8-7-2008

The Iron and Steel Shipbuilding Data Set, 1825-1914: Sources, Coverage, and Coding Decisions

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Revised: August 2008

This article is a supporting document to my paper "Selection and Firm Survival. Evidence from the Shipbuilding Industry, 1825-1914", *Review of Economics and Statistics*, **87**(1):26-36, February 2005. The article provides a basic description of data sources, coverage and limitations, along with coding decisions made for the purposes of statistical analysis. The data are available at http://www.fiu.edu/~thompsop/data/shipbuilding/shipbuilding.html.

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1. Vessel Data

Since the 1789 Act to Regulate Shipping (September 1, 1789, 1 Stat. 55), all merchant vessels built in the United States have been required to be registered or enrolled. A ship had to be registered if the owner intended to employ it in foreign trade, and it had to be enrolled if it had a capacity in excess of 20 tons and was intended to be employed in the domestic coastal and river trades. As the capacity of commercial ocean-going vessels invariably exceeds 20 gross tons, the capacity requirement is binding for documentation to exist.[1]

Certificates of enrollment and registration were drawn up in triplicate. One copy was held aboard the vessel, which was surrendered at the end of the vessel's life and submitted for archival purposes to the Office of the Register of the Treasury or its successor agencies. The second copy was held by the issuing customs office, and the third as a reference copy by the Office of the Register of the Treasury or its successor agencies. Registration and enrollment certificates provide a rich source of data on the date and place of construction, dimensions, rig, hull material, and other basic technological details of the ship, whether the vessel was intended for domestic use or for foreign trade, and the names of the first owners and master.

The attractiveness of such an extensive technological record will be readily apparent to students of technological change and industry evolution. There are, however, two limitations to be overcome. The first is that metal and wooden vessels are mixed by vessel name in these sources, and there are far too many records of wooden vessels for the extraction of metal vessels to be a reasonable endeavor. The second is that there was no requirement for vessel documents to record the name of the builder, a particularly desirable piece of information.[2]

All surviving documents of ships built prior to W.W.I are held by the National Archives, but it is a daunting task to systematically tabulate the records. In 1814, fire destroyed all existing surrendered and reference certificates of enrollment and registration;[3] in 1913, the Bureau of Navigation destroyed the reference copies for vessels built between 1815 and 1913; surrendered copies of documents held in Washington are incomplete, especially when vessels

[1] Vessels between five and twenty tons had to be licensed, but few licenses from the 19th century survive today. An act of June 7, 1918 (40 Stat. 602) extended the registration requirements. After this date, all mechanically powered vessels, except those under 16 feet powered by an outboard motor, were required to be numbered and recorded.

[2] One can often identify the builder from a vessel's registration document when he was a co-owner of the vessel; granting part ownership to the builder was a common way to finance part of the ship purchase during the 18th and 19th centuries.

[3] On August 24, 1814, British forces under Major General Robert Ross set fire to all the public buildings in Washington except the Patent Office.

were lost at sea; and many of the customs copies are scattered throughout the country in regional offices of the National Archives. Yet despite this shrinkage of the data, the National Archives continues to hold over 10,000 linear feet of vessel documentation records. Fortunately, maritime historians have long had an obsession with making lists. The most famous of these, the Lytle list (Lytle, 1932; Lytle and Holdcamper, 1952; Lytle, Holdcamper and Mitchell, 1975) tabulates register and enrollment records for all U.S.-built steamships from 1790 to 1868, and contains approximately 8,000 steam vessels with details of equipment (including form of propulsion), hull material, tonnage, place built, port of first registration, and its eventual fate. After 1868, the America Bureau of Shipping began to publish annually complete ship registries.[4] Although the Lytle list and the ABS registries are valuable, they do not contain the name of the builder even when this was recorded on a document.

The study therefore takes as a starting point a rather fortunate find in the National Archives. Around 1920, the Bureau of Navigation constructed a register of metal vessels built in the United States between 1825, the year the first iron vessel was built, and 1919.[5] The register, a hand-written leather-bound volume contains the key technological details from the vessel documents. But, remarkably in view of the work it must have entailed, the register also lists the builder for most of the vessels. The register suffers some omissions that I have filled from other sources. First, some of the earliest vessels, often of quasi-experimental vessels for which legal registration requirements were not fully satisfied, are omitted.[6] We have been able to fill in these gaps with vessel descriptions from diverse sources, especially Brown (1951) and typescript vessel lists held in various specialized manuscript collections. Second, the register reports only merchant vessels. I have added to the register vessels built for the U.S. Customs Service and the U.S. Navy by private companies using official records provided in Bauer and Roberts (1991), Benham and Hall (1913), Canney (1993, 1995, 1998), Conway (1979), Still (1996), and US Coast Guard (1989).

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[4] The ABS registries are tedious to use however, because a vessel appears in every volume issued in a year when the vessel was still registered or enrolled.

[5] I have subsequently found only one reference, Heinrich (1997), to this register.

[6] William M. Lytle, who was employed at the Bureau of Navigation around the time the register was produced and who may have been responsible for it, had been particularly severe in excluding some early vessels from the Lytle list because they lacked official documentation. Most notably, Lytle (1932) excluded John Fitch's S*teamboat*, which was operating commercially in 1790 without registration documents. The vessel is well-documented historically (see, for example, Wescott, 1857), and is particularly important as the first steamboat operated commercially anywhere in the world (only the 1975 revision of the Lytle list includes it). Lytle attributed the first commercial steamboat in the United States to Robert Fulton (*Clermont*, built 1807).

