

An Annual Index of U.S. Industrial Production, 1790–1915:

TECHNICAL DATA APPENDIX *

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Technical Data Appendix A

Industrial production data set

This appendix documents the underlying physical-volume series of the U.S. industrial production index presented in Davis (2004). Several modifications have been made to the previous Technical Data Appendix (Davis 2002b).

An alphabetical inventory of the 43 index components is concisely presented in Table A1. Compilation details for certain series follow the table, and the relative strengths and weaknesses of the data are assessed. Technical Appendixes B, C, and D separately address the locomotive, merchant shipbuilding, and pig iron series, respectively. Appendix E derives the value-added component weights of the new index. Taken together, the disclosure in the appendixes should permit a replication of the final index presented in Davis (2004).

APPENDIX TABLE A1
ALPHABETICAL INVENTORY OF INDEX COMPONENTS

Individual series	Initial coverage	Physical units	Sources
Anthracite coal	1790	Pennsylvania anthracite coal, in net tons	<i>since 1886: Mineral Resources of the United States</i> <i>1790-1885: Eavenson (1942, 426-34, table 20, 498, table 53)</i>
Army boots & shoes	1808	Pairs of leather boots & shoes made by private contractors & at U.S. Quartermaster depots for the U.S. Army	<i>Identical to wool stockings</i>
Beef cattle receipts	1827	Head of beef cattle received at Brighton market & at Chicago stockyards during the calendar year	<i>since 1827: New England Farmer; Maine Farmer; CBOT (various issues); Smith and Bridges (1982)</i>
^a Bituminous coal	1790	Net tons	<i>since 1886: Identical to anthracite coal</i> <i>1800-1885: Identical to anthracite coal</i> <i>1790-1799: Eavenson (1942, 485-90, table 49, 441-45, table 22, 500-501, table 54)</i>
^b Cloth regalia	1808	Units of wool & silk regalia, made by private contractors & at federal clothing depots	<i>Identical to wool stockings</i>
Copper consumption	1806	Domestic smelter output, plus imports of all unwrought copper exported from all British ports, in long tons	See Appendix A discussion below
^c Copper smelting	1790*	Smelter production, recoverable content, in short tons	<i>since 1845: U.S. Bureau of Mines (1928, 15, table 10)</i>
Cotton consumption	1790	Consumption of raw cotton and linters over 12 months ending in August, in equivalent 500-lb bales, gross weight	See Appendix A discussion below
Crude tin imports	1815	Unwrought tin from mines of U.K., British colonies, and foreign countries, exported to U.S. by all vessels from all British ports, in long tons	<i>since 1815: Sessional Papers (United Kingdom, Parliament, House of Commons)</i>
Die-sinking	1793	U.S. coin production of all denominations, in grams (weight; not face value)	<i>since 1793: Coin Price Guides, based on U.S. Mint records and private sources</i>
Dyeing chemicals	1790*	Pounds of prussiate of potash (potassium ferrocyanide) made by Carter & Scattergood and Henry Bower Chemical	See Appendix A discussion below

APPENDIX TABLE A1 - *Continued*

Individual series	Initial coverage	Physical units	Sources
^d Farm machinery	1790*	Units of reaping & harvesting machinery, including rakers mowers, droppers, harvesters, binders; and Deere steel plows	(A) Obed Hussey: <i>since 1833:</i> Rogin (1931, 72–79 and citations) (B) McCormick/International Harvester Company <i>since 1840:</i> Hounshell (1984, 161, table 4.1); McCormick Collection (series M/I) (C) John Deere & Company <i>since 1837:</i> Broehl (1984); Deere & Co. archives
Firearms	1790*	Military and commercial small arms made (all models), by federal & state armories, contractors & private firms	See Appendix A discussion below
Fish curing	1804	Salted mackerel barrels inspected, Massachusetts Salted mackerel barrels inspected, New England	<i>1804-1877:</i> U.S. Bureau of Fisheries (1934, 17, table 14) <i>since 1878:</i> <i>Ibid</i> (1934, 21, table 18), spliced
Gold mining	1824	Mined output at refinery stage, in fine ounces	<i>since 1824:</i> U.S. Department of Commerce, Bureau of Mines (1929c, 14, table 6); <i>Mineral Resources</i> (1911, I:211); <i>Historical Statistics</i> (1975, M-268)
Gunpowder	1804	Pounds of gunpowder and explosives produced by factories & controlling interests of E.I. du Pont de Nemours Powder Company	See Appendix A discussion below
Hand fire engines	1790	Units constructed	See Appendix A discussion below
Hide receipts	1827	Receipts of domestic & foreign dried & green hides at New York City and Chicago	<i>since 1827:</i> <i>NYCC; HMM; CBOT; Shoe and Leather Reporter Annual</i> (various issues)
Hog packing	1790*	Quantities of hogs packed in Cincinnati, Chicago, Indianapolis, and Omaha	See Appendix A discussion below
^e Lead smelting	1821	Refined output, in short tons Primary smelter production, in short tons	<i>since 1886:</i> U.S. Bureau of Mines (1929b, 14, table 10) <i>1821-1885:</i> <i>Ibid</i> (1929b, 12-13, tables 8-9)
Locomotives	1790*	Engines manufactured	<i>See Technical Data Appendix B</i>
Lumber shipments	1827	Feet, board measure (b.f.)	See Appendix A discussion below
Merchant shipbuilding	1790	Gross tonnage, Old Custom House Measurement basis	<i>See Technical Data Appendix C</i>

Continued on following page.

APPENDIX TABLE A1 - *Continued*

Individual series	Initial coverage	Physical units	Sources
Milled wheat flour	1798	Barrels received and manufactured by city flour mills in Baltimore, Buffalo, Chicago, and Minneapolis	See Appendix A discussion below
Naval shipbuilding	1790	U.S. Navy vessels constructed, in displacement tonnage, at private & government yards	See Appendix A discussion below
Newspaper publishing	1790	Number of daily newspapers in circulation	See Appendix A discussion below
Petroleum refining (1880 weight only)	1790*	Crude petroleum produced, in 42-gallon barrels	since 1859: <i>Historical Statistics</i> (1975, M-138)
Pig iron	1827	Gross tons produced	See <i>Technical Data Appendix D</i>
Pipe organs	1790	Units constructed	See Appendix A discussion below
Pocket watches (1880 weight only)	1790*	Movements produced	See Appendix A discussion below
Raw silk imports	1814	Raw, thrown, and waste silk of U.K., British colonies, and foreign countries, exported to U.S. by all vessels from all British ports, in pounds	See Appendix A discussion below
Rice milling	1819	Cleaned rice equivalent, rough rice crop, in pounds	See Appendix A discussion below
^f Salt production	1797	Inspected 56-pound bushels of processed salt (all types), at all New York salt wells and reservations, and from all Michigan salt producers	(A) New York salt inspections: since 1797: <i>New York State Museum Bulletins</i> (B) Michigan salt inspections: since 1860: Michigan Geological & Biological Survey (1914, 123; 1928, 96)
Sole leather receipts	1827	Inspected receipts of sole leather sides, including hemlock sole, union sole, and oak sole, in New York (before Boston consignment)	since 1827: Leupp (1846, 715-16); de Fontenelle and Malepeyere (1852, 24); Norcross (1901); <i>NYCC</i> ; <i>Shoe and Leather Reporter Annual</i> (various issues)
^g Sperm oil refining	1793	Barrels of sperm oil returned to port by American whaling fleet	since 1804: Hegarty (1959, 51) & Tower (1907, 126, app. table 3), compiled from data in Starbuck ([1878] 1964, 660-61, appendix J) 1793-1813: Tabulations of Starbuck's ship logs

Continued on following page.

APPENDIX TABLE A1 - *Continued*

Individual series	Initial coverage	Physical units	Sources
Steam fire engines (1880 weight only)	1790*	Units delivered, expressed in engine capacity of gallons per minute	See Appendix A discussion below
Steel production (1880 weight only)	1790*	Net tons, in thousands, open-hearth & Bessemer processes	since 1866: AISI Annual Statistical Reports
Sugar refining	1790	Domestic production of refined sugar consumption, converted to pounds	See Appendix A discussion below
Telescopes	1790*	Refractors & reflectors, in inches of objective	since 1830: Records provided by members of the Antique Telescope Society
Whalebone	1804	Baleen whalebone, in pounds	Identical to sperm oil refining
Whale oil refining	1793	Barrels of whale oil	Identical to sperm oil refining
Wool stockings	1808	Pairs of woolen stockings & half stockings made	See Appendix A discussion below
^h Zinc smelting (1880 weight only)	1790*	Mine recoverable content Primary production, smelter slab zinc from domestic ores, in short tons	since 1907: Historical Statistics (1975, M-249) 1858-1906: U.S. Bureau of Mines (1929a, 19, table 11)

General notes: HMM abbreviates for Hunt's Merchants' Magazine, CBOT for Chicago Board of Trade, and NYCC for Annual Reports of the New York Chamber of Commerce. Year marked by (*) indicates series captures the product's commercial introduction; earlier observations are recorded, by definition, as zero.

- ^a Quantities have been extended back from 1800 through 1790 by ratio-splicing Eavenson's estimates on three of the six coal-producing states (PA, VA, MD). This linkage is warranted since the absentee states (WV, KY, OH) accounted for less than 3% of 1800 output.
- ^b Cloth regalia include woolen, worsted, and silk quantities (*all colors*) of bands & tassels, pompons, sashes, aiguillettes, and pairs of chevrons, epaulettes, straps, and wings.
- ^c Figure for 1855 was adjusted upwards (to 3,904 tons) based upon recently uncovered Michigan data (Hyde 1998, 27, table 1.5).
- ^d Quantities of reaping machinery (67.6%) and steel plows (32.4%) have been value-added weighted from detailed returns on the farm-implements industry in the 1860 census (U.S. Census Office 1865, 733).
- ^e Series reflects smelter production before the late 1880s and does not contain meaningful amounts of domestically refined lead from foreign ores or base bullion. *Historical Statistics* series M-243 appears to be in error for 1888 and should read 176,015 short tons.
- ^f Michigan inspections began in 1860 following commencement of operations at the East Saginaw Salt Manufacturing Co., the state's first successful manufacturer. New York and Michigan were the preeminent salt-producing states before WWI.
- ^g Starbuck ([1878] 1964) traced nearly every whaling voyage of the American whaling fleet through 1876. Tower (1906) and Hegarty (1959) continued Starbuck's research using the same primary data sources, most significantly the weekly *Whalemens Shipping List* (series agree in the overlap). Before 1816, Starbuck's figures were converted using a standard factor of 31.5 gallons per barrel. If a whaling vessel's arrival was not documented, I assumed that the voyage was completed within the calendar year (see Davis et al. 1997, 379-80, table 9B.1 for the motivation). I did not extend the series back before 1793 because Starbuck could not secure 1791 shipping logs.
- ^h The Bureau of Mines splices data for refined zinc production from domestic ore, to refined production from domestic & foreign ores in 1907 (see *Historical Statistics* series M-250). Following Romer (1990), I use the zinc data for refined production from domestic ores through 1906; thereafter, I switch to the mine recoverable content series as reproduced in *Historical Statistics* series M-249.

Copper consumption (since 1806)

The quantity of unwrought copper available to domestic manufacturers indirectly measures the manufacture of wrought copper and brass products. Specifically, smelter output of domestic copper mines has been merged with the quantity of unprocessed copper imported. Such aggregation is appropriate because both series relate to the same metallurgical refining stage.

The U.S. Bureau of Mines (1928, 15, table 10) first reports the annual tonnage of smelted copper from domestic mines in 1845, which marks the initial exploitation of Michigan's Lake Superior deposits. Following discussions in Pettengill (1935) and Gates (1951), I have assumed that earlier quantities mined from the small ore deposits scattered across Connecticut and New Jersey (i.e. the Schuyler mine and the Solo Copper Works) were essentially *zero*. Careful examination of (i.) the quantities of raw copper ore shipped abroad, (ii.) U.S. Navy contracts for copper goods, and (iii.) the transatlantic buying habits of prominent metal merchants collectively suggest that this is a tenable working assumption.¹ Indeed, domestic ore contributes less than five percent to the unrefined copper consumed in 1845 despite the surge in smelted supplies out of Lake Superior.

Since U.S. government officials rarely collected import data on unrefined copper before the Civil War, I infer the imported tonnage of unwrought copper from Great Britain's *Sessional Papers* (United Kingdom, Parliament, House of Commons).² Specifically, I have included quantities of British and foreign unwrought and part-wrought copper (ingot or pig copper) exported from all British ports by American and foreign vessels directly to the United States. Gross imports of unfinished copper remained duty-free throughout the antebellum period because American manufactures and shipbuilders relied heavily on unwrought foreign copper for their metalwork and on part-wrought sheets in hulling wooden ships. Indeed, transatlantic imports continued to account for as much as three-fourths of copper consumption by the late 1800s despite the institution of duties on unrefined copper in 1861 and 1869.

Consultation of post-Civil War U.S. copper imports finds that the oceanic shipments in the *Sessional Papers* closely track quantities imported stateside. Nonetheless, it should be noted that the trade-flow data account for a decreasing share of total imports after 1900 on account of the

¹ Anecdotal evidence endorses this approach. Throughout the early 1800s, Paul Revere was constantly frustrated in his inability to secure sufficient quantities of American-mined block copper for his rolling mill and brass-bell foundry. Similarly, prominent Philadelphia metal merchants such as Hendricks and Trotter continued to import unwrought British copper products from their London commission merchants for decades after the War of 1812 (Whiteman 1971, 48–49; Tooker 1955, 91).

² Before 1854, the *Sessional Papers* reports exports by twelve months ending January 5th; thereafter, by calendar year. Minor reporting changes in the *Sessional Papers* before 1812 and after 1886 were resolved through a simple ratio splice. Cockton (1988) provides a comprehensive index to the *Sessional Papers*. See especially volume two for citations of the “Annual Statement of Trade [and Navigation] of the United Kingdom with Foreign Countries and British Possessions.”

development of South American copper mines. I do not view this as a grave shortcoming because annual changes in domestic smelting by then dominate consumption movements.

Cotton consumption (since 1790)

The production of cotton textiles and apparel items is quantified conventionally through the consumption of raw cotton and linters over the twelve-month period ending in August when the cotton crop was predominantly marketed. Quantities are expressed in equivalent five-hundred-pound bales (gross weight) as reported in *Bulletin 166* (U.S. Department of Commerce, Census Bureau 1929, 57–59, table 31). The government figures account for cotton consumed at textile mills, on the farm, and by households under the putting-out system.

The U.S. Census Bureau records annual cotton consumption figures as early as 1790, with continuous coverage commencing in 1826. Coverage gaps before 1826 have been interpolated on the domestic cotton supply marketed to manufactures using the FRB procedure. The domestic cotton supply is defined as the sum of the U.S. cotton crop less cotton net imports. Changes in year-end stocks were checked against implicit Census inventory changes using the perpetual inventory method.

Confidence in the estimated observations is bolstered by four factors:

- (i.) approximately 99 percent of cotton grown in the specified crop year was returned as ginned after the marketing year;
- (ii.) growth rates in the extended series track closely with formation of new New England cotton mills as recorded in Ware (1931, 37–38) and Day (1925, 452);
- (iii.) the estimates correlate well with short-run movements in the relative price of textiles in the Warren-Pearson index (i.e., 1810, 1819–20, 1825) and match the absolute decline of cotton-cloth output in 1816 at New England textile mills (Zevin 1975);
- (iv.) the observed correlation between quantities of cotton consumed and marketed cotton supplies is quite high in trend ($\rho > 0.9$) and cycle ($\rho > 0.6$) over the long nineteenth century.

Two caveats of the cotton-consumption series should be noted. First, the index's imputed-weighting principle assigns the value added of both cotton and woolen production to the cotton-consumption series. As noted in Table 1 of Chapter 1, this approach is necessary to avoid attributing a high and unwarranted importance to the manufacture of two relatively minor military apparel items,

namely cloth regalia and wool stockings. The exclusion of woolens in the index, however, may bias upwards the secular growth of the index, although the impact on business-cycle volatility is unclear.³

Second, calendar-year consumption has been assigned the reported fiscal year in order to effectively account for the inherent lag between cotton purchases and cloth manufacture. This adaptation was motivated by Frickey (1947, 144), who stressed, “the crop-year data for raw cotton consumed are fairly well representative of calendar-year production of cotton cloths.” This interpretation is consistent with actual cotton consumption figures collected by the U.S. Census.⁴

Dyeing chemicals (since 1834)

The production of dyeing chemicals is represented by the quantity of potassium ferrocyanide manufactured by Carter & Scattergood. The Philadelphia chemical firm was established on January 1st, 1834 and was the first American company to produce yellow and red prussiate of potash (*potassium ferrocyanide*). The firm’s pigments were sold throughout the country by other chemical concerns. Carter & Scattergood’s dyeing agents were utilized in various industrial applications, including calico printing (“Prussian blue”), fabric-making, and blueprinting. Carter & Scattergood was sold in 1911 to the Henry Bower Chemical Manufacturing Company. Annual data on the quantity of potassium ferrocyanide produced have been compiled from the Carter & Scattergood Collection (Accession 1070) and the Henry Bower Chemical Manufacturing Company Collection (Accession 376) archived at the Hagley Museum and Library in Wilmington, Delaware.

Firearms (since 1790)

Traditionally, the American small-arms industry has included the manufacture of firearms for military and commercial use. Accordingly, I have gathered manufacturing data from government-operated armories, private contractors, and civilian manufactories in order to accurately reflect domestic production. Appendix Table A2 documents the various organizations in the data set.

Following Deyrup (1948, 7), small arms have been conventionally defined as weaponry that can be “carried on the person.” The sample includes all varieties of muskets, musketoons, carbines, pistols, revolvers, rifles, and shotguns. By definition, domestic manufacturing excludes imported weapons,

³ I thank John Brown for emphasizing this point. The omission of woolen goods may monotonically *dampen* the aggregate volatility of the index, although an *opposite* argument could also be made on account of substitution effects observed between cotton and wool products over the business cycle.

⁴ For illustration, compare the fiscal-year consumption series with actual monthly consumption returns from textile establishments in *Census Bulletin 160* (U.S. Department of Commerce 1926, 27–28, table 14; 49–51, table 31).

gunsmithing and related handicraft services (i.e., repairs and alterations), and non-firearm production (i.e., accoutrements or cannons and other heavy ordnance).

APPENDIX TABLE A2
MILITARY & COMMERCIAL FIREARM MANUFACTURERS

Organization, by class	Location	Years active	Types of small arms made
Federal Armories			
Springfield Armory	Springfield, MA	<i>since 1795</i>	Carbines, muskets, pistols, rifles
Harpers Ferry Armory	Harpers Ferry, VA/WV	1801-1861	Carbines, muskets, pistols, rifles
Rock Island Arsenal	Rock Island, IL	<i>since 1904</i>	Magazine rifles, carbines
<i>Private contractors (50+ establishments)</i>		<i>since 1792</i>	Muskets, pistols
State Armories			
Virginia Manufactory	Richmond, VA	1802-1821	Muskets, pistols, rifles
<i>Private contractors (21 establishments)</i>		1800-1819	Muskets, pistols
Commercial Manufacturers & Quasi-independent Armories			
Simeon North	Middletown, CT	1800-1853	Carbines, muskets, pistols, rifles
Hall Rifle Works	Harpers Ferry, VA/WV	1817-1844	Hall breechloaders
Nathan Starr	Middletown, CT	1824-1845	Muskets, rifles
J & S Hawken	St. Louis, MO	1825-1858	Fur trade rifles, pistols
Colt's Patent Fire Arms Co.	Hartford, CT	<i>since 1837</i>	Pistols, revolvers, rifles, shotguns
Smith & Wesson	Springfield, MA	<i>since 1856</i>	Pistols, revolvers
Parker Brothers	Meriden, CT	<i>since 1866</i>	Shotguns
Winchester Repeating Arms Co.	New Haven, CT	<i>since 1866</i>	Rifles, shotguns

Sources: Cromwell 1975; Deyrup 1948; Haven and Belden 1940; Hicks 1940a; 1940b; Hounshell 1984; Huntington 1972; North and North 1913; Smith 1977; Wilson 1985; U.S. Congress 1838–60; 1866–1916; U.S. Ordnance Department [n.d.], RG 156, National Archives; Chouteau Accounts Collection [n.d.] and Hawken Collection [n.d.], Missouri Historical Society; and unpublished records provided by Smith & Wesson and the U.S. Repeating Arms Company.

