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AN ANNUAL INDEX OF U. S. INDUSTRIAL PRODUCTION, 1790–1915*

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As a remedy for the notorious deficiency of pre-Civil War U. S. macroeconomic data, this study introduces an annual index of American industrial production consistently defined from 1790 until World War I. The index incorporates 43 quantity-based annual series (most entirely new) in the manufacturing and mining industries in a manner similar to the Federal Reserve Board's monthly industrial production index. The index changes our view of the growth and volatility of the U. S. economy before World War I. A direct implication of the index is that antebellum-postbellum differences in industrial volatility are statistically indistinguishable. The index also demonstrates that the pernicious deflationary depressions that purportedly followed the financial panics in 1837 and 1873 were actually rather mild recessions when expressed in real output.

I. INTRODUCTION

Reliable data are an indispensable tool in accurately evaluating the evolution of an economy. In reality, economic historians, much like archeologists, are routinely forced to interpret past events from the statistical artifacts at hand. Since contemporary federal agencies and private organizations infrequently collected

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economic statistics, definitive facts on the historical growth and fluctuations of the early U. S. economy are scarce. Existing benchmark estimates of national income back to 1790 are very questionable and difficult to evaluate, prompting David [1967] to aptly coin the first half of the nineteenth century America's "statistical dark age."

Annual estimates of U. S. economic activity going back that far are even less reliable. Currently, macroeconomists have access to two annual output series for the pre-Civil War period: Robert Gallman's unpublished annual estimates for the 1834–1859 period compiled in the 1960s, and Berry's [1988] real GNP series from 1789. Gallman was never sufficiently confident of the reliability of his annual estimates to publish them, and chastised researchers who attempted to use them in an analysis of early American business cycles.[1] Berry employed regression analysis on a hodge-podge of industrial, financial, and price data in order to estimate annual real GDP for the 1789–1889 period. However, researchers (e.g., Engerman and Gallman [1983] and Rhode [2002]) have dismissed Berry's series as far removed from reality. The primary reason is that Berry's final data are an ad hoc average of select extrapolations drawn from hundreds of overlapping regression back-casts that ultimately rest on a sparse set of price indexes and nominal aggregates. In short, the vast majority of economic historians regard neither the Berry nor Gallman series to be of sufficient quality to confidently infer the historical evolution of the early American economy. Quite frankly, constructing a trustworthy U. S. GDP series is simply impossible before the Civil War owing to the comparative deficiency of annual data on agriculture, merchant and wholesale trades, and service industries. As it stands, researchers of historical U. S. business-cycle fluctuations today face essentially the same data constraints as those who studied these same phenomena more than a generation ago.

This study aims to fill this statistical void by building an annual output measure that consistently spans the entire pre-World War I economy. The paper begins by discussing the methodology and component data employed to construct the new index

1. See Rhode [2002] for Gallman's data. Rhode [p. 12] points out that a 1963 mimeograph from Robert Gallman containing the annual data circulated with the following disclaimer: "NOTE: These figures should not be regarded as reliable, annual estimates. They were derived for the purpose of computing decade averages and are supplied to interested technicians for testing, not for analysis as annual series."

in Section II. Specifically, the paper assembles an annual measure analogous in methodology and interpretation to the Federal Reserve Board's monthly industrial production index. In doing so, I have collected annual physical-volume data on 43 manufacturing and mining industries. The paper's quantity-based sample is quite comprehensive in the sense that its components indirectly represent close to 90 percent of the value added produced by the U. S. industrial sector during the nineteenth century.

Section III then considers some implications of the new index. Since our knowledge of American production before (and, indeed, after) the Civil War is severely limited, this new annual index of industrial production may give researchers new insights into old questions, and should even allow new questions to be answered. For one, is the conventional wisdom surrounding the pace of secular development of early American industry accurate? When did American industrial productivity take off and catch up to its European counterparts? Were business contractions in early America as severe as portrayed by contemporary observers? Did business-cycle volatility differ fundamentally before and after the Civil War? Are the early business cycle dates set down long ago by the National Bureau of Economic Research (NBER) realistic? Answers to these latter questions, in particular, gain additional relevance in light of the growing literature regarding the structural break in U. S. economic volatility since the mid-1980s (e.g., McConnell and Quiros [2000] and Stock and Watson [2002]). Section III addresses some of these questions, and Section IV concludes the paper. A Data Appendix briefly describes the sources and quality of the index components.