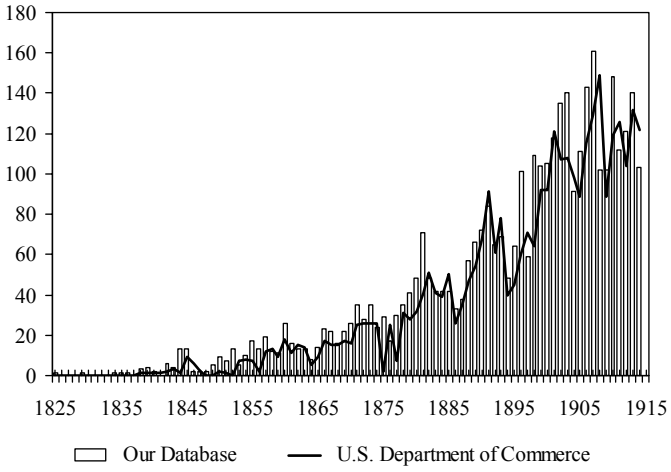

Figure 1. Metal Vessels Launched for Civilian Use, 1825-1914. To aid comparison with the Department of Commerce data, 370 military vessels constructed by private yards are excluded. Department of Commerce records allocate production vessels to year of registration or enrollment, the data set allocates vessels to year of launching. These dates coincide in the majority of, but not in all, cases. Source: Smith, H. G., and L.C. Brown (1948, Table 6).

The criteria for inclusion of vessels in the final sample were as follows. Because cost-plus contracts initiated during the Great War are of only marginal interest for the study of industry evolution, the database excludes vessels launched after 1914. Second, the sample was restricted to producers who launched at least one vessel in excess of the 20 gross tons capacity required to trigger enrollment or registration.[7] Third, in order to track more precisely the dates of activity of the included firms, all metal vessels known to have been produced by them are included regardless of gross tonnage. The restricted sample contains exactly 4,000 vessels and 273 producers.

Figure 1 compares the number of vessels for which I have information with the US Department of Commerce's (USDC) official tally of metal vessels built during the period. For the period 1825-1914, the USDC tally reports 3,222 documented merchant vessels. To

[7] It should be noted that not all of the vessels in our database were enrolled or registered, and some of those that were enrolled were not required to be. We have however, retained firms where I do not know the gross tonnage of their vessels. 57 firms, accounting for 114 boats in our records, were excluded by the minimum size criterion. The majority of these were back-yard enthusiasts, producing a vessel for their personal use.

facilitate comparison with the USDC tally, the figure excludes the 370 military vessels in the sample, all vessels under 20 gross tons capacity, and all vessels for which no gross tonnage is available. Even so, there remains an excess of 260 merchant vessels that should have been included in the USDC record.

I believe that, subject to the minimum size requirement, the database is the most complete record in existence of metal shipbuilding in the United States prior to 1915. The only major omission that I am aware is a failure to systematically include vessels constructed for export, and which therefore were not documented in the United States. Few firms exported vessels and, for most of those that did, export activity formed a minor part of their total production. There are a couple of exceptions, however. Between 1878 and 1914, James Rees and Sons of Pittsburgh, PA, produced hundreds of knock-down iron and steel steamboats for service on South American rivers (Rees and Sons, 1913), but only fourteen of their vessels are recorded in the United States. Marine Iron Works of Chicago, IL, also sold an unknown number of knock-down iron vessels to South America, although in their case the majority of their export trade consisted of the sale of machinery along with plans for wooden hulls to be built locally (Marine Iron Works, 1902).

2. Firm histories

I have attempted to produce detailed histories for as many of the 273 recorded producers as possible. The sources have been eclectic, employing local shipbuilding histories, country histories and biographies, manuscript collections, contemporary newspaper accounts, genealogical records, and personal communications with surviving relatives, representatives of surviving firms, and archivists in local historical societies. For some small producers, I have no information at all, while for others I have identified their pre-entry backgrounds from only city directories indicating their profession prior to entry in the database. For most large producers, in contrast, it was possible to construct extremely rich histories and document in detail the way in which they entered and left the industry.

From the textual firm histories, I have attempted to code systematically the producers' backgrounds, the dates of firm formation, entry into and exit from metal shipbuilding, and the mode of exit. None of these tasks proved to be straightforward and it is worth discussing at this point some of the decisions made. Before doing so, however, I need to discuss ambiguities in defining a firm.

Defining Firms

There were several challenges to overcome in constructing the basic count of firms and in assigning vessels to them. First, the source database contained many vessels assigned to individuals, although these individuals turned out to be employed by another firm. Second, it was not always a straightforward matter to decide when a reorganization or relocation constituted the creation of a new producer or the continuation of the old one.

Addressing the first difficulty required only detective work. The individual to whom a vessel had been attributed often proved to be the superintendent of construction, an owner of the firm, or even an owner of the vessel. Often, I was able to find biographies of the individuals that placed them in a firm at the right time. In other cases, I was able to cross-check vessel lists from multiple sources to link the individual to a firm. Sometimes, company records provided employee lists. And in one case, genealogical records linked multiple individuals with the same surname to a single family. It is certain that some individuals who continue to be named in the sample were, in fact, employed by another firm. On the other hand, I have documented that many individual names did indeed own their own foundry, engine works, or boatyard. My approach in this case has been to identify in the sample all individuals about whom I am suspicious (generally individuals who appear from nowhere, build one large vessel, and then vanish), and to conduct the statistical analyses with and without these individual observations.

It was frequently necessary to make judgments about the boundaries between firms. Some examples illustrate:

- On 20 July 1885, John Roach and Sons of Philadelphia, PA, declared bankruptcy in the wake of financial strains imposed by naval contracts. The yard closed for almost a year, putting 1,200 men out of work. Some negotiations allowed the receiver, George Quintard, to finish some incomplete cruisers on the stocks and ensure payment for them. The following year, after incorporation as the Delaware River Iron Shipbuilding and Engine Works in a reorganization involving new investors, the yard reopened. The father, John Roach, who was by now terminally ill with cancer, resigned, and the yard re-opened with the son, John B. Roach, at the helm (Heinrich, 1997; Swann, 1965).