Notes: Sample years terminating before 1915 do *not* indicate missing data, but rather firm closure (i.e. death or default) or cessation in production. Samuel Colt first worked in Paterson, New Jersey before declaring bankruptcy in 1841.

President Washington's sponsorship of the federal armory bill in 1794 effectively marked the beginning of the domestic small-arms industry. Up until this time, civilian and military firearms were predominantly imported from Europe and, when necessary, repaired or resold by local gunsmiths. The armory bill established two national armories for the exclusive production of military firearms: the Springfield Armory in Massachusetts, and Harpers Ferry Armory near Charleston, [West] Virginia.

After the destruction of the Harpers Ferry Armory in 1861, the Springfield Armory single-handedly provided government-made firearms throughout the remainder of the nineteenth century.

I have secured armory data from published and unpublished documents. The U.S. Ordnance Department submitted annual reports to Congress that detailed the quantity of firearms made at the national armories. Beginning in 1839, published armory statistics were delineated in fiscal-year frequencies in accordance with War Department guidelines. To quantify calendar-year production throughout the sample, I have consulted the well-preserved armory factory records in the vast U.S. Ordnance Department collection, Record Group 156 (RG 156), at the National Archives.

In addition, the data set accounts for military firearms produced by private contractors. Armory figures have been supplemented with firearms annually delivered by private contractors.⁵ Under the federal contract system actively in place as early as 1792 through the 1840s (and revived during the Civil War), private manufactories supplied an important share of military firearms. Due to the complexity of small-arms production, the U.S. War Department issued hundreds of cash-advance contracts to a battery of civilian arms makers. The bulk of contractors hailed from Philadelphia and New England, the latter region including Johnson, Pomeroy, and Whitney. Contractor output signifies units inspected by Ordnance Department officials, usually from nearby arsenals. The government set the standards to which contractors were held in producing these weapons. Since arms inspectors were required to issue certificates of authenticity for completed quantities, these monthly delivery records are more reliable than quantities specified in federal contracts. Private establishments commonly failed to meet contracted production targets on time. The domestic manufacture of large quantities of commercial firearms began several decades before the Civil War. I have accessed firm records for several prominent manufacturers who are listed in the table. Extant data for Ethan Allen, Marlin, Savage & Stevens, Spencer, and Remington are insufficient for their inclusion in the sample.

Gunpowder (since 1804)

The manufacture of black powder and other explosive powders is represented by output of the E.I. du Pont de Nemours Powder Company (henceforth *Du Pont*). The Du Pont data are expressed in pounds and include all variants of powder made annually at its numerous facilities: black “A” gunpowder and blasting powder; soda “B” black powder; black sporting powder; and smokeless

⁵ The data set includes output from the Virginia Manufactory, which was established by the State of Virginia to manufacture muskets for the state’s militia. Like the national armories, the Virginia Manufactory outsourced gun production to various private establishments during its existence. The Virginia Manufactory ceased operations in 1821 when the two federal armories began meeting state quotas. The Confederacy briefly resurrected the Richmond facility, albeit with limited success, during the Civil War.

sporting powder. Annual data have been compiled from the E.I. du Pont de Nemours & Company Collection at the Hagley Museum and Library in Wilmington, Delaware. Production records can be found in the following Soda House archives: Accession 384, Box 38, Papers of Lammot du Pont; Accession 472, E.I. du Pont de Nemours Powder Company; and Accession 1729, Du Pont Legal Department.

Du Pont was established in 1802 along the Delaware Creek near Wilmington. The Du Pont powder mills soon expanded and sold their products through sales agents located in virtually every major American city. Until 1857, Du Pont produced exclusively black powder, a mixture of charcoal and imported sulphur and saltpeter. Black powder was used commercially both as gunpowder and as a mine-blasting agent. In 1858, the company began manufacturing “soda” powder, the first explosive designed specifically for industrial use. The company began making dynamite and other explosive materials in 1880.

Du Pont was the largest member of the Gunpowder Trade Association, a trust of seven companies formed in 1872 to control the domestic powder market. When Du Pont was incorporated in 1902, its manufacturing establishment oversaw more than thirty powder works and dynamite mills (Chandler and Salsbury 1971, 70). Shortly before the First World War, Du Pont was found in violation of the Sherman Antitrust Act. Hence, a caveat of the Du Pont series is that the data overstate the secular growth in the explosives industry.

Hand-operated fire engines (since 1790)

Hand fire engines were the predominant means of fighting fires in the early 1800s. Hand fire engines, or *handtubs*, were wood or metal-framed wagons with copper tubs designed to hold water. Eventually, hand-pump engines were equipped with suction pumps to allow the water to be fed through a riveted leather hose. Municipal and volunteer fire departments, private firefighting companies, public institutions and large factories all purchased hand fire engines. The Civil War markedly accelerated the secular decline of handtubs in favor of steam-powered fire engines (see entry below). Post-Civil War demand never returned to antebellum levels.

Builder lists on a broad sample of these establishments constitutes the basis of an annual series on the number of hand fire engines constructed from 1790. Producers of hand (non-steam-powered) fire engines included machine shops that occasionally dabbled in fire-engine construction, and manufacturers devoted exclusively to the construction of fire engines, fire hose, and ancillary firefighting apparatus (i.e., ladders and hose wagons). Large and small operations outsourced or employed skilled wheelwrights and cabinetmakers in crafting the final product. Prominent builders

such as the Button and Hunneman pursued the development of steam-powered fire engines as demand for hand-pump devices waned.

Accessed firm production records are listed in Table A3. Construction data on more than 2,000 hand fire engines come from the Handtub Junction's (2001) *Encyclopedia of American Hand Fire Engines* and numerous sources cited therein. The database accounts for the largest builders of hand fire engines and an estimated two-thirds of all handtubs constructed in the U.S. The engine data set rests on various builder lists (i.e., Tufts (1995)), fire museum archives, and fire department histories. The published data have been corrected for occasional inconsistencies and have been supplemented by unpublished data generously provided by Handtub Junction.⁶

⁶ Handtub Junction is a private organization devoted to documenting the origin and history of all hand fire engines built in the United States.

APPENDIX TABLE A3: HAND FIRE-ENGINE PRODUCERS

Establishment	Location	Years active
Daniel Jackson	Providence, RI	<i>until 1791</i>
Richard Mason / Phillip Mason	Philadelphia, PA	<i>until 1806</i>
W. C. Hunneman [& Gay] & Company	Boston, MA	1792-1881
Patrick Lyons	Philadelphia, PA	1792-1824
Ephriam & Stephen Thayer	Boston, MA	1794-1860
Balthaser Sees	Harrisburg, PA	1797
Laomi Baldwin	Groton, MA	1802-1803
T. & N. Frothingham	Boston, MA	1803
David Wilkinson	Pawtucket, RI	1803
Luther Holland	Belchertown, MA	1810-1824
James Smith (<i>fragmentary roster</i>)	New York, NY	1810-1864
Perkins & Pollock	Boston, MA	1812
Perkins & Sellers / Perkins & Jones / Perkins & Bacon	Philadelphia, PA	1816-1822
George Fitts	Athol, MA	1817-1819
Dodd & Ward	Newark, NJ	1819
S. V. Merrick / Merrick & Agnew / John Agnew	Philadelphia, PA	1819-1867
Abraham Fisher	Claremont, NH	1820
Harry Ludlum	New York, NY	1820-1821
James Arnold	Philadelphia, PA	1821
Cooper, Phelps & Campbell	Windsor, VT	1825-1828
Delano & Durfee	New Bedford, MA	1827-1830
Asshel Hubbard / National Hydraulic	Procterville, VT	1828-1837
A. Godfrey	Boston, MA	1833
William Platt & Company	Waterford, NY	1834-1841
William Durfee	New Bedford, MA	1835
Dyer & Richmond	New Bedford, MA	1835-1836
A. Bisbee / Bisbee & Edwards	Boston, MA	1836-1840
Edward Leslie	Newburyport, MA	1836-1852
Joel Bates	Philadelphia, PA	1837-1845
J. S. Hill	Salem, MA	1837-1839
Seth Boyden	Newark, NJ	1839
Cowing & Seymour / Cowing & Company	Seneca Falls, NY	1840-1878
Button & Blake / Button Fire Engine Company	Waterford, NY	1841-1892
Samuel Ingraham	Newburyport, MA	1844
Henry Waterman	Hudson, NY	1844-1860
Van Ness & Torboss [& Co.]	New York, NY	1846-1861
Howard & Davis	Boston, MA	1847-1861
Leonard Crockett	Portland, ME	1848-1856
William Jeffers	Pawtucket, RI	1848-1875
Pine & Hartshorne / Charles E. Hartshorne	New York, NY	1850-1876
J. Tarr	Albany, NY	1851
J. & L. Allen	Newark, NJ	1852-1853
A. W. Roberts	Hartford, CT	1853-1857
John Dennison	Newark, NJ	1858-1861
Levi Taylor	Marlborough	1860
Gleason & Bailey	Seneca Falls, NY	1863-1895
Rumsey & Company	Seneca Falls, NY	1863-1901
Silsby / American Fire Engine Company	Seneca Falls, NY	1870-1903
B. J. C. Howe	Anderson, IN	1872-1908
Joseph Bennett	Mayfield, NY	1895

Unknown manufacturer, known construction date - 60 hand fire engines

Sources : See the text.

Hog packing (since 1809)

Quantities of hogs packed in Cincinnati, Chicago (since 1846), Indianapolis (since 1847), and Omaha (since 1872) represent the national pork-processing industry. Cincinnati and Chicago were the foremost meatpacking centers in the antebellum and postbellum periods, respectively, accounting for more than one-half of all hogs packed. The latter series account for the first recorded hog packs in the respective cities.

Trade publications such as the *Annual Report of the Cincinnati Chamber of Commerce*, *Cincinnati Prices Current*, and *Annual Reports* issued by the Boards of Trade in Chicago, Indianapolis, and Omaha typically recorded the number of hogs packed over the twelve months beginning March 1st. Consequently, I had to choose a consistent method for assigning the calendar year in which slaughtered hogs were packed. Before 1870 hog packing was a seasonal industry, with the official winter packing season lasting the four months from November 1st through the end of February.⁷ Since approximately three-fourths of winter packing occurred by the end of December, the winter hog pack was assigned the calendar year in which the commercial season began. At the close of the nineteenth century, more than 90 percent of pork processing occurred before January 1st given the rapid transition to year-round production.

Following Gallman's lead (1966, 65–70, table A–10), Cincinnati hog packing has been spliced in 1823 to the quantity of packed hogs shipped from the Ohio Valley to New Orleans (Berry 1943, 580–81, table 42). This linkage is appropriate since New Orleans was the sole destination for Cincinnati's hog pack before alternative transportation routes emerged (Pred 1973, 132–33). Five missing observations (1812, 1814, 1818–1820) have been linearly interpolated. Discrepancies between reported quantities were reconciled by adopting the series in Walsh (1982, 111, note 9).

Lumber shipments (since 1827)

The U.S. Forestry Service did not begin publishing annual estimates of lumber production until the early 1900s. I have circumvented the lack of aggregate statistics for the nineteenth century by collecting regional data on lumber shipments. Lumber shipments are expressed in millions of board feet (board measure) and, as in the present-day FRB index, proxy for the domestic manufacture of semi-finished wood products. Since lumber is inherently a bulky and heavy commodity, shipments should correlate well with actual output.

⁷ The successful adaptation of William Davis's refrigerator car to meatpacking plants in 1870 quickly ushered in the summer packing season and, hence, full-time slaughtering.

APPENDIX TABLE A4

REGIONAL LUMBER SHIPMENTS: ANNUAL SERIES

Lumber shipments point-of-origin	Primary state	First recorded	Lumber shipments point-of-origin	Primary state	First recorded
Bangor / Penobscot River	Maine	1826	Susquehanna River boom	Pennsylvania	1851
Mid-Atlantic canal-RR system	Pennsylvania	1826	Black River boom	Wisconsin	1853
St. Croix River boom	Minnesota	1839	Chippewa River boom	Wisconsin	1867
Chicago metropolitan area	Michigan	1847	St. Paul River boom	Minnesota	1888
Hudson River boom	New York	1851	Weyerhaeuser subsidiaries	Idaho	1902

Sources: Blair 1930, 53; Defebaugh 1906-7, 2 vols.; Hidy et al. 1963, 585-93; Jones 1908; Larson 1949, 25, 133, 225; Livingood 1946; Rector 1953, 305-308; Smith 1972, 12-13, 293, 431; Wood (1935, 206); various issues of *CBOT Annual Reports* and *Mississippi Valley Lumberman*; and canal and boom company records held at historical societies.

Notes: Lumber surveyed at Bangor extended back from 1832 through 1827 using quantity of lumber exported from Bath in order to avoid a jump-off. Mid-Atlantic canal shipments include the Chesapeak & Delaware Canal, Lehigh Canal, Morris Canal, and Schuylkill Navigation. Chicago shipments comprise all lumber transported by lake, canal, and railroad; series carried back to 1847 by splicing to Chicago receipts to eliminate a discrete jump in 1852 (pre-1847 shipments were immaterial). Weyerhaeuser Company's interests include the first companies to manufacture Idaho timber, namely the Humbird Lumber Company, Bonners Ferry Lumber Company, Potlatch Lumber Company, and Boise Payette Lumber Company (predecessor to Boise Cascade).

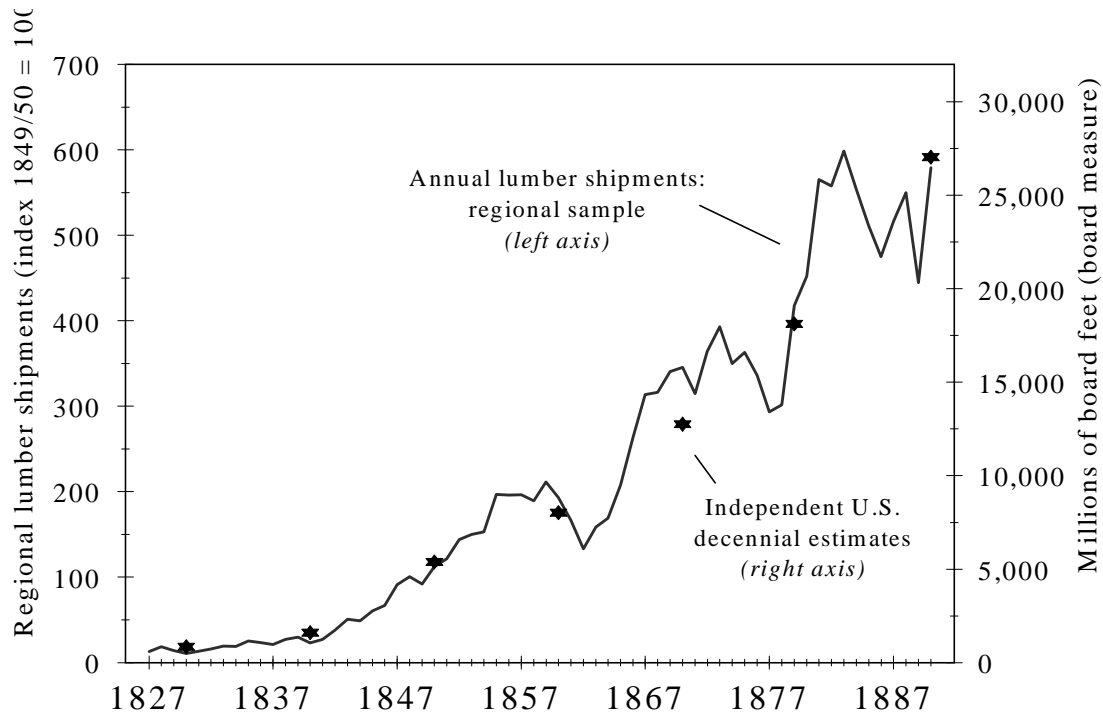
The series and their proximate sources are listed in Table A4. The regional sample consists of the quantity of lumber passing through various river booms, seaside ports, and wholesale districts beginning in 1827.⁸ *Booms* were effectively dams erected at river terminal points for the purpose of sorting upstream logs and consigning sawed lumber from local lumber mills. River booms were commonly operated by a controlling agency owned by a syndicate of the area's lumber manufacturers. Since their operational fees were derived from the volume of board feet cleared, boom companies maintained fairly accurate records of lumber shipments. Similarly, Maine statutes mandated that Bangor surveyors track the quantity of lumber that local sawmills shipped out-of-state.

Entries in Table A4 represent virtually all of the principal lumber-producing regions of the nineteenth century. Pennsylvania, for instance, was one of the two preeminent lumber-milling states by the late 1830s. The quantity of lumber manufactured in Pennsylvania is tracked along its major

⁸ Data before 1827 are scarce because lumber was either processed as a by-product of land clearings or was shipped to market by raft or wagon.

delivery networks—the Delaware and Susquehanna rivers. Canal and railroad companies reported the volume of lumber shipped along the Delaware River to their shareholders. Susquehanna’s output accelerated following the Civil War just as timber deposits along the Delaware River winnowed. Dozens of Williamsport sawmills transported their lumber through the massive Susquehanna River boom.

**APPENDIX FIGURE A1: LUMBER SHIPMENTS CONSONANT
WITH DECENNIAL BENCHMARKS**



Sources: Appendix Table A4; U.S. Department of Agriculture 1948, 10, table 1.

The expansion of the lumber industry into the Midwest’s vast pine belt is effectively captured by quantities scaled at various river booms and shipped from Chicago sawmills. Booms along the Black River, Chippewa, St. Croix, and St. Paul rivers were the principal routes for distributing Minnesota and Wisconsin white pine lumber down the Mississippi River. Chicago was the predominant wholesale market of the Great Lakes pine belt. It should be stressed that a region-by-region sampling is critical in accurately portraying the spatial evolution in lumber production. Local timber supplies were often exhausted after several decades of logging. Indeed, lumber booms of the Black, Penobscot, and Susquehanna rivers all peaked in the 1870s and essentially closed before the First World War. Hence, failure to account for the westward migration of lumber production would dramatically bias downward

(*upward*) lumber production after (*before*) the Civil War. As evident in Figure A1, the regional sample is consonant over time with decennial estimates of U.S. lumber production.

Milled wheat flour (since 1798)

Barrels of wheat flour received or locally milled at Baltimore, Buffalo, Chicago, and Minneapolis proxy for national production. Flour receipts are superior to shipments in gauging out-of-city production because wheat flour characteristically arrived at city auction houses and warehouses already milled. An aggregation of regional receipts should mimic the milling industry's geographical dispersion since the four cities ranked sequentially as America's largest manufacturing depot. City-milled flour accounts for an increasing share of total output over time.