II. Data and Index Methodology

II.A. Overview

My new annual index of industrial production for the 1790–1915 period compares conceptually with the Federal Reserve Board's historical monthly industrial production index available since 1919. Both indexes attempt to measure the same fundamentals, namely the level of physical production in the nation's manufacturing and mining industries. Naturally, the primary attribute of an index of industrial production is that it is devoid of nominal data, so that changes in the index reflect purely fluctuations in real output. And of particular relevance for the nineteenth century, my index often captures not only the factory output of incorporated businesses, but also the wares manufactured by private businesses and "industrial" goods produced at home (say, under the putting-out contract system) for later sale on the open market.

Yet how should we interpret an index of industrial production for the early U. S. economy that could best be characterized as a largely agrarian emerging market? While it is true that more than one-half of national output in the antebellum United States was agricultural, I strongly maintain that the new index is appropriate to define the historical evolution of American growth and business cycles, if for no other reason than the fact that America's emergence as an economic power is commonly equated with its industrialization.

More generally, the new index should be broadly indicative of the nation's broader economic conditions because the industrial sector has historically derived demand directly from nonindustrial occupations, particularly farmers, merchants, and the construction trades. The processing of foodstuffs, the demand for agricultural machinery, and the capital equipment required to transport agricultural commodities to market are all intimately tied to farm output and the relative price of agricultural goods, even though agricultural production is often characterized as acyclical. Likewise, the state of the nineteenth-century shipbuilding industry was heavily dependent upon the health of the maritime trades. Indeed, the nonintercourse period following the Embargo of 1807 had a devastating impact on the nation's shipbuilding industry (see Irwin and Davis [2003]). Likewise, the manufacture of lumber products and transportation equipment were acutely sensitive to business conditions in the construction trades, the railroad industry, and inland transportation sectors. Indeed, such synchronous relationships between nonindustrial and industrial sectors is precisely why the NBER and others classify industrial production indexes as coincident indicators of cyclical turning points despite the precipitous drop in the share of the nation's labor force dedicated to industrial production. In short, an annual measure of manufactured and mined quantities should provide a much-needed metric of prewar American economic activity.

II.B. Component Series

I have assembled annual data on the physical output of 43 industries based on two principal criteria advocated by Romer [1991] and Calomiris and Hanes [1994]. First, any annual series employed had to pertain either directly to actual output, or to a related physical-quantity proxy. This first selection guideline eliminated annual indicators of general business or financial conditions not explicitly associated with genuine production. Although conveniently available before the Civil War, wholesale prices, equity prices, and other financial variables such as bank clearings have been entirely omitted from the index. The new index's exclusive focus on physical quantities stands in sharp contrast to various late-nineteenth-century "business condition" indexes, as well as to Berry's ad hoc national income estimates.

As a second selection criterion, raw source data had to be available annually for long stretches, in order to preserve index consistency and comparability over time. Specifically, I omitted existing products whose aggregate coverage did not run at least 30 years before and after the Civil War. The second rule excluded five products that were manufactured before the Civil War—most notably alcohol and tobacco products—but whose annual output data were only collected thereafter.[2] The 60-year cutoff was not arbitrary, but rather was set to avoid building an index whose reliability changed over time.

Panel B of Table I presents the share of index components that come from government and private sources. Familiar commodity series, such as lead or coal production, come from the *Historical Statistics of the United States* [U. S. Department of Commerce, Bureau of Census 1975]; henceforth, *Historical Statistics*. More than one-half of the quantity-based series, however, are novel in the sense that the data have previously been unavailable to researchers in an aggregate, user-friendly format. This study develops the quantity-based series from private sources such as published trade publications, unpublished company records, historical society collections, antiquarian research, firm studies, and private correspondence. Historical societies, in particular, proved a rich source of base data that have only recently emerged following the culmination of years of research by its members. Collectively, these secondary sources act as a historical surrogate for the various agencies that currently provide statistics to the Federal Reserve for inclusion in its monthly index.

New annual production series have been compiled for an array of final manufactured products, including fire engines, naval ships,

2. The five excluded annual series would contribute less than 5 percent to the present index, and would not meaningfully alter the index's cyclical properties for the postbellum era.