- In 1903, a devastating fire along the waterfront in Racine, WI, destroyed the plant of the Racine Boat Manufacturing Company, a specialist in the construction of pleasure boats. The site had already been getting too small for the firm and, in response to an offer of free waterfront property, a $20,000 cash payment and tax breaks from the city of Muskegon, MI, the firm relocated to Michigan while continuing to operate under the Racine name. A majority of the employees moved to Muskegon, although only two members of the management team, Walter Reynolds and Clarence Palmer, moved. In 1906, the foreman Peter Gødske, who was unhappy with the company's attempts to expand into the construction of larger vessels, returned to Racine with a number of

employees to continue production of pleasure boats. Gødske's plant, doing business as the Racine Boat Company, closed some time between 1925 and 1927. In November of 1910, a boat-building combine to be known as the National Boat and Engine Company was organized, with Walter Reynolds as its president and the Racine Boat Manufacturing Company of Muskegon as its head company. The purpose of the organization was to control boat production of the United States east of the Mississippi, and subsequently to begin production of airplanes. The consolidation of the participating companies was to be financed with a large bond issue. However, the bond issue failed and on September 4, 1911, the Racine Boat Manufacturing Company was closed and put in the hands of a receiver. A new syndicate, the Racine-Truscott Shell Lake Boat Company was set up and assigned to run the Muskegon company. In March of 1912, charges of fraud were brought against the syndicate and the consolidation agreement was set aside. On November 28, 1915, foreclosure proceedings were started against the syndicate and the plant went into the hands of a receiver (Gunther, 1989; Wheeler, 1998).

- The Cleveland Ship Building Company operated a yard in Cleveland, OH from 1887 to 1898. Constrained by space, in 1898 the firm built a new yard in Lorain, OH on the Cuyahoga River, intending to use the old yard for repair work. In 1899, the Cleveland Ship Building Company joined the new trust being established under the name of the American Ship Building Company, which then operated both yards for new construction, with many of the same employees (Wright, 1969).

- In 1844, Thomas Reaney, Jacob Neafie and William Smith formed a partnership in Philadelphia, PA, to build fire engines, boilers and stationary steam engines. However, in that year they also launched four iron steamboats destined for export to South America (Morrison, 1905). Smith died in 1845, and Capt. John P. Levy was invited to join the firm. While Neafie and Levy were experienced mechanics, their social connections and financial resources were limited. Levy brought connections and money from his shipping activities, which facilitated the firm's subsequent expansion. In 1859, Reaney left the firm and established a yard in Chester, PA, in partnership with his son (Heinrich, 1997).

In the first three examples, I chose in favor of coding multiple producers. In the first case, I relied on a decision to code any reorganized firm after bankruptcy as a new and distinct firm, but coded the pre-entry background of the new firm as metal shipbuilding. Moreover, I additionally coded the new firm as having taken over an existing metal shipbuilding yard.

The Racine and Muskegon companies were coded as four distinct firms. In 1903, plant and facilities on offer in Muskegon were clearly sufficiently distinctive to induce a move. Because age and appropriateness of plant is expected to influence firm performance, I coded the two locations as separate producers, the latter having metal shipbuilding as a pre-entry background. Peter Gødske's return to Racine is logically coded as a new firm created by spin-off. I coded the Racine-Truscott Shell Lake Boat Company as a distinct entity, because it

was formed after a bankruptcy. I did not code the abortive National Boat and Engine Company consortium as a company distinct from the Racine Boat Manufacturing Company. In this case, the management remained unchanged, and the planned extensive trust never got off the ground.[8]

In the case of the Cleveland Ship Building Company, I relied on the principle of replication to code each plant as a separate economic entity, although I then provide indicators that the parent firm owned multiple plants.[9] The pre-entry background for the Lorain plant is coded as metal shipbuilding. I then decided to code all plant takeovers by the new trust companies that were emerging at the turn of the century as new firms, again coded with a metal shipbuilding background and takeover of existing metal yards.

In contrast, I treated the Philadelphia plant owned by various permutations of Reaney, Neafie, Smith and Levy, as a single firm created in 1844. Although Levy joined the firm after the company had launched its first vessels, the captain brought his connections to the firm at a sufficiently early stage that I include his shipping background as part of the firm's pre-entry experience. The Chester firm formed by Reaney and his son in 1859 is a new spin-off with metal shipbuilding as a pre-entry background, but the loss of Reaney from the Phildelphia partnership did not persuade me to code the surviving partnership of Neafie and Levy as a new firm.

In summary, my preference was to code more, rather than fewer producers. However, I did not code as firm changes the many recorded instances when partners left firms and were replaced by new partners, as long as some key partners remained in place. These criteria, although inevitably subjective, led me as a new firm any organization where I had reason to believe the operation of the firm had been substantively affected by a reorganization, or where the technological capabilities of the plant were believed to be substantively different.

Key Dates

I have recorded, whenever possible, four key dates for each firm: founding year[10], the years in which the first and last metal vessels were launched[11], and the year the firm went out of

[8] This example illustrates that coding decisions can be dependent to some extent on the success of new ventures. If the new consortium had become established and led to different management practices, I would have coded November 1910 as the date of formation of a new firm.

[9] Very few firms in our sample operated multiple plants.