The earliest flour-milling records come from Baltimore, which instituted an inspection system in 1796 to ensure product quality.⁹ From 1798 Baltimore officials maintained reliable quarterly accounts on the quantity of flour received citywide, including local mill production and wheat flour brought to market from Pennsylvania (i.e., Susquehanna flour) and northern Virginia. Approximately one-third of Baltimore flour was exported, while the balance was either consumed locally or shipped north to New York and Boston. The Baltimore data were published in contemporary publications such as *Niles Weekly Register*, *Hunt's Merchants' Magazine*, and *Annual Reports of the Board of Managers of the New York Produce Exchange*. Reid (1912, 517) presents an incomplete series that occasionally conflicts with the genuine data above.

While Baltimore was the largest domestic flour market as late as 1830, flour received and milled at the other cities effectively captures the subsequent westward migration of wheat acreage. Buffalo emerged as a principal destination for flour milled in upstate New York and Ohio shortly after the development of the Erie and Ohio Canals. Ohio was the largest wheat-producing state by 1840, and northern Ohio millers soon had the opportunity to ship their manufactures from Cleveland through Lake Erie. Data have been transcribed primarily from *Annual Reports of the Buffalo Merchants' Exchange* and *The Millers' Almanack and Trade Yearbook*. The Buffalo series reflects "Lake receipts (from the West)" and commences with the first Ohio flour sent from Maumee in 1828. Buffalo quantities were inconsequential before the late 1830s. Missing observations for 1832 and 1833 were linearly interpolated.

Chicago attracted milled flour from the entire Great Lakes region. Minneapolis eventually emerged as the nation's predominant milling center following the widespread adoption of spring wheat.

⁹ See Kuhlmann (1929) for a seminal treatment of early milling developments and Sharrer (1976) for details on the Baltimore flour industry.

Chicago mill and receipt data come from Clark (1966, 89, table 8), *Hunt's Merchants' Magazine*, and Chicago Board of Trade *Annual Reports*. The Minneapolis series begins in 1860 and has been adapted from data reported in *Annual Reports of the Minneapolis Chamber of Commerce*, *The Millers' Almanack and Trade Yearbook*, and *Annual Reports of the Board of Managers of the New York Produce Exchange*.

Flour data for several other cities have been excluded from the aggregate series. Philadelphia and Richmond eventually adopted Baltimore's inspection system, but extant records are incomplete. Milling activity within New York City was trivial after 1800, although city officials inspected the quantity of flour arriving from western (Buffalo) and southern (Baltimore) markets. New York City inspection records are available only from 1812 through 1826 and are of questionable reliability. City inspectors purportedly resented recordkeeping and often made haphazard returns, as indicated in the minutes of New York City's *Common Council* (Peterson 1917, 15:76–77). Milwaukee and St. Louis data have been excluded on account of considerable flow-thru movement via Chicago.

Newspapers (since 1790)

I measure newspaper publishing through the number of daily newspapers in active circulation. Daily newspapers should be fairly indicative of business conditions in printed materials because nineteenth-century publications primarily took the form of newspapers and periodicals. Newspaper publishing accounted for well over one-half of the value added in the pre-Civil War printing and publishing industry. Conversely, books constituted a minor share of early publishing output because they were prohibitively expensive and often imported.

The data set tracks more than two thousand daily newspapers that were published from 1790 through the 1870s from the exhaustive bibliographies of Brigham (1947) and the Bibliographical Society of America (1937). Newspapers were intentionally classified according to standards originally established by G. P. Rowell & Company's *American Newspaper Directory* so that Rowell's annual series could be adopted from 1870 forward.¹⁰ *Rowell's Directory* was the first trade publication to consistently provide a comprehensive listing of American newspapers. N. W. Ayer & Son's *American Newspaper Annual and Directory* later subsumed the collection of the Rowell data.

All daily newspapers were included in the data set, regardless of political affiliation (save for foreign-language newspapers). A newspaper was categorized as having operated in a calendar year if

¹⁰ Lee (1937) maintains that Rowell's counts are more accurate than census totals because census officials typically counted a newspaper's morning and evening editions separately. While morning and evening editions were rarely published outside of the largest metropolitan areas before the Civil War, I have strived to avoid this duplication in my compilations as well.

bibliographical records indicated at least one issue was published. Every effort was made to treat changes in newspaper titles seamlessly within the sample.¹¹ Once incorporated into the dataset, listings were unadjusted.

I compiled the data set in three steps. First, I transcribed daily newspapers in active circulation during the period 1790–1820 from Brigham (1947), whose bibliography is widely viewed as the benchmark reference. Second, post-1820 newspaper listings were tabulated from the Bibliographical Society of America (1937), whose citations draw from nearly the entire universe of U.S. library holdings. I checked the results by tracing back newspapers in Rowell’s first directory. Third, I cross-referenced all newspaper listings with specialized regional collections maintained at the *university libraries* of Chicago (1936), Duke (1932–37), Virginia (Capon 1936), and Yale (1916); at the *historical societies* of Pennsylvania (1944) and Wisconsin (Oehlerts 1958); as well as *large public holdings* at the Library of Congress (1901, 1936) and the New York Public Library (1915).

The resulting daily newspaper series is comparable over the entire sample because the data *exactly* match the circulation count in the 1870 *Rowell’s Directory*. Indeed, the series confirms that pre-Civil War census returns underreported daily newspapers on average by four percent.

My measurement of printing and publishing activity loosely approximates the contemporary methodology adopted by the Federal Reserve Board. As in the FRB index, the data set distinguishes daily newspapers from publications issued less frequently. Since non-daily newspapers draw from a more heterogeneous sample of publications, their circulation and market segments tend to vary considerably. Furthermore, bibliographical data on non-daily publications such as frequency and length of publication are more difficult to ascertain.

The paper’s series does differ from the modern-day FRB approach, however. The FRB index estimates monthly output of daily newspapers through their total circulation (i.e., number of printed copies). The FRB interpolates data on average circulation, and then multiplies these estimates by the number of daily newspapers in operation for any given month. I abstract from annual circulation here because estimates are infrequently reported and of dubious quality for the nineteenth century. Nevertheless, the two approaches are approximate because daily newspapers have historically suspended operations in poor economic conditions. Competition for readership was intense, and failure rates of daily newspapers were high.

¹¹ Mergers were obvious exceptions. In the (frequent) case of a merger between two distinct publications, I counted both newspapers separately during the merger year, and once thereafter. Fortunately, mergers have been well documented among the newspaper bibliographies.

Pipe organs (since 1790)

Pipe organs are musical instruments predominantly installed in churches, concert halls, theaters, and universities. Organs have historically represented a sizable investment for private and public institutions. Churches, for instance, relied almost exclusively on the charitable giving of its congregations to finance an organ's purchase.

I have compiled an annual series on more than 22,000 pipe organs produced in the U.S. for the 1790–1915 period. The production records of more than 250 artisan shops and manufactories have been accessed from four primary sources: the American Organ Archives of the Organ Historical Society (OHS) in Princeton, New Jersey; the OHS publication, *The Tracker*; sponsored OHS research; and, most importantly, George Nelson's *Organs of the United States and Canada Database* (OUSCDB©).¹² The pipe-organ sample excludes smaller chamber and reed organs.

The raw data originate predominantly from organ *opus lists*. Opus lists were essentially running histories of a firm's production, sequentially detailing completion dates and installed locations. Since opus lists were often published in firm catalogs and newspaper advertisements, the sample is not confined to extant business records. The series should be viewed as comprehensive because the sample draws from nearly the entire universe of known organ builders.

For nearly all establishments, I have recorded organ construction by date of completion. I have standardized the dataset to exclude organ repairs, tunings, and rebuilt actions. Out of necessity, a small number of organs were assigned their installation date. The sample omits a trivial fraction of organs possessing unknown construction dates. The sample does *not* contain interpolated observations, although some opus lists are incomplete. The catalog of George Jardine, for instance, did not provide dates aside completed organs. OHS members have reconstructed most, but not all, of the Jardine opus list from firm and church records, newspapers, and archival material.

Below chronicles the establishment sample. Opus lists with less than 85-percent definitive coverage are marked (*). If no citation is provided, then OHS/OUSCDB data are the immediate source. Entries are presented chronologically in the following format:

Name of establishment (sample years active, location(s); source)

Josiah Leavitt (*until 1804*, Boston); David Tannenberg (*until 1804*, near Philadelphia; Brunner 1990); Henry Pratt (*until 1849*, Winchester, NH*); Joel Allen (1790, Middlefield, CT); Dieffenbach family (since 1790, near Philadelphia; Brunner 1990); Krauss family (since 1790, Lancaster, PA; Brunner 1990); Peter Kurtz (1797, Philadelphia); John Geib (1798–1816, New York City; OUSCDB, Ogasapian 1977); Dr. Israel Newton (1798,

¹² I am grateful to George Nelson of the OUSCDB and Stephen Pinel of the OHS American Organ Archives for granting me superlative access to their archival materials.

Norwich, VT); George Catlin (1799–1814, Hartford, CT); Philip Bachman (1800–1821, Lititz, PA; Brunner 1990); Charles Taws (1800, Philadelphia); Gardiner Parker (1801, Westborough, MA); William Goodrich / McKay & Co. (1805–1833, Boston); Adam Hurdus (1806–1822, Cincinnati); Conrad Doll (1807–1809, Lancaster, PA); Ebenezer Goodrich (1807–1841, Boston*); John Lowe (1807–1813, Philadelphia); Erastus Wattles (1807–1808, Lebanon, CT); Jacob Hilbus (1808–1815, Washington, DC); William Redstone / Redstone & Sons (1810–1823, New York City); Thomas Hall / Hall & Erben / Hall, Labagh & Co. / Labagh & Kemp / Chapman & Symmes (1814–1892, New York City); Schmidt (1814–1816, Philadelphia); Bailey Brothers (1815–1820, Jaffrey, NH); John Wind (1815, Lancaster, PA); Peter Erben (1816–1818, New York City); Matthias Schneider (1818, Philadelphia); John Paine (1820, Portland, ME); Stephen Rice (1820, Claremont, NH); Barzillai Treat (1820–1832, Bristol, CT); Thomas Appleton / Appleton & Davis / Appleton & Warren (1821–1872, Boston); Lemuel Hedge (1822–1823, Windsor, VT); Watson & Powers (1822–1834, Cincinnati); Corrie & Hubie / Henry Corrie & Co. (1823–1854, Philadelphia & Boston); Wilfred Hall (1825–1826, Philadelphia); Joseph Richards (1825–1830, West Bridgewater, MA); Joseph Alley (1826–1834, Newburyport, MA); Henry Erben & Co. / Henry Erben & Son (1827–1884, New York City & Baltimore [branch shop]); E. & G. G. Hook & Hastings Co. (since 1827, Boston; Van Pelt 1991); Calvin Edwards (1828–1844, Portland, ME); Fisher & Hodges (1829–1830, Taunton, MA); John Ziegler (1830–1835, near Philadelphia); Mathias Schwab / Koehnken & Co. / Koehnken & Grimm / Gallus Grimm (1831–1897, Cincinnati); Eli Bruce (1832, Templeton, MA); Franklin S. Whiting (1832–34, New Haven, CT); Holbrook & Ware (1833–1904, Medway, MA); William Nash (1833, Cincinnati); Stevens & Gayetty / George Stevens & Co. / Stevens & Jewett / William Stevens (1833–1892, Boston & Cambridge, MA); Thomas Wagstaff (1833–1838, New York City); Alvinza Andrews / George Andrews (1834–1904, Waterville, NY & Oakland, CA); Richard Morss (1834–1838, Newburyport, MA); George Jardine & Son (1836–1900, New York City*); Firth & Hall (1837–1847, New York City); Henry Knauff & Son[s] (1837–1893, Philadelphia); Henry Crabb[e] (1838–1861, Brooklyn, NY); William Nutting (1838–1869, Bellow Falls, VT); Henry Pilcher / H. Pilcher & Son[s] / Pilcher Brothers / Henry Pilcher & Sons / Henry Pilcher's Sons (since 1838, New Haven, CT, New York City, St. Louis, Chicago, Louisville, New Orleans); Jonas P. Whitney (1838–1852, Springfield, MA & Worcester, MA); Thomas Robjohn (1839–1860, New York City); William H. Davis & Son / Davis & Ferris (1840–1913, New York City); John C. B. Standbridge / Standbridge Brothers (1840–1876, Philadelphia); Augustus Backus / Giles Beach / American Church Organ Works (1844–1876, Troy, NY & Gloversville, NY); William A. Johnson / Johnson Organ Co. / Johnson & Son (1844–1898, Westfield, MA & Springfield, MA; Elsworth 1984); Ferris & Stuart (1845–1876, New York City); Garret House (1845–1898, Buffalo*); W. D. B. Simmons & Co. / Simmons & Fisher / Simmons & McIntire / Simmons & Willcox (1845–1876, Boston*); John Nutter (1847–1853, Mont Vernon, NH); Henry Berger (1850–1855, Baltimore); Richard M. Ferris & Co. / Ferris & Stuart / Levi U. Stuart (1850–1876, New York City); Pomplitz & Rodewald / Pomplitz Church Organ (1850–1887, Baltimore); Rufus Johnson (1853–1862, Portland, ME); John G. Marklove (1857–1892, Utica, NY); Joseph Gratian / Gratian Organ Co. (since 1858, Alton, IL); LeDroit & O'Brien (1858–1860, Milwaukee); Bohler family (1859–1896, Reading, PA); J. H. & C. S. Odell (since 1859, New York City); Reuben Midmer & Sons (since 1860, Brooklyn, NY & Merrick, NY); Charles Durner (since 1861, Quakertown, PA); Samuel S. Hamill (1861–1903, Cambridge, MA); Marshall Brothers Organ Co. / Marshall & Odenbrett / Marshall Brothers & Clarke / Odenbrett & Abler (1864–1885, Ripon, WI & Milwaukee); J. G. Pfeffer & Son (1864–1909, St. Louis); Felix Barckhoff / [Carl] Barckhoff [Church Organ] Co. (since 1865, Philadelphia, Pittsburgh, Salem, OH, Latrobe, PA, Pomeroy, OH, & Basic, VA); Derrick & Felgemaker / A. B. Felgemaker Co. (since 1865, Buffalo & Erie, PA); William King & Son (1865–1900, Elmira, NY); Moritz Baumgarten (1866–1870, New Haven, CT*); Steere & Turner / J. W. Steere & Son[s] (since 1866, Westfield, MA & Springfield, MA); William Jackson (1868, Albany, NY); Chant & Jackson (1869–1870, Chicago); J. H. Willcox & Co. (1869–1874, Boston); W. K. Adams & Son / C. W. Adams / Wilson-Bolan Organ Co. (since 1870, Providence, RI); Davie, Jackson & Co. (1870–1871, Chicago); William Evans (1870, Lockport, IL); James D. Moore (1870–1871, Worcester, MA); Ryder & Butler / George H. Ryder (1870–1902, Boston, Reading, MA & Weymouth, MA); Allmendinger Piano & Organ Co. (1871–1888, Ann Arbor, MI); Charles Anderson / Anderson-Silby (since 1872, Denver, CO); Henry Niemann (1872–1908, Baltimore*); Hutchings, Plaisted & Co. / George S. Hutchings & Co. / Hutchings–Votey Organ Co. / Hutchings Organ Co. (since 1872, Boston, Cambridge & Waltham, MA); Roosevelt Organ Works (1872–1893, New York City, Philadelphia, & Baltimore); Clarke, Kingsley & Co. / W. H. Clarke & Co. (1873–1881, Indianapolis & Boston); George Kilgen & Son (since 1873, St. Louis); Lancashire & Turner / Moline Pipe Organ Co. / Lancashire–Marshall Organ Co. / Marshall-Bennett Co. / Bennett Organ Co. (since 1873, Moline, IL & Rock Island, IL); Gottlieb Votteler / Votteler–Hettche Co. / Votteler–Holtkamp–Sparling (since 1873, Cleveland); William M. Wilson (1874–1884, New York City); John Bergstrom & Sons (1875–1897, San Francisco & Minneapolis); L. C. Harrison & Co. (1875–1915, Bloomfield, NJ*); M. P. Möller (since 1875, Warren, PA & Hagerstown, MD); William Schuelke Organ Co. (since 1875, Milwaukee*); Felix F. Schoenstein & Co. [& Sons] (since 1877, San Francisco); Hinners & Albertsen / Hinners Organ Co. (since 1879, Pekin, IL); Emmons Howard (since 1883, Westfield, MA); Frank Beman (since 1884, Binghamton, NY); John Brown / Brown Organ Co. (1884–1912, Wilmington, DE);

William B. Williams (1884–1894, New York City); Cole & Woodberry / James Cole & Co. (since 1886, Boston & Melrose, MA); Thomas Whalley / Whalley & Genung / Whalley & Spencer (since 1887, Berkeley, CA & Oakland, CA*); Wirsching Organ Co. / Wirsching-Binder Organ Co. (since 1887, Salem, OH*); C. S. Haskell, Inc. (since 1888, Philadelphia); Sole [Church] Organ Co. (since 1888, Boston, Reading, MA & Fremont, OH); Woodberry & Harris / Jesse Woodberry & Co. (1888–1912, Boston); Austin Organ Co. (since 1889, Hartford, CT); Farrand & Votey Organ Co. / Votey Organ Co. (1889–1899, Detroit); Alfred Hillgreen / Hillgreen-Lane Co. (since 1889, Alliance, OH); Vogelpohl & Spaeth / H. H. Vogelpohl & Sons (since 1889, New Ulm, MN); W. W. Kimball Co. / Kimball, Smallman & Frazee (since 1890, Chicago*); E. W. Lane / Waltham Church Organ Co. (since 1890, Waltham, MA); Müller & Abel (1890–1903, New York City); Linus Clark (1891, Portland, OR); Ernest DesMarais (1892, St. Albans, VT); G. W. Reed & Son (since 1892, West Boylston, MA); Adam Stein Organ Works (since 1892, Baltimore); Aeolian Co. / Aeolian-Votey (since 1893, Detroit & Garwood, NJ); Morey & Barnes / C. E. Morey (since 1893, Utica, NY); A. J. Schantz Sons & Co. (since 1893, Orville, OH); Fletcher & Harris / M. M. Harris Organ Co. (1894–1913, Los Angeles); Bates & Culley (since 1895, Philadelphia); Brennan, Gleason & White (1895–1896, Boston); Lyon & Healy (1895–1910, Chicago); Salem Church Organ Co. (1895–1900, Salem, OH); Harrison & Hall / Hall Organ Co. (since 1897, New Haven, CT*); M. A. Clark & Sons (since 1898, Nyack, NY); Burlington Pipe Organ Co. (1899–1912, Burlington, IA); Eifert & Stoehr (since 1899; Queens, NY); Coburn & Taylor / Coburn Organ Co. (since 1900; Chicago); Estey Organ Co. (since 1900; Brattleboro, VT); Scultetus & Mantel (1900, New York City); Compensating Pipe Organ Co. (1901–1906, Battle Creek, MI); William E. Haskell & Co. (1901, Philadelphia); E. M. Skinner Organ Co. (since 1901, South Boston; Kinzey and Lawn 1997); Los Angeles Art Organ Co. / Electrolian Organ Co. (1903–1906, Los Angeles & Hoboken, NJ); Hope-Jones & Harrison / Hope-Jones Organ Co. / Hope-Jones Organ Department, Wurlitzer Manufacturing Co. (1904–1915, Bloomfield, NJ & Elmira, NY); Beach & Freitag (1906–1909, Troy, NY); Tellers-Sommerhoff Organ Co. (since 1906, Erie, PA); Wicks Pipe Organ Co. (since 1906, Highland, IL); Bartola Musical Instrument Co. (since 1909, Oshkosh, WI); American Photo-Player Co. (since 1912, Berkeley, CA); Casavant Frères (since 1912, South Haven, MI branch only); Johnston Organ & Piano Manufacturing Co. / California Organ Co. (since 1912, Los Angeles & Van Nuys, CA); Heatherington (1912, Fresno, CA); Frederick W. Smith & Sons Pneumatic Organ Co. (since 1912, North Tonawanda, NY); Wangerin-Weickhardt Co. (since 1912, Milwaukee); C. E. Grant (1913–1915, Portsmouth, VA); C. F. Winder Co. (1913–1915, Richmond, VA); American Master Organ Co. (since 1914, New York City & Warsaw, NY); Rudolph Wurlitzer Manufacturing Co. (since 1914, Chicago); Marr & Colton (since 1915, Warsaw, NY).

