4 Column (7) |
|---|---|---|---|---|---|---|---|
| **Under-identification tests** | | | | | | | |
| Kleibergen-Paap rk LM statistic | Chi-sq(1)= 33.86 | Chi-sq(1)=32.87 | Chi-sq(1)=33.21 | Chi-sq(1)=33.44 | Chi-sq(1)=33.02 | Chi-sq(1)=33.28 | Chi-sq(1)=33.75 |
| | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] |
| **Weak identification tests** | | | | | | | |
| Cragg-Donald Wald F statistic | 194.74 | 183.65 | 184.00 | 188.46 | 150.23 | 150.62 | 153.96 |
| Kleibergen-Paap Wald rk F statistic | 13.79 | 38.50 | 38.95 | 39.42 | 32.10 | 32.49 | 32.88 |
| **Weak-instrument-robust inference** | | | | | | | |
| Anderson-Rubin Wald test | F(4,450)=7.98 | F(4,450)=9.67 | F(4,450)=9.81 | F(4,450)=9.81 | F(4,449)= 8.47 | F(5,449)=8.47 | F(5,449)=8.96 |
| | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] |
| Anderson-Rubin Wald test | Chi-sq(4)=32.90 | Chi-sq(4)=39.88 | Chi-sq(4)=40.47 | Chi-sq(4)=40.46 | Chi-sq(5)=43.78 | Chi-sq(5)=43.74 | Chi-sq(5)=46.29 |
| | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] |

*p values* in brackets.

Under-identification tests, Ho: matrix of reduced form coefficients has rank=K1-1 (under-identified); Ha: matrix has rank=K1 (identified).
Weak identification test, Ho: equation is weakly identified.
Weak-instrument-robust inference, Tests of joint significance of endogenous regressors B1 in main equation, Ho: B1=0 and over-identifying restrictions are valid.

Table A.4: Validity of Instruments in TSLS regressions in Table 5

| | Table 5<br>Column (1) | Table 5<br>Column (2) | Table 5<br>Column (3) | Table 5<br>Column (4) | Table 5<br>Column (5) | Table 5<br>Column (6) | Table 5<br>Column (7) |
|---|---|---|---|---|---|---|---|
| Under-identification test | | | | | | | |
| Kleibergen-Paap rk LM statistic | Chi-sq(1)=35.41<br>[0.0000] | Chi-sq(1)=37.81<br>[0.0000] | Chi-sq(1)=36.36<br>[0.0000] | Chi-sq(1)=36.55<br>[0.0000] | Chi-sq(1)=37.42<br>[0.0000] | Chi-sq(1)=35.68<br>[0.0000] | Chi-sq(1)=35.91<br>[0.0000] |
| Weak identification tests | | | | | | | |
| Cragg-Donald Wald F statistic | 90.09 | 86.06 | 86.78 | 86.92 | 71.20 | 71.83 | 72.08 |
| Kleibergen-Paap Wald rk F statistic | 21.91 | 22.27 | 20.84 | 21.11 | 19.11 | 17.72 | 17.92 |
| Weak-instrument-robust inference | | | | | | | |
| Anderson-Rubin Wald test | F(4,372)=3.32<br>[0.0129] | F(4,372)=4.00<br>[0.0034] | F(4,372)=4.22<br>[0.0023] | F(4,372)=2.57<br>[0.0378] | F(5,371)= 5.71<br>[0.0000] | F(5,371)=5.89<br>[0.0000] | F(5,371)=4.97<br>[0.0002] |
| Anderson-Rubin Wald test | Chi-sq(4)=16.57<br>[0.0023] | Chi-sq(4)=19.95<br>[0.0005] | Chi-sq(4)=21.08<br>[0.0003] | Chi-sq(4)=12.81<br>[0.0122] | Chi-sq(5)=35.72<br>[0.0000] | Chi-sq(5)=36.86<br>[0.0000] | Chi-sq(5)=31.07<br>[0.0000] |

*p values* in brackets.

Under-identification tests, Ho: matrix of reduced form coefficients has rank=K1-1 (under-identified); Ha: matrix has rank=K1 (identified).
Weak identification test, Ho: equation is weakly identified.
Weak-instrument-robust inference, Tests of joint significance of endogenous regressors B1 in main equation, Ho: B1=0 and over-identifying restrictions are valid.