[10] It is important to distinguish this from the year of incorporation. William and Cramp and Sons, of Philadelphia, PA, was founded as a shipbuilding firm in 1830, but incorporated only in 1872 (Heinrich, 1997; Tyler, 1958), a decade after it had begun working with iron.

business. Because so many firms engaged in diverse manufacturing activities while also active in shipbuilding, and because others abandoned the industry by diversifying into new activities, there is little correlation between the year the last metal vessel was launched and the year the firm went out of business.

The basic proxy for the date of exit from the industry is, of course, the year the last metal vessel was launched, but it should be understood that these dates may not always be equivalent. For example, the Continental Iron Works of Brooklyn, NY, launched its last vessel in 1889, after 30 years in the industry. The firm had always been diversified -- in fact even while it was making iron-clad monitors during the Civil War, it was manufacturing the steel tubes that would make up the Croton Aqueduct -- and continued in business producing items such as industrial boilers and construction steel until 1949. Although the apparent industry exit date is 1889, the annual register of the American Bureau of Shipping continued to record the firm as a manufacturer of iron vessels for another decade. Is it simply that the ABS register is incorrect and the firm really had exited in 1889? Was the firm actively seeking construction contracts after this date, but without success? Or was it more passive, willing to undertake contracts if they came along without actively seeking them out? The evidence is contradictory. On the one hand, the Continental Shipyard changed its name in 1888 to the Continental Iron Works, and Eddey (1999) plausibly argues that the name change was to signal its movement away from "manufacturing maritime projects to manufacturing less seaworthy iron objects." On the other hand, the Continental Iron Works re-entered shipbuilding, albeit on a modest scale, during both World Wars. In fact, it is common for firms to produce no vessels for a number of years, and then to reappear in the database. Is this period of non-production an exit? Most firms repeatedly had to contend with the small numbers problem generated by the lumpiness of production: failure to win but a single contract could mean the difference between operating a yard at full capacity and having no shipbuilding work at all. Survival demanded diversification, which the more successful firms undertook with a vengeance (see Figure 2). It then follows that absence from the industry did not necessarily mean exit from the industry.

As illustration, Figure 3 plots annual launchings by two successful producers. David Bell of Buffalo, NY who was engaged in shipbuilding for over forty years until his death in 1903, had launched the first iron vessel built on the Great Lakes in 1861. Reaney, Neafie and Levy

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[11] These are taken from the vessel database. If a firm was still producing after observation ended in 1914, I attempted to obtain the last year of production from the textual histories. In a small number of cases I was not able to verify a final year, and for these I coded the last year for which I have documentary evidence of production activity as a censored observation.

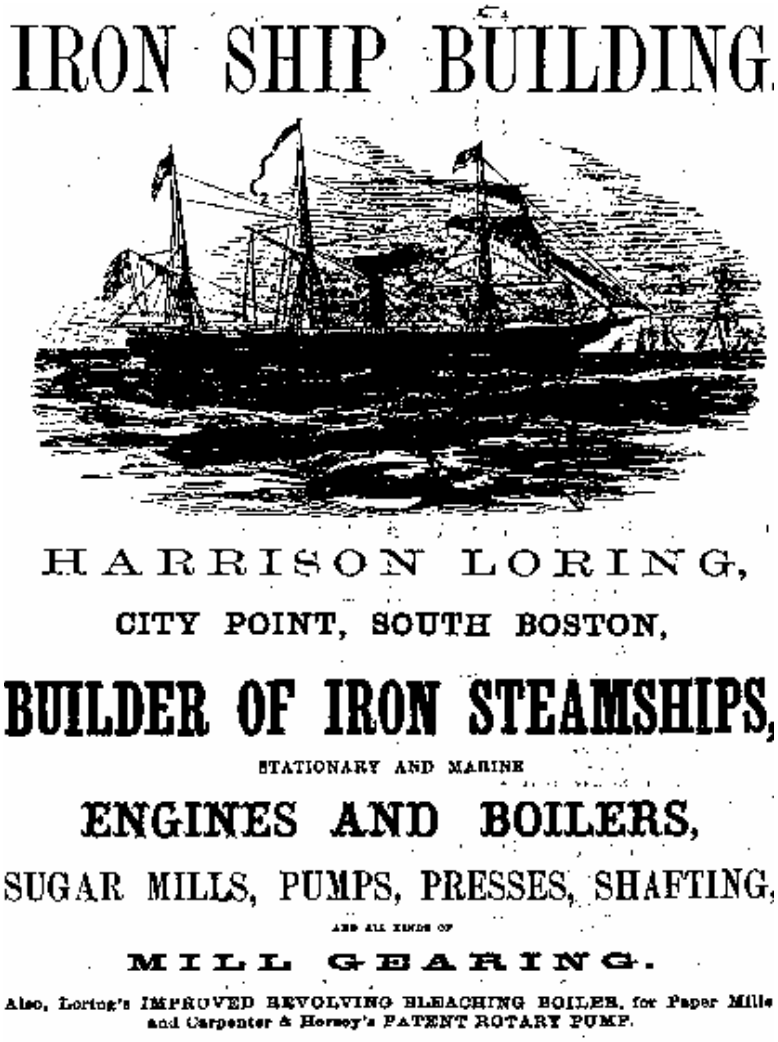

Figure 2. Printed Flyer for Harrison Loring, South Boston, MA, c.1860. Loring launched 13 vessels between 1858 and 1891 and, like many of his competitors, was engaged in the manufacturing of diverse products. Credit: Eldridge Collection, Mariners Museum, Newport News, VA.