Pocket watches (since 1851)

The history of the American watch industry has been well researched by members of the National Association of Watch and Clock Collectors, headquartered in Columbia, Pennsylvania. I have accessed primary and secondary reproductions of detailed factory records of several firms that, collectively, accounted for more than 80 percent of the pocket watches made in the U.S. before WWI.

The American watch industry effectively commenced with the establishment of the Boston Watch Company (predecessor of the American Waltham Watch Company) shortly after the enumeration of the 1850 Census. Earlier attempts to commercially manufacture pocket watches were short-lived, of trivial quantities, and commercially unsuccessful.¹³ Indeed, artisans who portrayed themselves as “watchmakers” in early American business directories, in actuality, never manufactured watches. Rather, they simply cleaned, repaired or reassembled imported European watches. Thus, the watch series receives only an 1880-base index weight.

¹³ See, among others, Howard (1895), Moore (1945, appendix E), Bailey (1975) and Hoke (1990). Luther Goddard of Shrewsbury, Massachusetts (1809-15) and the Pitkin brothers of Hartford, Connecticut (1838-41) are each believed to have made less than five hundred movements before giving up their efforts. Jacob Custer may have made one dozen movements

Pocket watches were the watchmaking standard of the late nineteenth century. Wristwatches were not introduced until WWI. The data set includes the manufacture of jeweled or railroad-quality pocket watches (all grades) and excludes cheap “dollar watches.”

The sampled firms, in alphabetical order, are as follows:

Boston / American Waltham Watch Company	<i>Waltham, MA; since 1850</i>
Elgin Watch Company	<i>Elgin, IL; since 1864</i>
Hamilton Watch Company	<i>Lancaster, PA; since 1892</i>
Springfield / Illinois Watch Company	<i>Springfield, IL; since 1870</i>
Seth Thomas Clock Company	<i>Thomaston, CT; 1884–1914</i>
United States Watch Company	<i>Marion, NJ; 1865–1877</i>

Quantities include movements made on behalf of the Webb C. Ball Watch Company of Cleveland, Ohio. The primary data originate from several key sources: *Bulletin of the N.A.W.C.C., Inc.* (various issues); Ehrhardt (1976a; 1976b; 1998); Ehrhardt and Meggers (1993; 1999); Landes (1983); Muir and Kraus (1985); and Townsend (1970; 1977; 2000). The watch sample incorporates firms whose source data are sufficiently detailed to permit an accurate trace of movements made year-to-year. Given that producers often set aside batches of movements in the manufacturing process, year-end differences in sequentially assigned serial numbers are not a tenable approach. Here, annual figures differ significantly at times with *approximated* year-to-year serial lists widely disseminated in price guides such as Schugart, Engle and Gilbert (2001). This is because the detail of the utilized source data permits a batch-by-batch account of when movements were made (day, month, or year), set aside (made out-of-sequence), or never completed within a company’s historical serial account.¹⁴ The Hampden Watch Company and the Rockford Watch Company have been excluded from the sample due to statistical limitations.

Raw silk imports (since 1814)

Raw silk was reeled and woven during the nineteenth century to make a diverse range of silken textiles. Processed silken goods included sewings and twist, broad goods and handkerchiefs, ribbons and lace, and apparel trimmings. On account of the country’s deficient silk culture, quantities of

in Norristown, Pennsylvania during the early 1840s. The American Waltham Watch Company, on the other hand, had made nearly *twenty million* pocket watches by 1915.

¹⁴ Pocket watches were typically produced on the assembly line in batches, or runs, of hundreds or thousands. The largest pocket-watch manufacturers commonly made millions of movements per year.

imported raw silk have traditionally gauged the manufacture of silken goods. Unfortunately, calendar-year quantities of raw silk imports were not consistently collected by federal agencies until 1867. Similar figures were gathered some years later for ancillary silk imports (waste and spun silk). Pre-Civil War reporting deficiencies for imported quantities are implacable.¹⁵

As is the case for tin imports, I have consulted Great Britain's *Sessional Papers* to arrive at a consistent series that stretches the pre-WWI era. British custom officials itemized the quantities of particular commodities exported from its ports in their annual statistical reports to Parliament. In particular, the parliamentary papers specified the countries of origin and destination for related quantities. From the *Sessional Papers*, I have tabulated the quantities of raw, spun, and waste silk exported to the U.S. from the United Kingdom, Her colonies, and foreign countries. Calendar-year quantities were available as early as 1814. Gross trade flows include all raw silk shipped by American and foreign vessels to both Atlantic and Pacific ports. Exports of raw silk to the U.S. encompass knubs or husks of silk, waste silk, and waste noils, and include considerable quantities from China, East India, Italy, and Turkey. Thrown silk and spun silk yarn—the critical raw material in making sewing silk and textile-machine twist—originate mostly from Britain and European countries.

Rice milling (since 1819)

The U.S. Department of Agriculture (USDA, Bureau of Statistics 1912, 5–11) compiled annual estimates of cleaned rice production from 1819.¹⁶ Since the USDA reported unadjusted state totals in lieu of aggregate production for intercensal years, however, there are gross reporting errors in the “official” USDA data that are clearly evident in Figure A2. For example, reported production for 1861 corresponds solely to Louisiana output. Since Louisiana accounted for only three percent of the 1860 crop, the original USDA series implies a 99-percent shortfall the following year. As a further complication, the USDA mistakenly reported the quantity of rough rice produced for several census-year crops, thereby overstating milled rice by 62 percent (Gallman 1963).

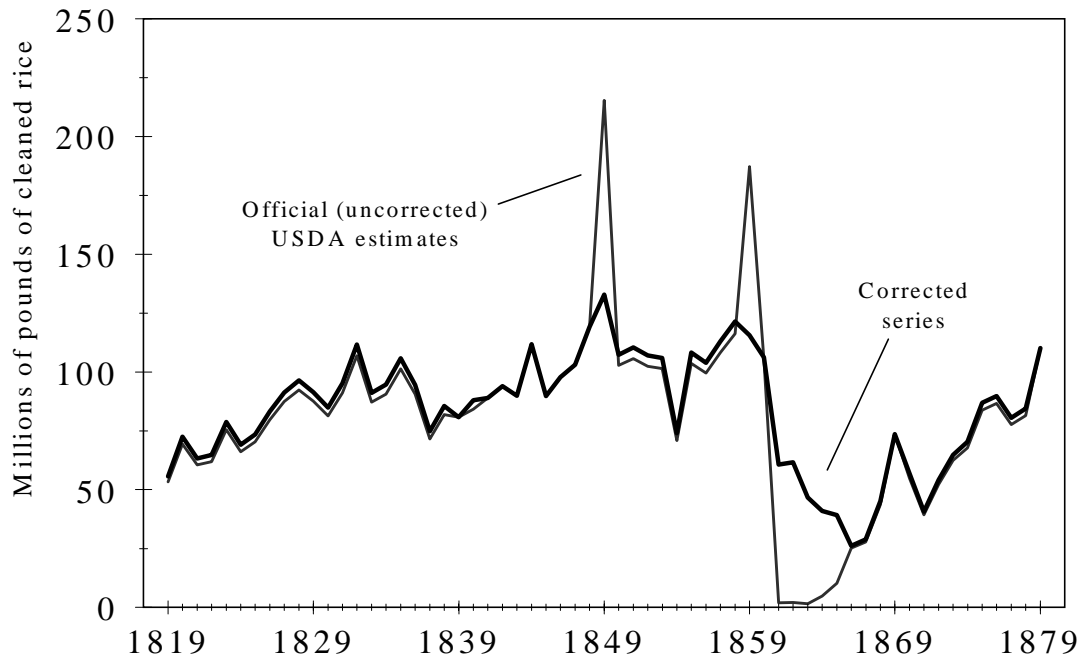
Accordingly, I made two critical adjustments that substantially altered the original series. First, I inflated annual state-level estimates to U.S. totals based upon census shares. Pre-Civil War observations were adjusted according to state shares of cleaned rice production from the 1860 *Census of Agriculture* (U.S. Census Office 1864). Thereafter, figures were reconciled from shares in the 1880 *Census of Agriculture* (U.S. Department of the Interior, Census Office 1883b). Second, I converted

¹⁵ Frickey (1947) resolved coverage gaps and fiscal-year breaks through interpolation.

¹⁶ More recent figures can be found in various issues of the USDA's *Yearbook*.

erroneous rough rice benchmarks to cleaned rice equivalents using the USDA's *Conversion Factors and Weights* (1952). Figure A2 compares the reported USDA data and the revised series.

FIGURE A2: REVISED RICE-MILLING ESTIMATES



Sources: See the text.

Steam-powered fire engines (since 1852)

More than 5,000 steam fire engines were made in the United States before WWI. Construction and specification information have been obtained on over 4,000 engines from builder and fire department records reproduced in Conway (1997, and sources therein) and Hass (1986). The firm sample, presented in Table A5, is comprehensive in part because of the oligopolistic structure of the fire-engine industry: the four largest firms produced more than two out of every three steamers ever built in the U.S. The detailed data set includes the construction of the first commercially-viable steam-powered fire wagon in 1852 (Latta and Shawk's *Uncle Joe Ross*) and traces the last engines turned out immediately before WWI.¹⁷ To account for technological and quality improvements in fire-engine

¹⁷ From late 1840 through the spring of 1841, the first U.S. steam fire engine was constructed by Paul Hodge at the invitation of New York City's fire insurance underwriters. However, Hodge's self-propelled engine, the *Exterminator*, was abandoned because its excessive weight prevented it from quickly reaching a fire (White 1970). No other steam-powered fire engine was manufactured in the U.S. until Latta and Shawk's *Uncle Joe Ross*.

capacity over time, the annual series is quantified in *total pump output* of newly constructed fire engines. Expressed in gallons of water per minute, pump output varied widely across producers in accordance with engine sizes.

APPENDIX TABLE A5

STEAM FIRE-ENGINE MANUFACTURERS (1852-1915)

Establishment (genealogy - predecessors)	Location(s)	Years active
International Fire Engine Company (Trust) <i>Consolidation beginning in 1900 of several firms including Amoskeag (see below)</i>		1900-1913
A & B Manufacturing - Corliss Works	Providence, RI	1902-1913
Manchester Locomotive Works	Manchester, NH	1879-1902
Amoskeag Manufacturing Company		1859-1879
Ahrens-Fox Manufacturing Company Ahrens Fire Engine Company <i>(withdrawal from American LaFrance in 1904)</i>	Cincinnati, OH	1910-1916 1905-1910
American-LaFrance <i>1904 merger with American Fire Engine Co.</i>		
LaFrance Manufacturing Company	Elmira, NY	1873-1904
American Fire Engine Company (Trust) <i>1901 merger of four companies</i>	Cincinnati, OH & Seneca, NY	1891-1904
Ahrens Manufacturing Company	Cincinnati, OH	1877-1891
C. Ahrens & Company		1869-1877
Lane & Bodley		1863-1868
A. B. & E. Latta / Latta & Shawk		1852-1862
Button Fire Engine Company <i>(plant closed in 1892)</i>	Waterford, NY	1882-1891
Button Engine Works		1865-1882
Button & Blake		1862-1865
Clapp & Jones Manufacturing Company <i>(plant closed in 1892)</i>	Hudson, NY	1862-1891
Silsby Manufacturing Company	Seneca, NY	1870-1891
H. C. Silsby, Island Works		1861-1870
Silsby, Mynderse & Company		1856-1860
Independent establishments		
Reaney & Neafie	Philadelphia, PA	1857-1867
James B. Johnson / Portland Company	Boston, MA & Portland, ME	1858-1870
Lee & Lanard / Novelty Iron Works	New York, NY	1858-1864
G. & J. Chapman	Philadelphia, PA	1860-1864
W. C. Hunneman & Company	Boston, MA	1866-1881
Cole Brothers	Pawtucket, RI	1867-1880

Sources : Conway (1997, and sources therein) and Hass (1986).

Notes: Entries sorted chronologically, by trust and non-trust genealogies, respectively.

Sugar refining (since 1790)

The New York City firm Willet and Gray compiled calendar-year consumption data on refined sugar imports and domestic refined production as early as 1822. The Willet–Gray estimates on sugar refining were widely disseminated in the *Statistical Abstract* and other official publications. Before 1822, the series has been spliced to similar source data that underlie the Willet–Gray estimates. Specifically, the Willet–Gray data have been ratio-spliced to the domestic supply of U.S. sugar, equal to the sum of domestic sugar-cane production (Guetter and McKinley 1924, 29–30, table 19) and net sugar imports. Sugar-cane output represents the *Commissioner of Agriculture's* estimates of brown and partially refined sugar. The *American State Papers* record net sugar imports on a fiscal-year basis ending September 30th.

The linked data effectively measure calendar-year production for two fundamental reasons. First, the southern fall harvesting season was strictly followed to avoid detrimental frosts. Second, processors predominantly undertook sugar meltings before October. U.S. exports for the 1790–1802 period include domestic and foreign sugar, as further designation was not provided. Nearly all exports pertained to foreign sugar, however, since domestic sugar represented less than one percent of brown-sugar exports at this time. Splice differentials to the Willett–Gray series are trivial given that: (i.) little sugar was manufactured from domestic molasses; and, (ii.) refining led to only two-percent waste of the original product.

U.S. Navy vessels (since 1790)

I have compiled an annual series that accounts for the construction of the thousands of U.S. Navy vessels built at federal and commercial shipyards from 1790 to 1915, inclusive. Naval shipbuilding is expressed in displacement tonnage.¹⁸ The tonnage data have been adapted from ship biographies extensively documented in Bauer and Roberts' 1991 volume, *Register of Ships of the U.S. Navy, 1775–1990*. Bauer and Roberts summarize and supplement construction data of all naval vessels originally listed in the U.S. Navy Department's *Annual Reports of the Secretary of War* and its eight-volume reference set, *Dictionary of American Naval Fighting Ships*.

The data set records each vessel's tonnage from the date shipyard construction commenced (year *laid down*) until completion (year *launched*). This level of detail is critical because the largest ship classes required at least two years to build. The resultant series includes all naval vessels that meet

¹⁸ Displacement tonnage is not directly comparable with merchant gross tonnage because the former is not a measure of capacity. However, it was necessary to cite measurement tonnage for a small fraction of vessels whose displacement tonnage was unavailable. This practice conforms to the convention of the U.S. Naval History Division (1959–1981, 8 vol.).

Bauer and Roberts' criteria for major combatants with respect to the *Old Navy* (prior to 1883) and the *New Navy* (since 1883). Most vessel classes in the data set meet these criteria, including ships-of-the-line, sloops of war, frigates, brigs, schooners, ironclads, steam floating batteries, and all rates and types of sloops, steamers, destroyers, cruisers, battleships, monitors, gunboats, submarines, and spar torpedo boats. I have incorporated armed merchant ships or Confederate vessels only if they were constructed or retrofitted at a government or commercial shipyard before naval commission.¹⁹

*Wool stockings (since 1808)*²⁰

Unlike other articles of military clothing, wool stockings were manufactured domestically and were rarely purchased on the open market. Calendar-year quantities of woolen hose, half-hose, and socks manufactured for enlisted men in the U.S. Army have been compiled by consulting the U.S. War Department's voluminous Records of the Office of the Quartermaster General, Record Group 92 (RG 92), maintained at the National Archives.

Before 1842 the responsibility for the procurement or manufacture of military clothing fell under various agencies of the War Department. The RG92 data can be found in two locations: the so-called *Coxe–Irvine Papers*, and the *Abstract of Contracts QMGC*.²¹ Until 1812 the Office of Purveyor of Public Supplies (RG 92.2) routinely issued contracts with civilian establishments to manufacture select articles of clothing and equipage for the Army and militia. At this time, contractors consisted almost entirely of male and female outworkers, or *sundry persons*, who manufactured the apparel items in their Philadelphia homes under federal contract.

From 1812 until 1842, the Commissary General of Purchases increasingly outsourced orders for military clothing to textile mills in Philadelphia, New York City, and Boston. Collectively, these various agencies inspected contractor deliveries before turning over the finished items to the Military Storekeeper in Philadelphia.

The Quartermaster Department (RG 92) subsumed the responsibilities of procuring and manufacturing all War Department food, clothing, and equipage in 1842. Thereafter, a considerable quantity of wool socks and other finished military apparel were manufactured at the Clothing

¹⁹ Confederate and Union forces commandeered hundreds of river steamers during the Civil War that were documented in my merchant marine series (see Technical Appendix C). Often, the stolen steamers were hastily converted to armed gunboats by simply affixing tin plates and loading the appropriate ordnance en route to military service. Vessels involved in such conversions were excluded from the Navy shipbuilding series since they did not represent genuine manufacturing activity.

²⁰ The sources cited for wool stockings pertain to the series for *regalia* and *Army boots and shoes* as well.

²¹ Military contracts with civilian establishments were occasionally published in the U.S. Congressional Serial Set. See *Contracts Made by the War Department* and *Annual Reports of the Quartermaster General*.

Establishment of the Schuylkill Arsenal in Philadelphia (RG 92.15) and, to a lesser extent, various Quartermaster Depots in New York City, Jeffersonville (Indiana), Cincinnati, and San Francisco.²²

²² The manufacturing branch of Philadelphia's Schuylkill Arsenal (later called the Philadelphia Quartermaster Depot) was a complex of close to twenty factories. The Clothing Establishment at the Schuylkill Arsenal was primarily in charge of manufacturing Army uniforms and specialized undergarments. I explore in detail the structure and operations of the Schuylkill Arsenal and its importance to Philadelphia's burgeoning industrial economy in a separate case study (Davis 2002c).

Technical Data Appendix B

Locomotives

This appendix documents the assembly of an annual series for American-built locomotives through 1915. The locomotive data should be viewed as a more comprehensive extension of the familiar *Historical Statistics* series originally compiled by Burns (1934). Burns compiled annual statistics from 1880 using construction data on more than one dozen prominent builders surveyed in the contemporary trade journals *Railroad Gazette* and *Railway Age*.²³ To-date, the Burns series remains the lone published source of national locomotive construction for the pre-WWI era. Fishlow compiled, but never published, a locomotive series for the antebellum period by consulting the annual production records of ten builders.

To improve upon this discontinuous pair of locomotive series, this appendix compiles an annual series of U.S. locomotive construction that spans the entire pre-WWI period. The data set incorporates the construction of more than 120,000 locomotives by cross-referencing the roster lists of nearly one thousand railroad companies and locomotive builders.²⁴ Overall, the series represents more than 90% of the rolling stock ever built before WWI. Incomplete construction lists involving small-scale builders and machine shops account for the missing one-tenth.