TABLE I
DATA QUALITY AND SOURCES FOR VARIOUS INDUSTRIAL PRODUCTION INDEXES

Production index	**New industrial production index**	**Frickey's annual manufacturing index**	**Federal Reserve's monthly G.17 index**
Data coverage	1790–1915	1860–1914	Since 1919
Panel A. Share (%) of index components pertaining to:			
Actual production	76.7	57.5	54.8
Indirect proxy	23.3	42.5	45.2
Panel B. Share (%) of index components obtained from:			
Government sources	39.5	72.5	75.0
Private sources	60.5	27.5	25.0

Sources: Author's calculations based on information in Frickey [1947], U. S. Board of Governors of the Federal Reserve System [1986, pp. 34–35, Tables 3.1 and 3.2] and Davis [2002].

Designations have been standardized to adhere to current Federal Reserve classifications. Series that represent a hybrid of official and secondary sources have been assigned to the source that contributes the majority of observations. Government sources include "official" data collected by national and state agencies. Private sources pertain to all other reporting bodies, including trade groups, individual companies, firm archives, and historical societies.

firearms, musical and scientific instruments, newspapers, watches, and minor apparel items. Furthermore, the data sets for locomotives, merchant ships, and pig iron extend or refine the conventional series currently available in *Historical Statistics.* The Data Appendix provides a brief description of the 43 index components; an unpublished companion Technical Data Appendix with considerably more detail is available from the author upon request.

My time series on U. S. locomotives in Figure I is a fine example of the reliability and comprehensiveness of the privately collected source data. I have successfully traced the year of construction for more than 120,000 engines by cross-referencing the rosters of thousands of railroad companies and locomotive builders, which have been meticulously assembled by various researchers over the past 80 years. Consequently, the present study's annual locomotive series is longer and more comprehensive than either Fishlow's [1965] unpublished antebellum locomotive series, or Burns's [1934] postbellum series.

The index also draws on largely ignored sources. Inspection records are a case in point. There is good reason to believe that inspection records were reasonably accurate, since it was in an authority's best interest to make them so. States mandated inspections on a wide array of manufactured wares not only to maintain product quality (thereby bolstering the area's reputa-

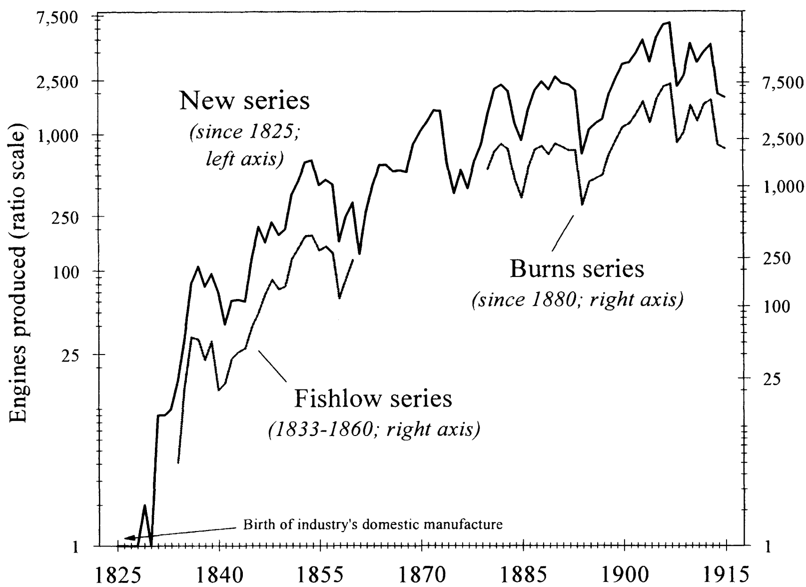

FIGURE I

U. S. Locomotive Construction—New and Old Data

Sources: See Davis [2002, 2004a].

Ratio scales have been offset for clarity.

tion in the trade), but also to ensure that they received the proper royalty payments. Because the State of New York collected royalties based on the quantity of salt produced by the hundreds of establishments that worked its leased Onondaga reservation, it is not surprising that state officials were inclined to maintain accurate inspection records. Although inspections often applied to localized production, states or cities typically established these regulatory systems precisely because of the industry's economic importance, with the result that local or state inspection records often accounted for a sizable share of national production. For example, officials in Massachusetts routinely inspected quantities of mackerel cured in its ports, and Massachusetts accounted for roughly 90 percent of the nation's salted mackerel output during the nineteenth century.