(subsequently Neafie and Levy) of Philadelphia, PA, were among the pioneers of industrial-scale ship production, launching their first vessels in 1844, and surviving in the industry for over 60 years. Both firms survived periods in which no vessels of any kind were launched by diversifying. Bell was a major producer of steam engines, a business that generated more revenue than his shipbuilding activities; in 1865 he had opened a locomotive factory; and he also built wooden vessels (Tondrowski, 1990). Neafie and Levy built fire engines, boilers and

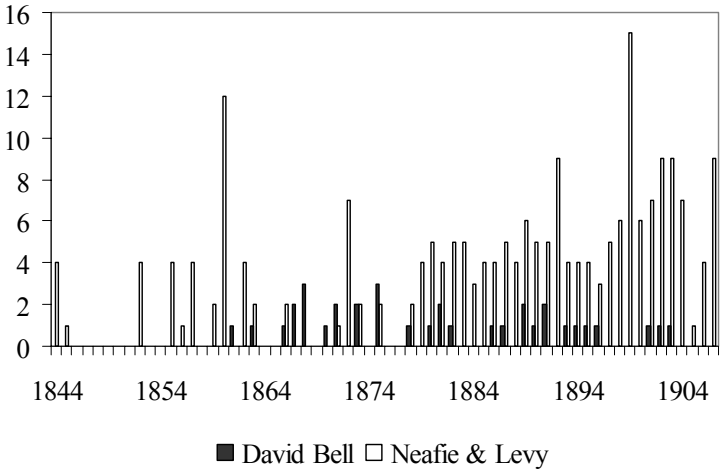

Figure 3. Number of Vessels Launched: David Bell's Steam Engine Works, Buffalo NY (1861-1903) and Neafie & Levy, Philadelphia, PA (1844-1907).

stationary steam engines, and made a steadier living manufacturing propellers for other yards, having obtained the rights to Richard Loper's design because of the inventor's friendship with John Levy. In the particularly dark days after the financial panic of 1873, the firm even manufactured refrigerating equipment (Heinrich, 1997).

Unless one can document that a firm dismantled its shipbuilding facilities in the process of diversifying out of the industry, the only confirmation that a firm has permanently exited is when the firm itself has folded. But in too many cases for such confirmation to be helpful, firm closure takes place many years after the last vessel was launched:

- The Sweeney Brothers of Jeffersonville, IN, launched just a single metal vessel, in 1891, but continued to build wooden vessels until they sold the yard in 1938 (Jeffboat LLC, 2001).

- The Tredegar Iron Works of Richmond, VA, launched their last vessel in 1867 but continued to be a successful enterprise for another 90 years, producing munitions for two world wars and becoming the oldest surviving iron works south of the Potomac river (Gardner, 2001).

While I use the last year of launching as a proxy for the year of exit, it may also make sense to think about exit in probabilistic terms. That is, one could imagine exit to be *ceteris*

paribus more likely the longer a firm has gone without launching a vessel. In this way, a firm may be viewed probabilistically as an exit even if it re-enters at a later stage.[12]

Producer Backgrounds

In coding the pre-entry backgrounds of shipbuilders, my primary focus has been on distinguishing firms that entered after gaining experience in manufacturing iron and steel products, wooden vessels, or shipping[13] (Figure 4 provides the distribution of firms across categories). Each background offered different advantages. Manufacturers of iron products were skilled in handling and shaping a relatively new industrial material. Builders of wooden vessels were experienced in hull design, marketing vessels, and had often earned a solid reputation for quality and reliability among vessel buyers. Entrants from the shipping industry had a clear understanding of buyers' needs, extensive contacts in the using industry, and in some cases they provided a market for their own output.[14]

Founders of firms often had pre-entry experience in various fields, and when this experience was significant, multiple coding was made. Firms that lacked relevant experience, hired it, or worked in close collaboration with firms having complementary experience, as the following examples attest:

- In the mid 1840s, Philadelphia engine-builders Reaney, Neafie, and Levy began to make contact with shipbuilders to help design ships and supervise the bending and mounting of frames. Because Reaney, Neafie and Levy had experience in metal work and engine work, along with the rights to the Loper propeller, collaboration with them was attractive to local shipbuilders (Heinrich, 1997).

- Charles Cramp, heir to Philadelphia wooden shipbuilding enterprise founded in 1825 by his father, William Cramp, served his apprenticeship at the local shipyard of his maternal uncle, Jacob Birely, between 1844 and 1846. Birely was at this time buying his engines from Reaney, Neafie and Levy, and was to launch his own iron boat only two years later. On returning as a master shipbuilder to his father's yard, Cramp immediately entered into close collaboration with the engine builders, and began to

[12] This probabilistic treatment has not been carried out.

[13] Among those firms whose background has been identified, alternative routes of entry are rare.

[14] In many cases of entrants with a background in metal work, I have further been able to confirm that the they manufactured steam engines. In view both of the importance of engine-building to shipbuilding and its technical difficulty, I have coded this activity as a sub-class of foundry work that merits particular attention. Most builders of wooden vessels were not equipped to manufacture engines and, although many operated small foundries to manufacture custom iron fittings, the normal practice was to sub-contract the major machinery to specialists.