The sample includes railroad and industrial locomotives constructed at both commercial and railroad-company machine shops. Geared locomotives designed for logging and mining companies (i.e., Shay engines) account for the bulk of non-railroad production. Table B1 presents the sample of commercial establishments. Dates of operation represent the years when an establishment was active

²³ Burns includes Canadian output after 1904 with the addition of the Montreal Locomotive Works to ALCO. Other minor sample changes plague the Burns series. For details, see the source notes to series a01152.db in the NBER *Macrohistory Database* and series P-293 in *Historical Statistics*.

²⁴ The annual data and more complete details can be found in a mimeo (Davis 2002a).

in locomotive building; numerous firms briefly manufactured engines before returning to their primary machine-shop products. A list of railroads with active machine shops follows the table.

Locomotives have been assigned the year in which they were completed or shipped, rather than when the order was received. In lieu of estimating annual firm production through year-end differences in sequential construction numbers, completed engines were *individually* cataloged for each year. Given that construction numbers were often assigned as orders were received, delayed or cancelled orders occasionally resulted in construction numbers that were built out-of-sequence.

The archives and scholarly publications of the Railway and Locomotive Historical Society (R&LHS) are the core source of information. Founded in 1921, the R&LHS is the nation's oldest organization devoted to railroad history. R&LHS members have developed and published historical locomotive rosters in the *Railway and Locomotive Historical Society Bulletin* and *Railroad History*.²⁵ Railroad company rosters, adapted from original company reports and ownership records, indicate the construction data of their engines. Rosters are available to R&LHS members at marginal cost.

Several features of the locomotive series are worth noting. Most importantly, the database encompasses virtually the entire universe of commercial builders, from prominent large-scale operations to the short-lived efforts of general machine shops. For instance, the Albany Iron Works manufactured only one engine in 1839, while Baldwin had turned out over 42,000 by 1915.

Indicative of the breadth of R&LHS research, my time series is more comprehensive than contemporary surveys conducted before and after the Civil War. For example, early sample observations are broader than canvasses conducted in the late 1830s by Gerstner ([1842-3] 1997) or the *Report on Steam Engines* (U.S. Congress, House of Representatives 1838). Likewise, the paper's data account for roughly one-tenth more locomotives than the Burns-*Historical Statistics* series since the R&LHS-based database is broader than that tracked at the time by *Railway Age*.

²⁵ See Bulletin 139 of *Railroad History* (1978) for an index to the major published rosters. White (1982) provides an expert summary of individual commercial firms involved in the manufacture of locomotives.

APPENDIX TABLE B1
LOCOMOTIVE BUILDERS & MACHINE SHOPS

Establishment	Location	Pre-WWI years
John Stevens (<i>experimental "Steam Waggon"</i>)	Hoboken, NJ	1825
Barlow and Bruen (<i>prototype</i>)	Lexington, KY	1828-1833
Peter Cooper (<i>experimental "Tom Thumb"</i>)	Baltimore, MD	1829
William T. James	New York, NY	1829-1832
West Point Foundry Association	New York, NY	1830-1835
Baldwin Locomotive Works	Philadelphia, PA	<i>since 1831</i>
Ezekiel Childs (<i>prototype</i>)	Philadelphia, PA	1831
Stacey Costell / Pennsylvania Locomotive Works	Philadelphia, PA	1831
Davis & Gartner	York, PA	1831-1832
Long & Norris / Norris Locomotive Works	Philadelphia, PA	1831-1867
George W. Johnson (<i>prototype</i>)	Baltimore, MD	1831
Davis & Gartner / Phineas Davis	Baltimore, MD	1832-1836
John Shields (<i>prototype</i>)	Cincinnati, OH	1832
E. A. G. Young / New Castle Manufacturing Co.	New Castle, DE	1832-1858
Eason & Dotterer	Charleston, SC	1833-1838
McClurg, Wade & Company	Pittsburgh, PA	1834-1837
Mill Dam Foundry	Boston, MA	1834-1835
Charles Reeder & Son (<i>prototype</i>)	Baltimore, MD	1834
William Avery (<i>prototype</i>)	Newark, NJ	1835
Coleman Sellers & Sons	Philadelphia, PA	1835-1838
Locks & Canals Co. / Lowell Machine Shops	Lowell, MA	1835-1865
D. J. Burr & Company	Richmond, VA	1836-1841
H. R. Dunham & Co. / Dunham & Browning	New York, NY	1836-1838
Garrett & Eastwick / Eastwick & Harrison	Philadelphia, PA	1836-1842
Gillingham & Winans / Ross Winans	Baltimore, MD	1836-1863
Seth Boyden	Newark, NJ	1837-1841
James Brooks / Bridgewater Iron Works	Philadelphia, PA	1837-1840
McLeish & Smith	Charleston, SC	1837
Thomas W. Smith & Company	Alexandria, VA	1837
Poughkeepsie Locomotive Engine Company	Poughkeepsie, NY	1838-1839
Albany Iron Works	Albany, NY	1839
Davis H. Dotterer & Company	Reading, PA	1839-1842
Dennis, Wood & Russell	Auburn, NY	1840-1842
Walter McQueen	Albany, NY	1840
Pennel, Lenher & Humes	Lancaster, PA	1840
Hinkley / Boston Locomotive Works	Boston, MA	1841-1889
A. Harkness / Harkness, Moore & Company	Cincinnati, OH	1843-1853
Burr, Pea & Sampson	Richmond, VA	1846
Taunton Locomotive Works	Taunton, MA	1847-1889
Ballardvale Machine Shop	North Andover, MA	1848-1849
Jabez Coney	South Boston, MA	1848
Portland Company	Portland, ME	1848-1906
Souther / Globe Locomotive Works	South Boston, MA	1848-1864
Springfield Car & Engine Company	Springfield, MA	1848-1858
Swinburne, Smith & Company / Swinburne	Paterson, NJ	1848-1857
Seth Wilmarth	South Boston, MA	1848-1855
Amoskeag Manufacturing Company	Manchester, NH	1849-1859
Corliss, Nightingale & Company	Providence, RI	1850-1851
Cuyahoga Steam Furnace Company	Cleveland, OH	1850-1857

Continued on following page.

APPENDIX TABLE B1 - *Continued*

Establishment	Location	Pre-WWI years
Davenport, Bridges & Kirk	Cambridgeport, MA	1850-1852
Essex Company	Boston, MA	1850-1852
A. & W. Denmead & Son	Baltimore, MD	1851-1859
Grant / New Jersey Loco. & Machine Works	Paterson, NJ	1851-1893
Niles & Company	Cincinnati, OH	1851-1858
George E. Sellers	Cincinnati, OH	1851-1852
Smith & Perkins / Virginia Locomotive Works	Alexandria, VA	1851-1857
Uriah Wells	Petersburg, VA	1851-1861
H. & F. Blandy	Zanesville, OH	1852-1858
Lawrence Machine Shops	Lawrence, MA	1852-1857
Cincinnati Locomotive Works	Cincinnati, OH	1853-1868
Covington Locomotive Works	Covington, KY	1853-1854
Mason Machine Works	Taunton, MA	1853-1890
Menomonee Locomotive Works	Milwaukee, WI	1853-1857
H. H. Scoville / Chicago Locomotive Works	Chicago, IL	1853-1856
Breese, Kneeland & Co. / Jersey City Loco. Works	Jersey City, NJ	1854-1873
A. Latham & Company	White River Junction, VT	1854-1856
Matfield Manufacturing Company	East Bridgewater, MA	1854-1856
Murray & Hazelhurst	Baltimore, MD	1854-1857
Kentucky Locomotive & Machine Works	Covington, KY	1857-1858
Vulcan Iron Works	San Francisco, CA	1862-1869
Hayward & Bartlett / Baltimore Locomotive Works	Baltimore, MD	1863-1867
McKay & Aldus Iron Works	East Boston, MA	1864-1869
Union Iron Works / Henry J. Booth & Co.	San Francisco, CA	1865-1882
Campbell & Whittier	Cambridge, MA	1866
H. K. Porter & Company	Pittsburgh, PA	<i>since 1866</i>
Port Oram Foundry Company	Port Oram, NJ	1868
Dawson & Bailey	Connellsville, PA	1875-1882
Lima Locomotive Works	Lima, OH	<i>since 1878</i>
Dunkirk Iron Works / Dunkirk Engineering Co.	Dunkirk, NY	1882-1896
Rome / New York Locomotive Works	Rome, NY	1882-1891
Climax Manufacturing Company	Corry, PA	<i>since 1888</i>
Struthers, Wells & Company	Warren, PA	1888
Stearns Manufacturing Co. / Heisler Loco. Works	Erie, PA	<i>since 1894</i>
Curtis Manufacturing Company	St. Louis, MO	1896
Davenport Locomotive Works	Davenport, IA	<i>since 1902</i>
Glover Machine Works	Marietta, GA	<i>since 1903</i>
<i>ALCO predecessors</i>		
Rogers Locomotive Works	Paterson, NJ	<i>since 1837</i>
Schenectady Locomotive Works	Schenectady, NY	<i>since 1851</i>
Cooke Locomotive & Machine Company	Paterson, NJ	<i>since 1853</i>
Manchester Locomotive Works	Manchester, NH	1855-1913
Dickson Manufacturing Company	Scranton, PA	1862-1913
Rhode Island Locomotive Works	Providence, RI	1866-1907
Pittsburgh Locomotive & Car Works	Pittsburgh, PA	<i>since 1867</i>
Brooks Locomotive Works	Dunkirk, NY	<i>since 1869</i>
Richmond Locomotive Works	Richmond, VA	<i>since 1886</i>

Sources : [Baldwin Locomotive Works 1924]; Edson 1992; Hoffman 1979; *The Heisler Locomotive* 1982; Taber and Casler 1960; White 1965; 1968; and rosters maintained by the R&LHS and its publications: *Railway and Locomotive Historical Society Bulletin* (1921-72), and *Railroad History* (1972-).

Railroad Company Machine Shops

While machine shops predominantly conducted repair and maintenance services, the largest railroad companies turned out an impressive number of locomotives. The Mt. Clare shops of the Baltimore & Ohio Railroad, Pennsylvania Railroad's Altoona works, and the Reading shops of the Philadelphia & Reading Railroad are notable examples. Although railroad-built engines historically accounted for just one-tenth of total output, machine shops tended to "build-up stocks" during recessions as repair work slackened.

R&LHS rosters and Edson (1992) detail new locomotive construction at railroad company machine shops. Sampled railroads (including predecessor or acquired roads) with active shops are presented alphabetically below.

Atlantic Coast Line

Predecessor / acquired railroads: Atlanta, Birmingham & Coast; Atlantic & Gulf; Franklin & Carolina; Petersburg, Richmond & Petersburg; Wilmington & Manchester; Wilmington & Raleigh; Wilmington & Weldon; Wilmington, Columbia & Augusta.

Baltimore & Ohio Railroad

Predecessor / acquired railroads: Buffalo & Susquehanna; Buffalo, Rochester & Pittsburgh; Central Ohio; Chicago Terminal Transfer; Cincinnati, Hamilton & Dayton; Cincinnati, Indianapolis & Western; Coal & Coke; Columbus & Cincinnati Midland; Emlenton & Shipperville; Foxburg, St. Petersburg & Clarion; Indian Creek Valley; Marietta & Cincinnati; Morgantown & Kingwood; Ohio & Mississippi; Pittsburgh & Connellsville; Pittsburgh & Western; Pittsburgh Southern; Reynoldsville & Falls Creek; Sandusky, Mansfield & Newark; Toledo, Cincinnati & St. Louis.

Boston & Maine Railroad

Predecessor / acquired railroads: Boston & Lowell; Boston, Concord & Montreal; Manchester & Lawrence; Massachusetts Central; Nashua & Lowell; Northern, Portland & Rochester; Portland, Saco & Portsmouth; Troy & Boston; Vermont & Massachusetts; Worcester & Nashua; Worcester, Nashua & Rochester; York & Cumberland.

Chesapeake & Ohio Railroad

Predecessor / acquired railroads: Ashland Coal & Iron; Chicago, Cincinnati & Louisville; Richmond & Allegheny; Virginia Central.

Chicago, Burlington & Quincy Railroad

Predecessor / acquired railroads: Black Hills & Fort Pierre; Burlington & Western; Chicago & Iowa; Denver, Utah & Pacific; Hannibal & St. Joseph; Kansas City, St. Joseph & Council Bluffs.

Chicago, Milwaukee, St. Paul & Pacific Railroad

Predecessor / acquired railroads: Chicago, Milwaukee & Gary; Chicago, Terre Haute & South Eastern; LaCrosse & Milwaukee; Milwaukee & Mississippi; Minnesota Central; Racine & Mississippi; St. Paul & Chicago; Southern Minnesota.

Delaware, Lackawanna & Western Railroad

Predecessor / acquired railroads: Cayuga & Susquehanna; Erie & Central New York; Leggetts Gap; Morris & Essex; Oswego & Syracuse; Syracuse & Binghamton.

Erie Railroad

Predecessor / acquired railroads: Atlantic & Great Western; Buffalo, Corning & New York; Buffalo, New York & Erie; Erie–Lackawanna; New Jersey & New York; New York & Erie; New York, Lake Erie & Western; New York, Pennsylvania & Ohio; Tioga.

Georgia Railroad

Predecessor / acquired railroads: Montgomery & West Point; Western of Alabama.

Illinois Central Railroad

Predecessor / acquired railroads: Chicago, Memphis & Gulf; Mississippi & Tennessee; Mississippi Central; New Orleans, Jackson & Great Northern; St. Louis, Indianapolis & Eastern; Vicksburg & Meridian.

Lehigh Valley Railroad

Predecessor / acquired railroads: Beaver Meadow; Delaware, Susquehanna & Schuylkill; Elmira, Cortland & Northern; Hazleton; Lehigh & Mahanoy; Montrose.

Louisville & Nashville Railroad

Predecessor / acquired railroads: Atlanta, Knoxville & Northern; Covington & Lexington; Cumberland & Manchester; Lexington & Frankfort; Louisville & Frankfort; Louisville, Cincinnati & Lexington; Memphis & Ohio; Mobile & Montgomery; Nashville, Chattanooga & St. Louis; Nashville & Decatur; St. Louis & South Eastern.

Maine Central Railroad

Predecessor / acquired railroads: Androscoggin; Androscoggin & Kennebec; Bangor, Oldtown & Milford; Penobscot & Kennebec; Portland & Kennebec; Portland & Ogdensburg; Portland & Rumford Falls; Somerset; Washington County.

New York Central Railroad

Predecessor / acquired railroads: Albany & Schenectady; Albany & West Stockbridge; Black River & Utica; Boston & Albany; Boston & Worcester; Buffalo & State Line; Cleveland & Toledo; Cleveland, Cincinnati, Chicago & St. Louis; Cleveland, Indianapolis, St. Louis & Chicago; Cleveland, Columbus & Cincinnati; Fall Brook; Hudson River, Mohawk & Hudson; Indianapolis & Cincinnati; Lake Shore & Michigan Southern; Michigan Central; Michigan Southern & Northern Indiana; New York & Harlem; New York & Ottawa; New York, Boston & Montreal; New York Central & Hudson River; New York, West Shore & Buffalo; Pittsburgh & Lake Erie; Potsdam & Watertown; Rome, Watertown & Ogdensburg; Syracuse, Ontario & New York; Toledo & Ohio Central; Ulster & Delaware; Utica & Schenectady; Watertown & Rome; Western.

New York, New Haven & Hartford Railroad

Predecessor / acquired railroads: Boston & New York Airline; Boston & New York Central; Boston & Providence; Boston, Concord & Fitchburg; Boston, Hartford & Erie; Cape Cod Branch; Central New England; Connecticut Western; Danbury & Norwalk; Fall River; Hartford & Connecticut Valley; Hartford & Connecticut Western; Hartford & New Haven; Hartford, Providence & Fishkill; Meriden, Waterbury & Connecticut River; Milford & Woonsocket; Naugatuck; New Bedford; New Haven & Derby; New Haven & Northampton; New York & Boston; New York & New England; New York & New Haven; New York, Providence & Boston; Norwich & Worcester; Old Colony; Poughkeepsie & Eastern; Providence & Springfield; Providence & Worcester; Providence, Warren & Bristol; Taunton Branch.

Norfolk & Western Railroad

Predecessor / acquired railroads: Atlantic, Mississippi & Ohio; Cincinnati, Portsmouth & Virginia; Norfolk & Petersburg; Shenandoah Valley; South Side; Virginia & Tennessee.

Pennsylvania Railroad

Predecessor / acquired railroads: Alexandria & Fredericksburg; Allegheny Portage; Allegheny Valley; Baltimore & Potomac; Baltimore & Susquehanna; Bells Gap; Belvidere–Delaware; Camden & Amboy; Camden & Atlantic; Cincinnati & Muskingum Valley; Cincinnati, Lebanon & Northern; Cincinnati, Wilmington & Zanesville; Cleveland & Marietta; Cleveland & Pittsburgh; Cumberland Valley; Danville & Pottsville; Grand Rapids & Indiana; Little Miami; Madison & Indianapolis; New Castle & Frenchtown; New Jersey Railroad & Transportation Company; New York, Philadelphia & Norfolk; Northern Central; Ohio River & Western; Philadelphia & Erie; Pennsylvania & Northwestern; Philadelphia & Baltimore Central; Philadelphia & Columbia; Philadelphia, Wilmington

& Baltimore; Pittsburgh, Cincinnati & St. Louis; Pittsburgh, Fort Wayne & Chicago; Terre Haute & Peoria; Terre Haute & Richmond; West Chester & Philadelphia; Western New York & Pennsylvania; Williamsport & Elmira.

Reading Railroad

Predecessor / acquired railroads: Bloomsburg & Sullivan; Catawissa, Williamsport & Erie; Little Schuylkill; Mine Hill & Schuylkill Haven; North Pennsylvania; Pennsylvania, Poughkeepsie & Boston; Philadelphia, Germantown & Norristown; Raritan & Delaware Bay; Schuylkill & Susquehanna; Wilmington & Northern.

Richmond, Fredericksburg & Potomac Railroad

Predecessor / acquired railroads: Washington Southern.

Seaboard Air Line

Predecessor / acquired railroads: Charlotte Harbor & Northern; Georgia, Florida & Alabama; Florida Central & Peninsular; Pensacola & Georgia; Portsmouth & Roanoke; Raleigh & Gaston; Seaboard & Roanoke; Tampa & Gulf Coast; Tampa Northern.

Southern Railroad

Predecessor / acquired railroads: Alabama & Chattanooga; Alabama & Tennessee Rivers; Alabama Great Southern; Atlanta & Charlotte Air Line; Atlantic & Danville; Charlotte & South Carolina; Charlotte, Columbia & Augusta; Cincinnati, New Orleans & Texas Pacific; Cincinnati Southern; Columbia & Greenville; East Tennessee & Georgia; East Tennessee, Virginia & Georgia; Georgia Southern & Florida; Greenville & Columbia; Manassas Gap; Mobile & Birmingham; Memphis & Charleston; New Orleans & Northeastern; New Orleans Terminal; Richmond & York River; Roanoke Valley; South Carolina; Virginia Midland; Western North Carolina.