As they continue to do so today, local trade organizations and industry groups in the nineteenth century also tracked the physical movement of select manufactures to and from their cities. In most cases, the production and flow of manufactured items from multiple regions have been aggregated to gauge national output. The broadening of the regional data sets for lumber shipments (eleven series), flour receipts (four series), and hog packing (four series) parallels the nation's ongoing westward expansion and thereby explicitly incorporates profound spatial shifts in timber and farming.

Still, some production measures are not as comprehensive as one would like. For agricultural machinery and gunpowder, production at the dominant firms substitutes for industrywide output. Although these two series are inherently more susceptible to survivorship bias and idiosyncratic shocks, the approach is tenable due to the oligopolistic structure of the respective industries. By the early 1900s, DuPont and the International Harvester Corporation controlled over 80 percent of the powder and harvester markets, respectively, and both firms were eventually divested for antitrust violations. These and other data limitations are discussed in the Data Appendix at the end of the paper.

As shown in Panel A of Table I, approximately one-fourth of the components only indirectly represent production. In conventional output indexes, quantities of primary inputs substitute for the output of a manufactured good when suitable production data are unavailable. For instance, Miron and Romer [1990] infer the output of dressed beef from the head of cattle arriving at Chicago stockyards on grounds that cattle were slaughtered soon after receipt. Following this approach, my index uses the quantity of unprocessed oil returned by the U. S. whaling fleet to substitute for oil processing, since virtually all barrels of sperm and whale oil were immediately refined dockside. Similarly, the present index follows standard practice by using the quantity of raw cotton consumed as a surrogate for the production of cotton textiles. This substitution is necessary because quantities on more finished products (e.g., yarn or apparel) were not consistently reported for the 1800s. In fact, the Federal Reserve's monthly industrial production index continues to measure the output of cotton and wool fabrics by the quantity of fiber consumed.

Trade volume can also accurately reflect relative changes in domestic production when the imported commodity represents a primary, nonindigenous material. Researchers have routinely inferred the manufacture of silken goods from raw silk imports or coffee roasting from the importation of green coffee beans. Unfortunately, pre-1870 data on U. S. imports are tainted by breaks in fiscal-year definitions and often pertain only to imported values.[3]

3. The U. S. Treasury Department switched reporting trade statistics in 1843 from fiscal years ending September 30 to years ending June 30.

In the absence of reliable import deflators, imported quantities cannot be imputed with confidence. Moreover, many U. S. imports that were delineated in quantities before the Civil War were subject to tariffs, which is often the reason domestic officials tracked certain quantities in the first place.[4]

This paper circumvents these complications by consulting British custom records for three imported quantities: copper, silk, and tin. Trade statistics published for Great Britain's House of Commons in the *Sessional Papers* (a.k.a. the Parliamentary Papers) are attractive for the present study because the British data are available much earlier and are of higher quality vis-à-vis their American counterparts.

My approach may be illuminated by a more detailed consideration of implied copper and tin consumption. Consistently defined over the prewar era, Great Britain's customs records list the quantities of unwrought copper and unprocessed tin shipped from all British ports directly to the United States in both American and foreign vessels during the calendar year. In addition, the *Sessional Papers* are extremely detailed, delineating quantities by type of manufacture and by country to which exported. The detailed *Sessional Papers* allow me to measure the domestic manufacture of copper and tin products (e.g., pewter) by the transatlantic shipments of British and foreign unwrought copper and tin departing British ports for the United States. Indeed, these transatlantic flows accounted for nearly two-thirds of the unwrought ores imported by the United States during the nineteenth century, given the predominance of the Bristol, Cornwall, and Devon mines, and given the fact that London and Liverpool were the last ports-of-call before crossing the Atlantic Ocean.[5]

II.C. Component Weighting

To arrive at an index of industrial production, individual component series must be weighted by their relative importance. Federal census reports have historically provided such information in the form of an industry's value added, or the difference

4. Consider the case of coffee. Unroasted, or green, coffee beans imported by the United States were subject to duties before 1832. Coffee duties were lowered temporarily in 1797 and doubled during the War of 1812. From 1832 until the Civil War, imports were duty-free, in part because the federal government substituted coffee for ***rum*** *(!)* in military rations.