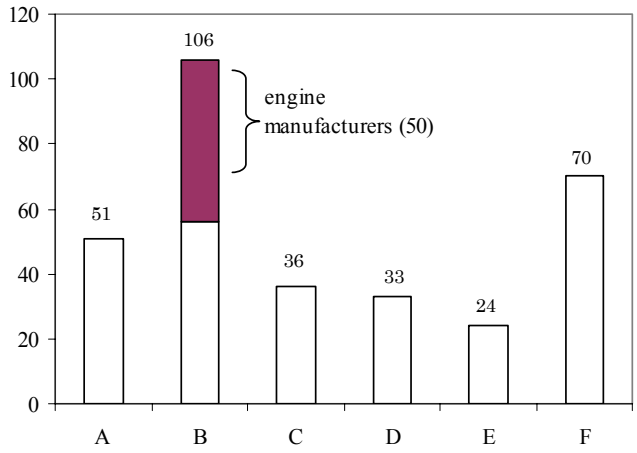

Figure 4. Number of Firms by Prior Background. Categories are not mutually exclusive. A: Wooden vessel construction. B: Iron works, including foundries, rolling mills, steam engine manufacturers, manufacturers of railcars and locomotives, and general ironware manufacturers. C: Transportation sector, including railroads, shipping, and dredging. D: Iron or steel shipbuilding. E: Firm acquired on entry an existing iron or steel shipyard. F: Prior background unknown.

experiment with screw propulsion. In 1846 he launched the country's first screw tug, *Sampson*, with the engine built by Reaney, Neafie and Levy. (Buell, 1906; Johnson, 1904).

• Alexander McDougall (1845-1923) began sailing at the age of 16, after limited schooling and being apprenticed as a blacksmith. By 1863 he had risen to second mate on a schooner, and in 1871 he became captain of the *Japan*, which in the winter of 1870-71 was one of three iron vessels being built for the Anchor Line by the William King's iron works in Buffalo, NY.[15] In his capacity as captain of the *Japan*, McDougall

[15] Most accounts call this firm the (Sidney) Shepard Iron Works, a firm established in 1848. Shephard relinquished active management of the firm in 1865, and William J. King Jr. had bought a majority share of the firm by 1871. The Anchor Line vessels were built at King's yard under the oversight of the wooden shipbuilding firm of Gibson and Craig. Shephard must have retained a minority interest in the firm: it is recorded that in 1885 he transferred to a son, C. Sidney Shepard, his interest in the old firm. By the late 1880s, the firm was owned by H.G. Trout, who had learned his trade at the King works, and then leased the property. He was a major supplier of propellers using what was known as the "Trout" pattern. In addition, the company supplied marine engines and other manufactured machinery (Buffalo Courier, 1890; Hall, 1895, vol 1, pp. 592-3; Larned, 1911, vol. 2 pp. 3-4).

spent the winter supervising construction at the yard. When shipping business was slow during the mid 1870's, McDougall went into the fishing business in partnership with Alexander Clark of Collingwood, and in the winter of 1875-6, he built the 58-foot wooden steam fish tug *Siskiwit*. Then, in 1879, shipowner Thomas Wilson, who had sailed with McDougall on the *Meteor*, asked McDougall to supervise construction of the steamer *Hiawatha* and the schooner-barge *Minnehaha*, which were being built for him at the Linn and Craig yard in Gibralter, MI. Between 1878 and 1881, McDougall commanded the *Hiawatha*. It was during this period he gave thought to barge design, and on May 24, 1881 he was granted patent 241,813 for a towboat with a cylindrical hull (possibly influenced by the design of the hull built to transport Cleopatra's Needle between Egypt and London, which McDougall had an opportunity to view on a visit to England in 1873). Design improvements, most importantly a shift from wood to iron or steel, led to a second patent, 259,889 on June 20, 1882. The familiar bow shape of the whaleback design is evident in this second patent. Further design changes during the subsequent decade led to patents in December 1883 (no. 393,997) and June 1890 (nos. 429,467 and 429, 468). Patent 429,467 was the design for McDougall's first vessel, launched in 1888; while 429,468 was the basic design for nearly all the subsequent whalebacks built by McDougall. So, when McDougall built his first steel vessel in Duluth, MN, he could draw on his experiences as blacksmith, supervisor of iron and wooden ship construction, builder of a wooden vessel, and captain of iron steamers. Nonetheless, he contracted out the difficult parts of his boat construction. In particular, the *101*'s conoidal bow and stern were fabricated at the Pusey & Jones Shipbuilding Company of Wilmington, DE. Only the straight mid section of the hull was built locally. In 1890, after securing financing from Colgate Hoyt of New York, who represented the John D. Rockefeller interests, and other New York financiers, McDougall established the American Steel Barge Company. He again looked elsewhere for expertise. In particular, he hired Joseph Kidd, who had been running his own iron works for several years in Linwood, PA. Kidd was an English shipbuilder from the Tyne. He had for eight years served as foreman for John Roach, one of the country's most successful large-scale shipbuilders, and certainly its most outspoken. Kidd then established his own firm, with Roach's assistance. He had been engaged for several years manufacturing iron conductors for the Union Line cable-roads in Philadelphia, and had also built several modest iron vessels. By the time McDougall approached Kidd, he had won contracts for two government lightships, but was not succeeding financially. McDougall induced Kidd to close his firm and take the position of Superintendent for $200 per month. (Ashmead, 1884; McDougall, 1892, 1968)

Inevitably, some judgment has to be made to exclude certain experiences. My choice in these instances was to favor the dominant experience, rather than code all known experiences, however slight. Thus, William Cramp and Sons has wooden shipbuilding as pre-entry experience, and the American Steam Barge Company has shipping coded as its pre-entry experience. But I cannot claim to have been dogmatic about this decision: recall that

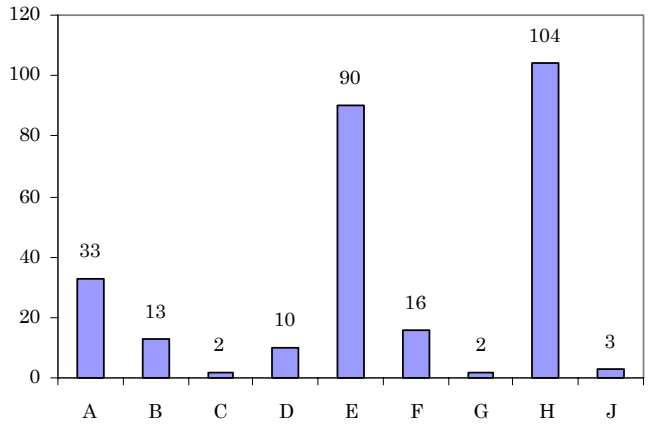

Figure 5. Number of Firms by Exit Destination. Categories are mutually exclusive. A: Firm declared bankruptcy, or known to be unprofitable at time of closure. B: Entered one of the new shipbuilding holding companies. C: Exit by merger. D: Owner died or retired. E: Firm continued operating in another industry (often the one from which it had originally entered). G: exit destination known, but non-standard. H: Exit destination unknown. J: No exit (firms still produces metal vessels today).