Southern Pacific Railroad

Predecessor / acquired railroads: Arizona & New Mexico; California & North Eastern; California Pacific; Carson & Colorado; Central Pacific; Corvallis & Eastern; El Paso & South Western; Los Angeles & Long Beach; Los Angeles & Pacific; Nevada–California–Oregon; New Orleans, Opelousas & Great Western; Oregon Pacific; Portland, Eugene & Eastern; San Antonio & Arkansas Pass; San Joaquin & Sierra Nevada; South Pacific Coast; Texas & New Orleans; Texas Midland.

Union Pacific Railroad

Predecessor / acquired railroads: Columbia Southern; Idaho Northern; Kansas Central; Kansas Pacific; Oregon Portage; Pacific & Idaho Northern; Utah & Northern; Utah Central; Utah Eastern; Walla Walla & Columbia River.

Wabash Railroad

Predecessor / acquired railroads: North Missouri; Toledo & Illinois; Toledo & Wabash; Toledo, Wabash & Western; Wabash Railway; Wabash, St. Louis & Pacific.

Technical Data Appendix C

Merchant ships

Since 1789 customhouses nationwide have granted registers, enrollments, or licenses to virtually all American-built merchant vessels according to federal mandates.²⁶ These certificates of registry and enrollment specify a vessel's vital information: her name, rigging, tonnage, linear dimensions, home port, and date and place of construction. Custom districts routinely filed copies of such documentation with federal agencies, beginning with the U.S. Treasury Department, which compiled aggregate tonnage statistics on newly constructed merchant vessels. From these reports the U.S. Department of Commerce pieced together an annual series, beginning in 1797, on the gross tonnage of merchant shipbuilding in its *Merchant Marine Statistics, 1936* (Bureau of Marine Inspection and Navigation 1937). The official series, recapitulated in *Historical Statistics* (1975, 1997; series Q-434), is shown below in Figure C1.

Unfortunately, two notable shortcomings plague the official series. First, federal twelve-month reporting periods changed twice before the Civil War, thereby making the annual data inconsistently defined over time. Tonnage data were originally available on a calendar-year basis before fiscal-year frequencies were instituted, first in 1835 and again in 1843. Breaks in reporting periods cannot be easily rectified on account of vessel depreciation. This is primarily because official rosters of the documented American merchant fleet—most notably the U.S. Treasury Department's *Annual List of*

²⁶ Custom officials issued certificates of registration to vessels engaged in foreign trade or whaling. Vessels measured at over 20 gross tons required enrollments for coastal trade and fishing. In addition, customhouses were authorized to issue annual licenses to vessels under 20 tons as well as to vessels whose documentation had expired while away from their home port. Vessels under 5 net tons were exempt from the above requirements and remained undocumented unless their owners voluntarily provided information to local port authorities.

Merchant Vessels of the United States—were not published until after the Civil War.²⁷ Hence, an ad hoc attempt to proxy calendar-year construction, such as an average of adjacent fiscal-year tonnage figures (Frickey 1947), is problematic because shipbuilding was predominantly active in the summer months.

A second caveat of the official series is that historical changes in maritime law fundamentally altered how a vessel's tonnage was measured.²⁸ Before 1865 a merchant vessel's gross tonnage was calculated from her linear dimensions (length, breadth, and depth; in feet and inches) using the Old Custom House formula (sometimes referred to as the *old English rule*). By an 1864 act of Congress, the U.S. government adopted Britain's Moorsom System. The Moorsom System, otherwise known as New Custom House Measurement, is essentially the system still in use today. Under the Moorsom System, gross tonnage was derived through more complicated calculations of a vessel's internal volume via Simpson's rule.

Measurement differences adversely affect the comparability of the *Historical Statistics* series before and after the Civil War.²⁹ Pre-1865 tonnage cannot be conveniently spliced to post-Civil War quantities because discrepancies in tonnage arising under the two measuring systems vary substantially across rigs.³⁰ Consequently, while the old English rule generally registers larger tonnage (roughly on the order of 15%) vis-à-vis the Moorsom System, year-to-year differences would vary considerably depending upon the given distribution of rigs constructed.

²⁷ The U.S. Treasury Department first published its *Annual List of Merchant Vessels of the United States* in 1868. Private trade groups, such as the American Shipmasters' Association (known as the American Bureau of Shipping since 1908), also began publishing registration lists at this time.

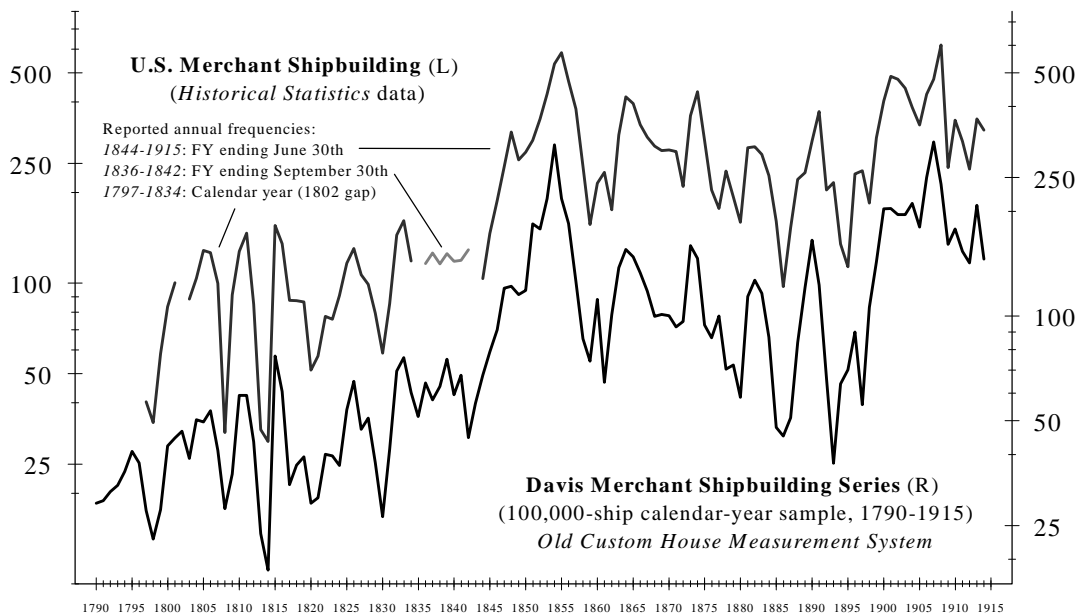
²⁸ Gross tonnage is not a measure of weight, but rather refers to the capacity of the entire space within the frames and the ceiling of the hull, along with pertinent closed-in spaces above deck. Before 1865 gross tonnage was expressed as 95 cubic feet to a ton (sometimes referred to as *tons burden*). Since the adoption of the Moorsom system, gross tons have been expressed in 100 cubic feet.

²⁹ Footnotes to *Historical Statistics* series Q-434 warn that the U.S. tonnage figures are "mixed" over the transition period (1865-1868), apparently because shipbuilders were accustomed to pricing vessels under the Old Custom House regime.

³⁰ To drive home this point, consider two vessels of identical rig (*ship*), constructed at the same shipyard (*Bath, Maine*) in the same year (*1882*) by the same builder (*William Rogers*). The ship *Abner Coburn* (225.0' length x 43.2' breadth x 18.2' depth) registered at 1,879 gross tons under the New Custom House Measurement but falls to only 1,675 gross tons burden by the pre-1865 formula. Conversely, the ship *Richard P. Buck* (220.4' x 40.3' x 24.0') registered under the Moorsom system at 1,567 gross tons, yet her burden rises to 1,998 tons on an Old Custom House basis.

APPENDIX FIGURE C1: MERCHANT SHIPBUILDING—A CONSISTENT TIME SERIES

(Quantities expressed in thousands of gross tons, log scale)



Sources & notes: U.S. series is reported in *Merchant Marine Statistics, 1936* (1937, 42-45, table 22, 65-66, table 30) and represents the sum of domestically built merchant vessels (*Historical Statistics* series Q-434; errors corrected) and yachts. Tonnage statistics in *Merchant Marine Statistics* were derived under the widespread Old Custom House Measurement System before 1865; thereafter, the Moorsom System was gradually adopted. Ratio scales have been offset slightly for clarity.

This appendix establishes a shipbuilding series that circumvents the handicaps of the official data. The new series, which continuously spans the 1790–1915 period, is presented in Figure C1 alongside the official data. My tonnage series rests on a database of approximately 100,000 merchant vessels, or more than two-thirds of the American merchant fleet built before WWI.³¹ The data set includes all

³¹ There appears to be no systematic drift over time in the tonnage ratio between my series and that supplied in *Historical Statistics*. Year-to-year ratios, however, do vary after 1843 on account of discrepancies in reporting frequencies. Specifically, my calendar-year series more accurately captures turning points in construction activity that can be distorted or obfuscated by fiscal-year definitions. Moreover, my research suggests that tonnage figures reported for the years 1808, 1813, and 1814 in the *Historical Statistics* series may be understated. While shipbuilding during these years was unarguably depressed, inspection of ship registers shows that a disproportionate number of brigs and other merchant vessels built in those years were constructed away from the northeastern coastline and major seaports. Since such vessels were commonly “put on the books” years later, contemporary statistics may not reflect their construction. This observed pattern is consistent with the legal and military realities facing merchants and shipbuilders during the embargo and the War of 1812.

types of merchant rigs and incorporates the four major specialty classes (clippers, packets, steamers, and whalers).³²

Official merchant marine documents provide the raw data for the shipbuilding sample. Ship registries from different custom districts have been reproduced over the years by various government and private organizations. The Essex Institute published the first comprehensive listing of ship registers in 1906 for the custom district of Salem and Beverly, Massachusetts. The Work Projects Administration (WPA) later issued separate ship registries for other prominent New England custom districts in Massachusetts (*Dighton–Fall River, Newburyport, New Bedford, and Plymouth*), Maine (*Machias and Saco*), and Rhode Island (*Bristol–Warren, Newport, and Providence*). Conducted by the Survey of Federal Archives and co-sponsored by The National Archives Project, the WPA reproduced all extant vessel documentation from customhouse and archival records. Baker (1973) has produced an analogous and comprehensive listing of all vessels built in the custom district of Bath, Maine—the nation’s largest shipbuilding center—and numerous neighboring Kennebec ports. Collectively spanning from the late 1700s through the early 1900s, these sources are extremely attractive because ship records indicate the linear dimensions and construction data of each vessel.

The WPA published similar directories for the major commercial ports of New Orleans, New York (Holdcamper 1968), Philadelphia, and Eureka, California (formerly part of the San Francisco custom district). Unlike the other WPA references, however, the New Orleans, New York, and Philadelphia directories only summarize certificates issued before 1870. These volumes refer the reader to the *Annual List of Merchant Vessels* for later vessel documentation. To ensure that my data set draws from a fairly uniform distribution, merchant vessels documented at the three city ports were included only if they were constructed in the said port city, or if their hailing port belonged to one of

³² The Davis sample includes (but is not limited to) in alphabetical order: barges; barks (sail and steam); barketines (sail and steam); boats (canal, flat, lake, scow, and steam); brigs; brigantines; catboats; ferryboats (steam and other); flatboats; gas screws; hermaphrodite brigs; keelboats; ketches; light vessels; motor vessels; ships; schooners (sail and steam); shallops; sloops; snows; steamers; steamships; steam scows; tugboats; yachts (motor, schooner, and steam); and yawls. Vessels built for military service or resold by the government to the merchant marine were naturally excluded from the sample.

the New England custom districts above. For instance, a vessel issued registration in Philadelphia but constructed in New Bedford, Massachusetts would be eligible, yet a Philadelphia-registered vessel built and hailing from Baltimore would not. This approach allows me to consistently trace shipbuilding activity in these three ports after 1870 from the *Annual List of Merchant Vessels*.

I have consulted additional reference works to verify and supplement shipbuilding accounts for particular vessel types, namely packets, clippers, and Mississippi River steamboats. Albion (1938) documents the construction of nearly three hundred transatlantic and coastal packets, the vast majority of which were built in New York City. Major packet lines from New York to European (Liverpool, London, and Havre) and southern cotton (Charleston, Mobile, New Orleans, and Savannah) ports were most active during the so-called packet era of 1818–1858. Fairburn's (1945–1955, 5:3:2807–821) *Merchant Sail* provides vessel data of wooden clippers constructed by the major New York City builders during the shipbuilding boom of the 1840s and 1850s.

Steam-powered merchant vessels (steamers, for short) were the major source of early freight and passenger transportation along the Mississippi River and its tributaries. Since steamers that operated on the Mississippi River system were rarely constructed at the aforementioned northern coastal ports, I have secured construction data on the western river steam fleet from two overlapping sources: the *Lytle–Holdcamper List* (Lytle and Holdcamper 1975, 1978, 1982, 1984) and *Way's Packet Directory* (1983). The former provides a reference list of all merchant steamers constructed through 1868, while the latter focuses on those documented along the Mississippi River system after 1848.

Since not all (albeit most) of the steamers in the *Lytle–Holdcamper List* operated on the Mississippi River network, steam vessels constructed before 1848 were isolated on the basis of their port of construction and initial hailing port as consistent with the geographical focus of Way's subsequent listing. This approach eliminates potential jump-offs between sources and is indicative of the fact that the overwhelming majority of Mississippi River steamers were built at ports that were actually located in the region.

From the aforementioned sources, I compiled a U.S. shipbuilding database of vessels constructed between the years 1790 and 1915. Documented vessels were individually cataloged, first by name, then by place and year of build, and finally by linear dimensions and registered tonnage. The recorded information was critical in eliminating inconsistencies embodied in the official series, as well as in isolating redundancies across ship registries.

The latter was especially problematic with respect to New England ports because vessels constructed in one custom district were often later documented elsewhere. For instance, *Ship Registries and Enrollments of Newport, Rhode Island* contains 2,142 vessels registered or enrolled in the Newport Custom District. Approximately one-half of the vessels presented in the WPA listing, however, hailed from one of 150 other ports. Redundancies were frequently encountered for vessels issued temporary licenses while away from their home ports.

Once vessels were uniquely identified in the database, the next pressing issue was the measurement of gross tonnage. I have expressed shipbuilding activity in terms of gross tonnage as defined under the Old Custom House Measurement System. Unlike the Moorsom System—which requires a copy of a ship’s schematics in order to arrive at her gross tonnage—the Old Custom House Measurement System requires *only her linear dimensions*, rudimentary information ubiquitously provided in ship records.

Consequently, any vessel’s gross tonnage can be approximated on an Old Custom House basis, Q_{it}^{old} , using the following formula:

$$(C.1) \quad Q_{it}^{old} = \frac{\left(l - \frac{3}{5}b\right) \cdot b \cdot d}{95},$$

where l is the *length* from the fore part of the stem to the after part of the stern-post, measured on deck; b equals the *breadth* (of *beam*) from the outside to outside of planking at the broadest part of the vessel; and d represents the *depth* of hold from the plank of the deck to the ceiling of the hold.³³ Gross tons under the old English rule have been rounded to the nearest cubic ton in 95^{ths}.

The sole drawback of my methodology was that (C.1) had to be applied on a ship-by-ship basis to all vessels built after 1865, as well as to older vessels re-measured following the Civil War. In all, the registered tonnage of more than forty thousand merchant vessels was re-expressed on an Old Custom House basis.

³³ For further details see Albion (1938, 298, appendix IV) and Baker (1973, 1:515–16). I should note that vessels built in the 1790s were occasionally registered using the “Carpenter’s Measurement,” an unofficial calculation that tended to inflate a vessel’s measurement. I corrected the afflicted observations using the formula in (C.1).

Technical Data Appendix D

Pig iron

Since its founding in 1854, the American Iron and Steel Association (AISA) has conducted mail surveys of the nation's forges and foundries in order to assess the quantity of pig iron produced. While the subsequent AISA tabulations are deemed comprehensive and reliable, considerable contention surrounds the reliability of earlier national output estimates that the trade group adopted.³⁴ Motivated by the absence or shortcomings of contemporary census returns, various organizations periodically undertook the task of estimating national iron production before the AISA's formation. Unfortunately, tariff debates (which many of these groups had a vested interest in) and the misinterpretation or intentional mishandling of survey data engendered vastly different accounts of pre-1854 output. The first two columns of Table D1 illustrate the extent of the statistical discord.

Fogel (1964, 151–67) has reconstructed annual estimates from 1840 through 1853, the period he considers most “wrapped in confusion.” Fogel's estimates are valuable in reassessing the controversial picture of national production during the 1840s. Researchers, among others Paskoff (1983) and Calomiris and Hanes (1994), merge the Fogel and AISA data to form a continuous U.S. pig iron series from 1840.

In this appendix, I further extend the AISA–Fogel series back through 1827. Specifically, I employ Fogel's intuitive procedure of plugging gaps in national production records by inflating Pennsylvania benchmarks to U.S. levels. In doing so, Fogel's earliest estimates have been revised to accord more accurately with prevailing evidence.

³⁴ In 1912 the AISA changed its name to the American Iron and Steel Institute (AISI). The historical pig iron production data are reproduced in the Census Bureau's *Historical Statistics* (1975, 1997). Today, the AISI continues to provide shipments data for the Federal Reserve Board's monthly IP index.

Table D1 copiously documents the technicalities of the extended and revised estimates (see especially notes to columns [4]–[6]). Nevertheless, it is useful to overview the procedure and to summarize noteworthy findings.

Fogel estimated the quantity of U.S. pig iron produced for years with missing or dubious figures by fitting a quadratic trend through known U.S.-to-Pennsylvania output ratios. Pennsylvania is an appropriate choice. The state was the century’s largest producer of pig iron, and trade groups periodically conducted surveys of the state’s furnaces.

Since Fogel was only concerned with inflating post-1840 Pennsylvania data, however, his trend, as illustrated in Figure D1, turns out to be inaccurate in deriving earlier estimates. The Fogel curve would grossly overstate pre-1840 output since the trend implies a tenuously low Pennsylvania share in the early 1800s.³⁵ Indeed, the pre-1840 Fogel plot contradicts prevailing theories concerning the spatial and technological developments in the early iron industry. Consequently, I have recalculated Fogel’s inflation curve by incorporating pre-1840 Pennsylvania output shares.³⁶ The revised trend in Figure D1 displays a more consistent, muted *U-shape*, yet closely resembles Fogel’s curve after 1840.

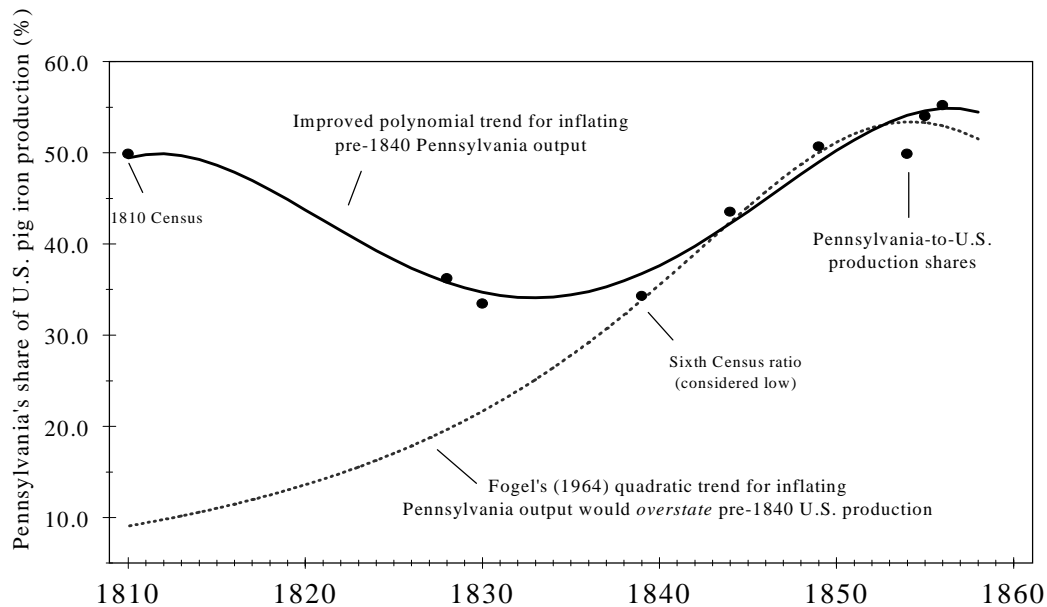
History provides compelling reasons why the revised trend shown in Figure D1 should be more accurate. While Pennsylvania accounted for roughly one-half of domestic output around 1810, American iron production was nevertheless decentralized insofar as most states had charcoal iron forges to meet local blacksmithing demand.³⁷

³⁵ Applying Fogel’s trend to Pennsylvania benchmarks generates the counterintuitive result that American iron production in 1810 (approximately 300,000 gross tons) roughly equaled that observed in 1840.