Reaney, Neafie and Levy are recorded with backgrounds in both engine-building and shipping.

Modes of Exit[16]

Eight categories of exit destination have been coded: bankruptcy/unprofitable; exit into one of the shipbuilding trusts; merger; owner died or retired, firm abandoned shipbuilding but continued in another industry; firm sold; non-standard motivation for exit; and destination unknown. The distribution of exit destination by category are given in Figure 5. In many cases, I just do not know what happened to the firm – they simply vanish from the database. Of those for which I have information, 53 percent continued in business, having diversified out of iron or steel shipbuilding. In the majority of these cases, the firm reverted to the activity it had undertaken both before and during its life as a metal shipbuilder. Nonetheless, in a sizable minority of cases, the firm ceased to exit contemporaneously with its exit from shipbuilding: the firm was unprofitable and closed, or bankruptcy was formally declared (20 percent); the firm was sold, without there being documentary evidence that the owner was

[16] The mode of exit was not studied in Thompson (2005).

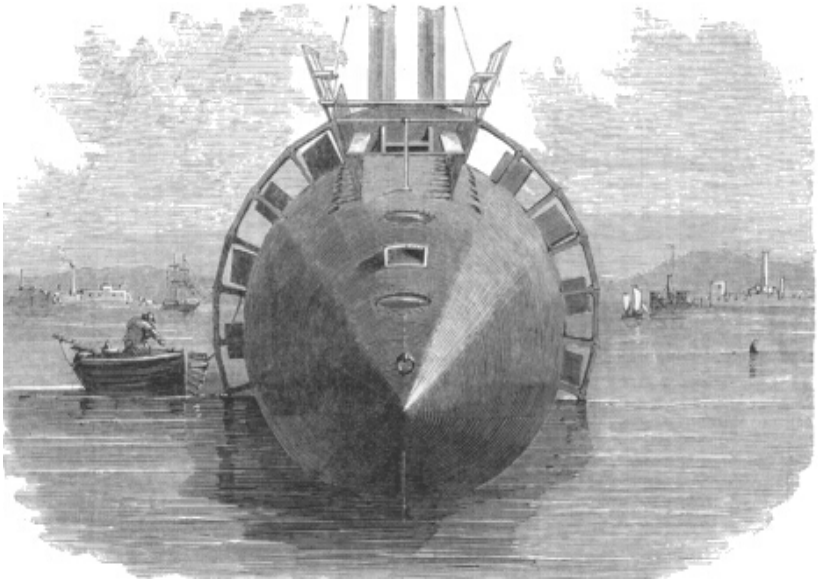

Figure 6. The first Winans Cigar Boat, 1858. Crisafulli (2001) notes the similarity between this boat and Jules Verne's *Nautilius*, arguing that Verne would undoubtedly have seen the Winans design. Source: *The Illustrated London News*, November 27, 1858.

retiring or the firm was insolvent (9 percent); or the firm exited by merger or into one of the trust companies being formed at the end of the 19th century (9 percent); or the owner died or retired (6 percent).

In two cases, I coded the exit destination as non-standard. One was the demise by fire, already mentioned, of the Racine Boat Manufacturing Company of Racine, WI. The second, the Winans Brothers, is more interesting:

> • The Winans brothers were sons of Ross Winans, the railway pioneer. Ross Winans had begun his engineering life in 1830 as an assistant to Phineas Davis, who in 1825 had been involved in the construction of the first American iron vessel, *Codorus*. Winans eventually went into business on his own with the founding of the Winans Locomotive Works. His son Thomas became an active collaborator around 1840. The family accumulated considerable wealth overseeing railway development for the Russian Government, traveling frequently to Russia. In 1858 the Winans brothers launched a novel ship into Baltimore harbor. Known as the cigar ship, it was built in two sections with a radial propeller amidships joined by a shroud ring over the propeller (see Figure 6). Power was provided on a single shaft by two railroad steam engines, one in each hull. The superstructure consisted of a narrow deck with railings, a lookout tower atop the propeller shroud, and narrow smokestacks on each hull. The helmsman sat in a compartment in the bow with a small, forward-looking view port. The boat made

several trial trips, but was never put into commercial use. Ross Winans designed the novel cigar boat, but Thomas Winans was responsible for its construction (Thomas' brother was at the time in Russia carrying out the contracts the family had won). Plans were laid for a second vessel. But in 1861 Ross Winans, a southern sympathizer, built a self-propelled steam gun. It was loaded on a B&O car bound for Harper's Ferry but was intercepted by the Federal troops and dismantled. Winans was arrested for his part in the affair and jailed until November 1862. After his release, the Winans family moved to Europe. They first tried to persuade the Russian government to purchase the design for their Navy, and two vessels were built in St. Petersburg. The Russians did not bite, and a third vessel was launched in La Havre in 1865. Two Winans vessels eventually made their way to England and remained moored in Southampton until late in the century when they were sold for scrap (Shugg, 1998; Crisafulli, 2001).

Compared with pre-entry backgrounds, there were relatively few instances in which judgments had to be made about coding the exit destination. But two similar examples, in which the death of an owner is shortly followed by bankruptcy but in which different assignments were made, may shed light on those judgments that were made.

• After John B. Roach assumed the presidency of his father's yard in 1885, the firm was incorporated under the name of the Delaware River Iron Shipbuilding and Engines Works. Over the next, 22 years, the firm launched 75 vessels for a total 18,2,656 tons, remaining one of the most active producers in the country. The yard was receiving fewer orders by the turn of the century, and in 1903 it closed for a while, but by 1906, business picked up. Seven vessels were launched in 1906 and 1907, for a total of 21,073 tons, far exceeding the firm's lifetime average annual production rate of 8,302 tons per year. Although orders dropped again in later 1907, and the yard closed temporarily, there is no evidence suggesting that conditions were much different than had previously been experienced. However, John B. Roach died in 1908, and his family quickly announced that they no longer wished to continue production. The yard entered receivership only five months after Roach's death. (Heinrich, 1997; Swann, 1965)

• In 1883, the Navy began to seek bids from a new fleet of steel ships, and a new yard, the American Shipbuilding Company,[17] was established in Philadelphia, PA, to secure some of these contracts. It was financed by New York interests with $250,000, and placed under the direction of Lieutenant-Commander H.H. Gorringe who had earned fame in 1880 by shipping Cleapoatra's needle from Egypt to Central Park. Gorringe hired 700 craftsmen, issued subcontracts for engines to Neafie and Levy, and hired foremen who had learned their trade at John Roach's yard. Unfortunately for Gorringe, a quarrel developed between him and the secretary of the navy, Chandler. Gorringe advocated the cause of free ships, because he was more interested in the US having a

[17] This firm is unrelated to the American Ship Building Company formed by the merger of a number of large producers in the Great Lakes region in 1899.

strong merchant marine than a strong shipbuilding industry. Chandler was a protectionist. In a letter to Gorringe, Chandler wrote that "there is no objection to the public expression by a naval officer of his unpurchased opinions on any subject of general interest." Gorringe took the word "unpurchased" as a slander and resigned from the navy. Two events conspired to close the firm only two years after its creation. First Gorringe died in 1885 after attempting to board a moving train. Second, the firm's financial prospects were severely shaken by its failure to win any navy contracts, even though it had managed to launch a dozen private vessels, and financing was withdrawn after 1885 (Johnson, 1904; Heinrich, 1997).

In the former case, I coded the exit destination as death of owner, and in the latter as bankruptcy. The different choices result from my interpretation of the textual histories. In the case of Gorringe's company, I concluded that continued financing was not conditional on Gorringe's participation—he had been central to the strategy of winning Navy contracts, but that strategy had already fallen apart by the time of his death. Gorringe also had no particularly rare shipbuilding talent. In contrast, John B. Roach had become accustomed to the cyclical nature of the demand for new construction over 35 years in the business; he had even closed the yard temporarily on more than one occasion. My reading is that Roach would not have been defeated by what appeared to be a quite typical lapse in new orders in late 1907, and that the family's decision to close the firm was directly predicated on Roach's death.

3. Coverage and Selection Bias

In industrial competition, as in war, history is written by, or for, the winners. Firms for which I have been able to code reliably their backgrounds and their destinations after exit from metal shipbuilding are consequently more likely to be among the successful. Table 1 provides some summary data on firm duration, mean vessel size and total production according to whether it has been possible to code on background and exit. Firms for which I have adequate histories produced many more, and larger, vessels, and survived on average five times as long as the average uncoded firm.

The differences are sufficiently large that, although I have been able to completely code for background and exit destination for only a little over 60 percent of the firms that appear in the database, the contribution of the coded firms to vessel production is much larger. As Table 2, shows, the sample coverage of the coded firms, whether measured by number of vessels produced, tons of production, or the number of firm x year observations in the panel, is about 90 percent.

TABLE 1
Group and Firm Means, By Data Availability

	Firm Averages			Group Totals		
	No. of Firms	No. Of Vessels Built	Firm Output (Gross Tons)	No. of Vessels Built	Average Vessel Size (Gross Tons)	Average Duration (Years)
Total	273	14.6	23,750	4,000	1,622	10.2
Background Known	203	18.9	31,779	3,833	1,668	12.9
Background nknown	70	2.4	694	167	291	2.4
Type of Exit Known	170	21.4	35,422	3,645	1,634	14.5
Type of Exit Unknown	103	3.4	4,711	355	1,367	3.2
Background & type of exit known	169	21.5	35,615	3,639	1,636	14.5
Background & type of exit unknown	69	2.3	657	361	126	2.4

TABLE 2

Sample Coverage by Data Availability

	PERCENTAGE OF TOTALS WITH . .		
	BACKGROUND KNOWN	TYPE OF EXIT KNOWN	BACKGROUND AND TYPE OF EXIT KNOWN
NO. OF FIRMS	74.4	62.3	61.9
NO. OF VESSELS	95.8	91.1	90.1
TONS PRODUCTION	98.5	91.8	91.7
OBSERVATION YEARS[a]	94.0	88.5	88.0

[a] The product of average firm life and number of firms.

While it is gratifying to be able to account for so much of the production, the bias towards the more successful firms evidenced in the coverage of the textual histories raises serious questions about sample selection bias in statistical analyses. Simply including "unknown" as one of the categories into which a firm may fall is problematic when these categories are used as regressors. For example, negative idiosyncratic shocks cutting short the life of a firm or reducing its output, increase the likelihood that the firm falls into the "unknown" category. Survival analysis on the dataset is therefore especially susceptible to endogeneity problems.

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