³⁶ See notes to Table D1 concerning my adjustments to the Pennsylvania industry surveys.

³⁷ The deficiencies in the 1810 manufacturing survey have been well documented, most cogently by Fishbein (1963). While evidence exists that iron returns outside of Pennsylvania were erroneously tabulated, the Pennsylvania iron industry also voiced considerable dissatisfaction with the deficiencies in the reported state totals. By incorporating Pennsylvania’s returned 1810 share (49.9%, see Coxe (1814)) in the calculations, I have conventionally assumed that the census bias is distributed symmetrically between Pennsylvania and all other iron-producing states. That said, the final results are resilient to changes in the 1810 observation because trend values before 1827 are discarded.

APPENDIX FIGURE D1: IMPROVED PRE-CIVIL WAR PENNSYLVANIA-TO-U.S. TREND



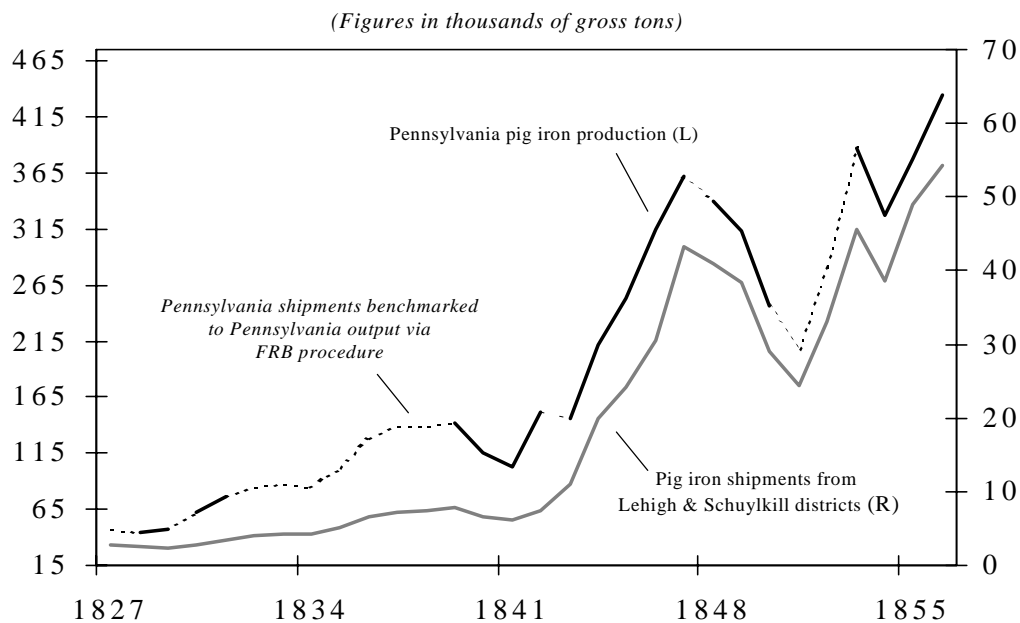
Sources and notes: Benchmark Pennsylvania shares derived from Coxe (1814), the Sixth Census (U.S. Department of State 1841, 358), the Seventh Census (DeBow 1854, 181), Lesley (1859, 750), Fogel (1964, 160-62), Temin (1964, 264-65, table C.1, 280, table C.12), and Paskoff (1983, 75, table 20) and Technical Appendix table D1. Fogel (1964, 163, note 33) trend computed as the inverse of his quadratic function of national-to-Pennsylvania production (this regression could not be replicated exactly). The improved trend has been derived from a fourth-order nonlinear equation fitted over known pre-1860 observations (benchmarks designated above). Note that *neither* trend is intended to project postbellum shares.

Scholars on the pre-Civil War iron industry, most notably Bruce ([1931] 1967) and Paskoff (1983), have argued that iron production spatially diversified in the 1820s and early 1830s on account of accentuated frontier development. The combination of high transportation costs and a reliance on blast-furnace technology, meanwhile, hampered Pennsylvania furnaces from reliably serving distant markets. Coupled with the frontier discoveries of iron-ore deposits and the widespread use of charcoal technologies, Temin (1964, 240–41) argues that Pennsylvania's iron industry lost market share throughout the 1820s to more rapidly growing states.³⁸

Confidence in the revised curve in Figure D1 is bolstered by several factors. First, the new ratio curve implies that Pennsylvania began to regain market share by the mid-1830s with the emergence of anthracite coal as an alternative smelting fuel. The relationship between Pennsylvania's market share and the share of pig iron produced with non-conventional fuels is documented in Table D2. Following

the development of the hot blast, anthracite rapidly replaced charcoal as the primary mineral fuel in eastern Pennsylvania blast furnaces. Since anthracite deposits were highly concentrated in eastern Pennsylvania, Temin (1964, 241) argues “the rising proportion of mineral fuel production can account for the change in the proportion of production made in Pennsylvania.” Concomitant transportation improvements (canals, railroads) only further facilitated non-local consumption of Pennsylvania iron.

APPENDIX FIGURE D2: PENNSYLVANIA IRON SHIPMENTS & ESTIMATED OUTPUT



Sources and notes: See Technical Appendix Table D1 for Pennsylvania production series. Shipments represent the sum of descending pig iron tonnage from the Lehigh and Schuylkill iron districts (bound toward Philadelphia). Shipments data transcribed from *Hunt's Merchants' Magazine* (various issues), *Annual Reports of the Board of Managers of the Lehigh Coal and Navigation Company* (1831–1885), and Jones (1908).

To arrive at pre-1840 totals, I multiplied my revised Pennsylvania-to-national trend from Figure D1 to an extended annual series on Pennsylvania pig iron production (see Table D1, column [4]). Pennsylvania output is based partially on existing state estimates. Missing observations, however, have been interpolated on pig iron shipments from the Lehigh and Schuylkill iron districts. While this approach undoubtedly introduces a degree of measurement error, Figure D2 shows that trends between the two series are highly correlated and display similar turning points. This should not be surprising,

³⁸ Auxiliary data in Lesley (1859), Grosvenor (1871, 192), and Paskoff (1983) support this claim. Records of charcoal-

given that the regions' shipments accounted for the bulk of pig iron arriving in Philadelphia. The Schuylkill and Lehigh Canals opened in the early 1820s and forwarded pig iron from eastern Pennsylvania furnaces toward a legion of Philadelphia forgeries and wrought ironworks.

The Pennsylvania series, coupled with the revised ratio curve, provide the basis for the national estimates. The extended series is listed in column [6] of Table D1. Several features of the U.S. iron estimates should be noted. Most importantly, the series validates the despondent views held by furnace owners following the recessions in 1837 and 1839. Furthermore, the extended pig iron series revises Fogel's earliest estimates from 1840 through 1843.

The most significant change from Fogel's series involves the quantity produced in 1842. The revision results from discarding Carey's pro-tariff (and subjective) U.S. estimate and instead inflating Reeves's 1842 Harrisburg tabulations to national levels. My only logical explanation of why Fogel accepts the 1841 Pennsylvania figure but excludes the 1842 observation is that Fogel, like Carey, wished to illustrate the industry's depression in his post-1840 series.

In straining to defend Carey's figure, Fogel argues that the 1842 protectionist Harrisburg convention is in itself evidence that production was depressed. This is a valid point, but depressed since when? Iron masters certainly must have been concerned that 1841 production had fallen more than one-third below the levels attained before the late 1830s. More compelling quantitative evidence points to a rebound in the iron industry by 1842 in lockstep with other broad sectors of the U.S. economy. More anecdotally, contemporary observers talked of forges increasing supply in anticipation of improved market conditions following the enactment of the tariff on imported iron (Grosvenor 1871; Paskoff 1989, xvii). Yet perhaps the most convincing reason why the Fogel-Carey estimate is

furnace construction indicate that new Pennsylvania iron capacity lagged additions elsewhere until the mid-1830s.

untenable is that it implies Pennsylvania accounted for nearly *two-thirds* of U.S output in 1842 but only *one-third* the previous year.³⁹ This change is simply implausible.

³⁹ Fogel also struggled to explain his increase in production for 1843. The revised series displays a slight drop in output that year.

TECHNICAL APPENDIX D1 (p. 1 only)

APPENDIX TABLE D1 – continued

- [1] AISA data obtained from its *Annual Report* (AISI 1918, 9–10) and *Historical Statistics* series M–217. Beginning in 1854 the AISA series represents actual production compiled from its industry-wide surveys and is commonly regarded as *de facto* benchmarks. AISA and *Historical Statistics* adopted earlier figures from census returns and secondary sources. Figures from 1828 through 1830 were initially gathered by the 1831 Philadelphia free trade convention. The New York Friends of Domestic Industry (1832), a protectionist trade group, accepted the convention's estimates for 1828 and 1829, but provided revised figures thereafter to demonstrate the impact of the Tariff of 1828. AISA adopted Carey's (1872, 11) subjective pro-tariff extrapolations for 1842 and from 1847–49, but dismissed his 1840 figure.
- [2] Quantities reflect estimates Temin (1964, 264–65, table C.1) deems "reliable" based upon his discussion in appendix A (see especially pp. 233–45). Temin notes that the adopted AISA figures from 1828–30 are inaccurate in that they include the pig iron equivalent of wrought iron production; Pearse (1876, 278) reports the appropriate figures. The correct 1830 estimate (180,000 gross tons) was amended in the Friends of Domestic Industry pamphlet and is superior to the plagued McLane Report (Paskoff 1989, xxix). However, Temin nullifies Pearse's estimates for 1831 and 1832: Pearse's 1831 figure is an erroneous compilation of Carey's 1830 estimate, while the 1832 figure is simply an extrapolation. He disregards Carey's estimated range (215,000 – 230,000 gross tons) for 1842 since Carey extrapolated downward U.S. output from defective Sixth Census returns to conform to his belief that the iron industry was severely depressed. Similarly, Temin contends that an appropriate interpretation of the 1846–49 AISA–Carey data lies between Carey's pro-tariff figures (upper bound) and Grosvenor's (1871) opposing pro-trade estimates (lower bound). For a concise series comparison, see Fogel (1964, 154, table 5.1).
- [3] Fogel (1964, 166, table 5.6) provides an alternative set of U.S. estimates from 1840 through 1853. Fogel fits a second-order time through observed U.S.-to-Pennsylvania ratios reported for 1839/40 (Sixth Census), 1844 (Home League), 1849/50 (Seventh Census), and for 1854–1856 (AISA surveys, from Lesley (1859, 750)). Fogel accepts Pennsylvania estimates for 1841 from the *Philadelphia Commercial List* and for 1844 from the Home League survey. Calendar-year figures for 1849 and 1850 were derived from Seventh Census returns and shared according to data collected by the Philadelphia convention of iron masters (Smith 1851, 576–77). Fogel provides new estimates of Pennsylvania output for the years 1845–47 based upon the Philadelphia convention data and his assumption of 50-percent utilization of new furnace construction (see p. 162, table 5.4 for the derivations). Fogel adopts the Home League's 1840 estimate to replace the understated census figure. Fogel ostensibly accepts the upper bound of Carey's 1842 figure to reflect depressed conditions in the iron industry, thereby effectively endorsing Carey's subjective method. Fogel linearly interpolated the remaining missing values (1843, 1848) on adjacent U.S. estimates.
- [4] Bold figures refer to existing estimates from previous surveys or research. Quantities for 1841, 1844, 1845, 1846, 1847, 1849, and 1850 agree with Fogel (see [3]). Pennsylvania's 1842 estimate is based on a furnace survey conducted by the state's Coal and Iron Association, which held a convention of iron masters in Harrisburg. Since the response rate to the Harrisburg circular was low (only 79 of the 210 known furnaces responded), estimates issued separately by two of the association's members vary, based on the productivity assumptions made for the excluded establishments. Both estimates assume that average productivity at unreturned furnaces was below average, contending that such establishments were of "inferior class" and were often operated on a part-time basis. Childs (*Hunt's Merchants' Magazine* 1847, 587) placed 1842 output at 194,580 gross tons. Reeves (U.S. Congress, Senate 1849, 809) calculated production at 151,885 tons in a letter to William Meredith. The latter figure has been accepted based on the discussion in Temin (1964, 237–38) and Paskoff (1983, 75, table 20; note that Paskoff incorrectly assigns Childs's 1842 Harrisburg estimate to 1840) and should therefore be interpreted as a lower bound for total output. Fogel's implication for 1842 Pennsylvania output is untenable: returned firms alone produced 84,885 gross tons of pig iron that year, and Reeves's lower bound would imply Pennsylvania accounted for two-thirds of U.S. production as expressed by the Carey–Fogel estimate. Pennsylvania counts for 1828 and 1830 originate from surveys conducted by the 1831 Philadelphia convention. According to returned schedules, Pennsylvania pig iron production was 28,515 gross tons in 1828 (24,822 tons pig iron + 3,693 tons of direct castings) and 36,562 gross tons in 1830 (31,056 + 5,506), as summarized in Childs (1847, 584–85) and Paskoff (1983, 75, table 20; note Paskoff's 1830 figure erroneously omits castings). Philadelphia convention members arrived at national estimates (see [2]) for these years by assigning mean output at the unreturned furnaces the average of those returned. This approach, however, significantly understates aggregate Pennsylvania output, as there was an obvious *regional bias* in completed schedules. Specifically, 44 of the 63 furnaces responding in 1828 and 45 of the 73 in 1830 were located in Pennsylvania, while a disproportionate number of unreturned circulars pertained to more distant establishments, who presumably did not make the longer trip to Philadelphia (Smith 1847; Paskoff 1983). This

hypothesis is bolstered by the fact that the 19 out-of-state returns in 1828 were predominantly located in nearby states (11 in New Jersey; 5 in Maryland; 2 in Virginia; and 1 in Delaware). The convention noted that of the 129 furnaces unreturned in 1830, many were located in states completely un-represented in the survey, including all of New England, Tennessee, New York and Ohio. These states possessed a significant number of charcoal furnaces. While the over-representation of Pennsylvania firms in the Philadelphia survey does not affect the national totals, it surely biases downward the share of output attributable to Pennsylvania (PA output was not inflated by the committee). Failing to account for this survey bias would lead to a spuriously low PA-to-US trend (see Figure D1) and would thus overstate U.S. iron output during the 1830s. I have attempted to correct for this regional response bias by accessing additional data on furnace counts at the state level as a mechanism to properly inflate Pennsylvania output in 1828 and 1830. The number of operational furnaces was compiled from information in Lesley (1859), Smith (1851), "Documents relating to the manufacture of iron in Pennsylvania," (*Journal of the Franklin Institute* 1851), Swank (1878, 1892), Bining ([1938] 1973), and Paskoff (1983). Pennsylvania output was then imputed from the underlying weighted average of Pennsylvania and out-of-state returns, adjusted to reflect the number of additional unreturned Pennsylvania furnaces in the inflated totals. Pennsylvania's revised output share was checked against non-Pennsylvania furnace data from existing case studies and federal and state censuses. The procedure appropriately revises downward the survey's share of Pennsylvania furnaces in 1828 from 70 percent (*reported, unadjusted, non-inflated*) to 36 percent (*adjusted, inflated*). The latter share is more consistent with the ratio of Pennsylvania iron furnaces reported in the broader 1810, 1832, and 1840 national canvasses. The revised state furnace shares were subsequently used to arrive at Pennsylvania estimates in [4] based on the 1828 and 1830 U.S. estimates discussed in [2]. Note that changes in Pennsylvania output between 1828 and 1830 accord well with increases in new charcoal furnace capacity constructed in the state over this period (Smith 1851). Non-bold state figures have been interpolated on pig iron shipments descending from the Lehigh and Schuylkill iron districts, home to the major anthracite coal deposits in eastern Pennsylvania.

- [5] Bolded quantities reflect U.S. estimates adopted from columns [1]–[4]. All other figures follow from Fogel's methodology of inflating Pennsylvania estimates in [4], but using the revised Pennsylvania-to-U.S. ratio trend. See the text of Technical Appendix B for motivation.
- [6] Bolded quantities reflect U.S. estimates adopted from columns [1]–[4]. Observations from 1844 through 1853 reflect the Fogel series since differences between [3] and [5] are negligible. Note, however, that the revised estimates from 1845–48 validate Fogel's (1964, 163) concern that his figures for those years "may be low." Differences in 1840 and 1843 reflect additional information from the Pennsylvania series [4] and slight discrepancies in the revised trend equation. The difference in 1841 is trivial and solely reflects revised trend values in Figure D1. The difference in 1842 results from discarding the Carey–Fogel estimate and instead inflating Reeves's Harrisburg tabulations in [4] to national levels.
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APPENDIX TABLE D2

**PENNSYLVANIA'S SHARE OF THE U.S. PIG IRON INDUSTRY
CORRESPONDS WITH STRUCTURAL CHANGES IN FUEL TECHNOLOGY**

Year	PA % of U.S. pig iron output	U.S. pig iron production, by fuel (%)			
		Charcoal	Anthracite coal	Bituminous coal & coke	
	[1]	[2]	[3]	[4]	
1830	34.3	falls	100.0	-	-
1831	34.2		100.0	-	-
1832	34.1		100.0	-	-
1833	34.1	* <i>nadir</i>	100.0	-	-
1834	34.2		100.0	-	-
1835	34.4		100.0	-	-
1836	34.8	<i>rises</i>	98.2	1.5	0.3
1837	35.3	<i>sharply</i>	96.4	3.1	0.5
1838	35.9		94.6	4.6	0.8
1839	36.7		92.8	6.1	1.1
1840	37.6		91.0	7.6	1.4
1841	38.6		87.7	10.5	1.8
1842	39.8		84.3	13.4	2.2
1843	41.9		81.0	16.4	2.6
1844	43.5		77.7	19.4	2.9
1845	44.1		74.3	22.4	3.2
1846	45.7		71.0	25.4	3.6
1847	47.3		68.0	28.3	3.7
1848	48.7		65.0	30.7	4.3
1849	50.0		62.1	33.0	4.9
1850	51.2		59.1	35.3	5.6
1851	50.3		56.1	38.5	5.5
1852	52.0		53.0	41.2	5.8
1853	53.6		49.7	43.5	6.8
1854	49.9	<i>AISA</i>	46.5	46.1	7.4
1855	54.0	<i>AISA</i>	43.3	48.7	8.0
1856	55.2	<i>AISA</i>	41.9	50.2	7.9

Sources [1] See table D1. [2]-[4] From 1854, fuel-distribution statistics are provided in *AISA Annual Reports*.

& notes: Earlier values have been prorated on Eavenson's (1942) anthracite and bituminous coal output shares from charcoal data provided in Bull (1882), Debow (1854), French (1858), Paskoff (1989, xxxv, table A.1), Pearse (1876), Schallenberg (1975), Swank (1878, 1892), and Temin (1964, 266-7, table C.2). Missing observations have been linearly interpolated. The smelting of pig iron by mineral fuel commenced shortly after the successful adaptation of British puddling techniques to the hot-blast furnace. Anthracite smelting reportedly occurred at the Schuylkill (PA) Furnace in 1836; bituminous coke was employed shortly thereafter in Fayette County (Swank 1878, 1892).

Technical Data Appendix E

Index value-added weights

Tables E1 and E2 document the derivation of the value-added weights assigned to the index components. Value added is defined as the difference between gross product and the costs of raw materials consumed in production. By convention, two or more series within an industry were proportionally distributed two-digit SIC totals. Value-added weights in the final column of Table E1 are those employed in compiling the fixed 1850-base index. Table E2 component weights are presented in order of their 1850 rankings. Starred (*) entries designate industries that emerged after the 1850 Census.

APPENDIX TABLE E1
U.S. INDUSTRIAL PRODUCTION INDEX: VALUE-ADDED WEIGHTS, 1850

Major industry groups [2-digit S.I.C. code] <i>Seventh Census industry classifications</i> Individual quantity-based components	Value added, 1849/50 <i>(Unit: \$M)</i>	Index weights <i>(percentage basis)</i>	
	Industry groups	Industry groups	Individual series
I - Chemical & Fuel Products [11, 12, 14; 28, 29]	26.00	6.36	
<i>Coal mining</i>	8.52	3.62	
Anthracite coal			2.39
Bituminous coal			1.24
<i>Oil, whale; chandlers (soap, candles)</i>	3.89 ^{a, b}	1.65	
Sperm oil refining			0.87 ^b
Whale oil refining			0.78 ^b
<i>Salt and salt refining</i>	1.13	0.48	
Salt production			0.48
<i>Powder, gun; shot</i>	0.96 ^a	0.41	
Gunpowder and explosives			0.41
<i>Dyers</i>	0.33	0.14	
Dyeing chemicals			0.14
<i>Whalebone</i>	0.13	0.05	
Whalebone processing			0.05
II - Ordnance & Accessories [19]	1.40	0.34	
<i>Guns; U.S. armories; military equipment</i>	1.24 ^a		0.34 ^{c, d}
Firearms from private & government armories			
III - Food & Kindred Products [20]	44.45	10.87	
<i>Flour and grist mills</i>	23.02	8.23	
Milled wheat flour			8.23
<i>Sugar refiners; confectioners</i>	3.58 ^a	1.28	
Refined sugar consumption			1.28
<i>Pork and beef packing</i>	3.28 ^e	1.17	
Hog packing			0.81 ^e
Beef packing			0.36 ^e
<i>Fish curing and packing</i>	0.27 ^f	0.10	
Salted mackerel			0.10
<i>Rice mills</i>	0.25	0.09	
Cleaned rice			0.09
IV - Textiles & Textile Products [22, 23]	89.13^g	21.80	
<i>Cotton and wool products (grouped)</i>	87.78 ^g	21.47	
Cotton consumption			21.47
<i>Hosiery</i>	0.61	0.15	
Wool stockings, U.S. military			0.15
<i>Regalias; fringe, gimp, and tassels</i>	0.38 ^a	0.09	
Mixed cloth regalia (cotton, silk, wool)			0.09
<i>Sewing silk; silk cloth</i>	0.37 ^a	0.09	
Raw silk imports			0.09

Continued on following page.

APPENDIX TABLE E1 - *Continued*

Major industry groups [2-digit S.I.C. code]	Value added, 1849/50	Index weights	
	(Unit: \$M)	(percentage basis)	
<i>Seventh Census industry classifications</i> Individual quantity-based components	Industry groups	Industry groups	Individual series
V - Lumber & Wood Products [24]	51.37 ^h	12.57	
<i>Lumber, sawing and planing</i>	30.93		
Lumber shipments			12.57 ^c
VI - Printing, Publishing, & Paper Products [26, 27]	32.92	8.05	
<i>Printers and publishers</i>	24.80 ⁱ		
Daily newspapers in circulation			8.05 ^c
VII - Leather & Leather Products [31]	53.62	13.12	
<i>Boots and shoes; leather belting; etc.</i>	32.20 ^a	8.98	
Sole leather receipts			8.95 ^j
Boots and shoes, U.S. troops			0.03 ^j
<i>Tanners and curriers</i>	14.84	4.14	
Dry and green hide receipts			4.14
VIII - Metals & Metal Products [33, 34; 10]	52.87 ^k	12.93	
<i>Iron forges; iron foundries; iron mining; etc.</i>	29.04 ^a	8.13	
Pig iron production			8.13
<i>Gold mining</i>	9.49	2.66	
Gold, mine output			2.66
<i>Tin and sheet iron works</i>	4.63	1.30	
Unprocessed tin imports			1.30
<i>Copper and brass</i>	1.88	0.53	
Copper, gross consumption			0.47
Copper, smelter production			0.06
<i>Lead; lead pipe</i>	0.74 ^a	0.21	
Lead smelting, refining			0.21
<i>Die sinkers; engravers</i>	0.44	0.12	
Coinage			0.12
IX - Transport Equipment & Machinery [35, 36, 37]	53.55	13.10	
<i>Shipbuilding and boats; etc.</i>	10.29 ^a	6.55	
Merchant ships & yachts			5.40 ^l
U.S. Navy vessels, navy & private shipyards			1.15 ^l
<i>Locomotives; cars, railroad; etc.</i>	5.69 ^{a, m}	3.62	
Steam locomotives			3.62
<i>Agricultural implements</i>	4.40	2.80	
Reaping & harvesting machinery; steel plows			2.80
<i>Fire engines; fire hose; hose, riveted</i>	0.20 ^a	0.13	
Hand fire engines			0.13
X - Musical & Scientific Instruments [38, 39]	3.49 ⁿ	0.85	
<i>Musical instruments</i>	1.88 ⁿ	0.66	
Pipe organs			0.66
<i>Mathematical instruments</i>	0.54	0.19	
Telescopes			0.19

Continued on following page.

APPENDIX TABLE E1 - *Continued*

Total U.S. industrial value added, 1849/50	463.5	^o	
Industries directly represented	307.7	<i>Direct share</i>	66.4
Industries directly & indirectly represented	408.8	<i>Indirect share</i>	88.2

Sources: U.S. Department of State 1841; U.S. Department of the Interior 1858, 137-43, "General Summary;" U.S. Census Office 1902b; U.S. Bureau of the Budget 1945; Gallman 1956, 219, table 22, 245-46, table 25, 247-48, table 26, 280, table 34, 355, table 59, 357-58, table 61; Gallman 1960, 54-55, table A-4, 59, table A-7; Gallman 1966, 46-47, table A-7; worksheets in Robert E. Gallman papers [n.d.]; and author's calculations.

- ^a Sum of multiple industry returns, as delineated by semi-colon (;). Leather value added includes returns for *patent leather* and *morocco dressers*. Shipbuilding include *sails, masts and spars, oakum, oakum pickers, and oars* for consistency with postbellum census designations. Pig iron is assigned value added in *iron forges, iron foundries, iron furnaces, iron mining, iron manufactures, iron rolling, nails, steel furnaces, and steel works*.
- ^b Computed from census returns for *oil, whale* and *chandlers*, where latter value added has been assigned whale oil's share in whale and animal oils (*oil, lard*). Percentage weights have been prorated on the basis of gross output derived from New Bedford unrefined oil prices (Davis, Gallman, and Gleiter 1997, 353-54, table 9.6, 370-75, tables 9A.1-2). Calendar-year 1849 and 1850 aggregates have been converted by geometric mean to a census-year equivalent.
- ^c Individual series assigned value added of industry group.
- ^d Private and government ordnance remained a distinct manufacturing classification until 1972, when ordnance was redistributed between two durable manufacturing industries (U.S. Board of Governors 1986, 9, 25-26, 159).
- ^e Value added adjusted from calculations in Walsh (1982, 109-11) to account for underenumeration in pork packing. Weights prorated between pork and beef slaughtering based upon total value delineated in 1880 U.S. Census.
- ^f Industry not returned in 1850; Gallman's (1956, 245-6, table 25) estimate derived from census returns for *fisheries*.
- ^g Industry value added includes all textile products and apparel. Weighting for cotton consumption derived through subtraction so as to not overstate the relative importance of minor apparel items.
- ^h Excludes furniture.
- ⁱ Undercounted returns for periodical press adjusted upwards by \$18.16 million (Gallman 1956, 245-46, table 25).
- ^j Value added assigned to U.S. Army boots and shoes prorated on the basis of gross product and subtracted from Seventh Census returns for *boots and shoes*.
- ^k Sum of related manufacturing and mining industries reported separately in Gallman (1956, 355, table 59), save for *gold mining* which comes from the Seventh Census (U.S. Department of the Interior 1858, 139). *Metals and metal products* exclude ordnance, machinery, transportation equipment, and agricultural implements. Mining industries include *iron, copper, lead, zinc, and mercury* ("metals"). Zinc, however, was not returned until the 1860 Census.
- ^l Value added between merchant and naval shipbuilding has been prorated on returns of the Twelfth Census (U.S. Census Office 1902b) since segregation is not permissible from earlier surveys.
- ^m Value added derived from returns for locomotives, railroad cars, and 25.45% of *machinists and millwrights* (locomotive makers as well as steam railroad company shops were underenumerated). Cited percentage represents output share of transportation-equipment industry purchased by steam railroads before the Civil War (Fogel 1964, 140, table 4.10, 145, table 4.12)
- ⁿ Musical instruments technically should be classified in *miscellaneous industries* (SIC 39). Here, Seventh Census returns for musical instruments are merged with Gallman's figure for scientific and professional instruments since allocating musical instruments the value added of all miscellaneous industries would be inappropriate.
- ^o Sum of value added in manufacturing and mining industries for census year 1849/50, as adjusted by Gallman (1956, 219, table 22, 245-46, table 25, 247-48, table 26, 280, table 34, 355, table 59, 357-58, table 61; 1960, 44, 54-55, table A-4, 59, table A-7; 1966, 46-47, table A-7).

APPENDIX TABLE E2
U.S. INDUSTRIAL PRODUCTION INDEX: VALUE-ADDED WEIGHTS, 1880

Major industry groups [2-digit S.I.C. code] <i>Tenth Census industry classifications</i> Individual quantity-based components	Value added, 1879/80 <i>(Unit: \$M)</i>	Index weights <i>(percentage basis)</i>	
	Industry groups	Industry groups	Individual series
I - Chemical & Fuel Products [11, 12, 14; 28, 29]	205.47	11.02	
<i>Coal mining</i>	84.16	8.26	
Anthracite coal			3.48
Bituminous coal			4.78
<i>Oil, illuminating; soap and candles</i>	1.10 ^{a, b}	0.11	
Sperm oil refining			0.08 ^b
Whale oil refining			0.03 ^b
<i>Salt; salt, ground</i>	2.84 ^a	0.28	
Salt production			0.28
<i>Gunpowder; high explosives; ammunition</i>	3.21 ^a	0.32	
Gunpowder and explosives			0.32
<i>Dyestuffs and extracts</i>	1.33	0.13	
Dyeing chemicals			0.13
<i>Whalebone and rattan</i>	0.16	0.02	
Whalebone processing			0.02
* <i>Petroleum refining</i>	19.38 ^c	1.90	
* Crude petroleum			1.90
II - Ordnance & Accessories [19]	4.56	0.24	
<i>Fire-arms</i>	3.88		0.24 ^a
Firearms from private & government armories			
III - Food & Kindred Products [20]	244.75	13.12	
<i>Flouring- and grist-mill products</i>	63.64	6.86	
Milled wheat flour			6.86
<i>Sugar & molasses, refined & beet; confectionery</i>	19.39 ^a	2.09	
Refined sugar consumption			2.09
<i>Slaughtering and meat-packing</i>	35.82	3.86	
Hog packing			2.66
Beef packing			1.20
<i>Fish curing and packing</i>	2.38 ^c	0.26	
Salted mackerel			0.26
<i>Rice cleaning and polishing</i>	0.47	0.05	
Cleaned rice			0.05
IV - Textiles & Textile Products [22, 23]	399.21^e	21.40	
<i>Cotton and wool products (grouped)</i>	373.54 ^e	20.03	
Cotton consumption			20.03
<i>Hosiery and knit goods</i>	6.71 ^e	0.36	
Wool stockings, U.S. military			0.36
<i>Regalia and society banners and emblems</i>	1.14 ^f	0.06	
Mixed cloth regalia (cotton, silk, wool)			0.06
<i>Silk and silk goods</i>	17.82 ^f	0.96	
Raw silk imports			0.96

Continued on following page.

APPENDIX TABLE E2 - *Continued*

Major industry groups [2-digit S.I.C. code] <i>Tenth Census industry classifications</i> Individual quantity-based components	Value added, 1879/80 <i>(Unit: \$M)</i>	Index weights <i>(percentage basis)</i>	
	Industry groups	Industry groups	Individual series
V - Lumber & Wood Products [24]	165.71 g	8.88	
<i>Lumber, sawed; lumber, planed</i>	99.44 a		
Lumber shipments			8.88 d
VI - Printing, Publishing, & Paper Products [26, 27]	168.64	9.04	
<i>Printing and publishing</i>	116.80 h		
Daily newspapers in circulation			9.04 d
VII - Leather & Leather Products [31]	150.02	8.04	
<i>Boot and shoe, factory; etc.</i>	68.70 a	5.11	
Sole leather receipts			5.10 i
Boots and shoes, U.S. troops			0.01 i
<i>Leather, curried; leather, tanned</i>	39.44 a	2.93	
Dry and green hide receipts			2.93
VIII - Metals & Metal Products [33, 34; 10]	243.85 j	13.07	
<i>Iron and steel; iron forgings; etc.</i>	118.61 a	8.95	
Pig iron production			7.33 k
* Bessemer and open-hearth steel			1.61 k
<i>Gold mining</i>	8.12 j	0.61	
Gold, mine output			0.61
<i>Tinware, copperware, and sheet-iron ware</i>	22.86	1.72	
Unprocessed tin imports			1.72
<i>Brass and copper, rolled; etc.</i>	17.13 a	1.29	
Copper, gross consumption			0.85
Copper, smelter production			0.44
* <i>Zinc; lead, bar, pipe, sheet, and shot; etc.</i>	4.46 a	0.43	
Lead smelting, refining			0.26 j
* Zinc, smelter production			0.17 j
<i>Engraving and die-sinking</i>	0.92	0.07	
Coinage			0.07
IX - Transport Equipment & Machinery [35, 36, 37]	261.55	14.02	
<i>Shipbuilding and boats</i>	20.71	3.28	
Merchant ships & yachts			2.70 l
U.S. Navy vessels, navy & private shipyards			0.58 l
<i>Cars, railroad, street, and repairs; etc.</i>	29.71 a, m	4.71	
Steam locomotives			4.71
<i>Agricultural implements</i>	37.11	5.88	
Reaping & harvesting machinery; steel plows			5.88
<i>Fire extinguishers, chemical; racking hose; etc.</i>	1.00 a, n	0.16	
Hand fire engines			0.01 n
* Steam fire engines			0.15 n
X - Musical & Scientific Instruments [38, 39]	21.56	1.16	
<i>Musical instruments, organs and materials; etc.</i>	10.89 a	0.77	
Pipe organs			0.77

Continued on following page.

APPENDIX TABLE E2 - *Continued*

<i>Instruments, professional and scientific</i>	1.19	0.08	
Telescopes			0.08
* <i>Watches; watch cases; watch materials</i>	4.24 ^a	0.30	
* Pocket watches			0.30
Total U.S. industrial value added, 1879/80	2,115.1		
Industries directly represented	1,237.0	<i>Direct share</i>	58.5
Industries directly & indirectly represented	1,865.3	<i>Indirect share</i>	88.2

Sources: U.S. Department of the Interior, Census Office 1883a, 9-14, table II; 15-87, table III; 446-65, table VII; U.S. Department of the Interior, Census Office 1872b, 394-98, table VIII(B); and sources in Appendix Table E1.

- ^a Sum of multiple census returns, as delineated by semi-colon (;). Value added in boots and shoes includes returns for *boot and shoe, factory only* (excludes custom work and repairing); *boot and shoe cut stock*; *boot and shoe findings*; *belting and hose, leather*; *leather goods*; *leather, patent and enameled*; and *bellows*. Pig iron has been assigned value added in *iron and steel*; *iron bolts, nuts, washers, and rivets*; *iron forgings*; *iron nails and spikes, cut and wrought*; *iron pipe, wrought*; and *iron railing, wrought*. Copper consumption includes value added for *brass castings, brass ware, bronze castings, and coppersmithing*.
- ^b Weights for sperm and whale oil prorated on 1879/80 gross product as spelled out in Table E1.
- ^c Gallman's (1956, 245-46, table 25) value-added estimates derived from special reports of Tenth Census.
- ^d Individual series assigned value added of industry group.
- ^e Industry value added includes all textile products and apparel. Weighting for cotton consumption derived through subtraction of other three component weights. Value added for *hosiery and knit goods* adjusted on share (48%) attributable to *woolen and mixed half-hose and hose*, because 1850 returns for the manufacturing of hosiery omit other knit products (*shirts, drawers*, etc).
- ^f Cloth regalia assigned share (4.0%) of silk finished goods attributable to *upholstery and military trimmings* on the basis of net product. See Special Agent Wyckoff's "Report on the Silk Manufacturing Industry of the United States" in Part III of the 1880 Census of Manufactures (U.S. Department of the Interior, Census Office 1883a, 26)
- ^g Excludes furniture.
- ^h Undercount for periodical press adjusted upwards by \$58.48 million (Gallman 1956, 245-46, table 25).
- ⁱ Value added assigned to U.S. Army boots and shoes prorated on the basis of gross product and subtracted from Tenth Census returns for *boots and shoes*.
- ^j Sum of related manufacturing and mining industries reported separately in Gallman (1956, 355, table 59), save for *gold mining*, which was prorated on basis of gross product. *Metals and metal products* exclude ordnance, machinery, transportation equipment, and agricultural implements. Mining industries include *iron, copper, mercury, lead* and *zinc*. Since mining returns in the latter two industries were merged in 1880, their share value added in mineral operations has been prorated on the basis of Gallman's 1874/75 worksheet estimates of gross product.
- ^k Value-added share for Bessemer and open-hearth steel derived from Swank's detailed report on *iron and steel* returns in the Tenth Census (1883a, 756-58, table III)
- ^l Value added in naval shipbuilding has been inflated on the percentages derived in table 1 since Tenth Census returns exclude "operations of the various navy-yards of the U.S." (U.S. Department of the Interior, Census Office 1883a, 1).
- ^m Value added consists of 1880 census returns for *cars, railroad, street, and repairs, not including establishments operated by steam RR companies; steam fittings and heating apparatus; springs, steel, car, and carriage*; and Gallman's worksheet estimate for steam railroad company shops (\$17.913 million).
- ⁿ Tenth Census returns predominantly classified fire engines under the broad category of *foundry and machine-shop products*. Consequently, value added for two minor industries above was supplemented by prorating 1870 returns for: *machinery, fire engines; machinery, steam engines and boilers; machinery (not specified); iron castings (not specified)*. The resulting share (< 1.0%) was prorated between hand and steam fire engines based on relative 1879/80 output.

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