5. Merchants in Boston, New York, Philadelphia, and elsewhere routinely commissioned London merchants to deliver specific metal cargoes. By 1790 shipments took less than a month to traverse the Atlantic Ocean and regularly arrived stateside during the spring and fall shipping seasons.

between gross product and the costs of raw materials consumed in production. In the past, the Federal Reserve Board has reformed its industrial production index to reflect newer value-added data as new census data became available so as to better account for relative price changes, the emergence of new products, and broader structural developments. However, the lack of correspondence in scope, concept, and reliability across nineteenth-century industrial surveys necessitates a less ambitious approach when constructing historical output series. For instance, Frickey [1947] and Miron and Romer [1990] each adopt the 1899 U. S. manufacturing census as their sole value-added base year in compiling their fixed-weight postbellum indexes.

In deciding upon the census year(s) that would dictate the relative importance of my new index, I considered two principal objectives. Most importantly, I wished to model as accurately as possible the industrial structure of the pre-Civil War economy because no annual measure exists for this period. Furthermore, I wished to account for the evolving composition of industrial output that resulted from structural changes between the Civil War and World War I. Indeed, distinct antebellum and postbellum base years permit the incorporation of additional manufactures and minerals that were not commercially produced before the enumeration of the 1850 Census (i.e., pocket watches in 1851, steam-powered fire engines in 1852, zinc mining in 1858, petroleum in 1859, and Bessemer steel in 1866). This supplementation allows us to update the antebellum basket of goods with additional high-growth industries for the postbellum period, yet does not fundamentally violate the selection criteria or historical comparability of the index.

For a variety of reasons, I selected the 1850 U. S. Census as the basis for tabulating pre-Civil War value-added weights, and the 1880 U. S. Census for the postbellum value-added component weights. Most importantly, economic historians widely view the 1850 Census as the first adequately reliable antebellum industrial survey. Earlier decennial surveys conducted in 1810, 1820, 1832 (the McLane Report), and 1840 were severely underenumerated and lacked industrial detail. Indeed, the 1850 Census stands out in comparison to its predecessors primarily because the U. S. Census Office adopted more sophisticated and innovative survey methods that vastly improved industrial returns. Not only did the federal government compensate enumerators for each firm reported, but it also reassured firms (particularly southern firms fearing taxation) of the confidentiality of their responses and even imposed penalties on establishments that refused to participate. The 1850 census year approximates the midpoint of the index's 125-year sample (1790–1915), which should mitigate the familiar growth-bias characteristic of a Laspeyres index. Finally, the industrial surveys of 1850 and 1880 have been standardized through the seminal revisions of Gallman [1956, 1960, 1966]. Gallman reworked official census schedules from 1840 through 1880 to produce greater industry comparability across two-digit standard industrial classifications (SIC). Of the five decennial censuses that Gallman improved upon, the 1850 and 1880 returns are the most complete and comparable at the industry level.

Table II lists the manufacturing and mining series in the industrial production index and maps their relative importance. The first set of columns pairs each physical-volume series with its 1850 value-added weight adapted primarily from the 1850 Census and Gallman's subsequent revisions. The second set of columns documents the 1880-base weights. Following Frickey's imputed-weighting principle, the percentage weights in Table II have been distributed proportionally within an industrial group containing multiple series. Otherwise, an individual series has been allocated the entire two-digit industry weight. Lumber shipments, for instance, are assigned the value added in the lumber and wood products industry. The motivation for the imputed-weighting principle is to guard against assigning excessive top-line representation to those two-digit industries that are better represented by source data. In cases where disaggregated series lack precise correspondence with census industry classifications, I have adopted the Federal Reserve's approach of prorating weights from auxiliary information.

II.D. Index Construction

Table III presents the new annual U. S. index of industrial production.[6] Physical output across the 43 manufacturing and min-

6. On account of expanded data coverage and an improved methodology, the index data in Table III differ somewhat from previous unpublished versions (e.g., Davis [2002] and later variants distributed via private correspondence). Researchers should consider the series in Table III as the final and "correct" series.

TABLE II
A LIST OF INDEX COMPONENTS AND THEIR RELATIVE IMPORTANCE

Major industry groups	**1850 weights (%)**		**1880 weights (%)**	
Quantity-based index component	**Industry**	Series	**Industry**	Series
Chemical & Fuel Products	**6.36**		**11.02**	
Anthracite coal		2.39		3.48
Bituminous coal		1.24		4.78
Sperm oil refining		0.87		0.08
Whale oil refining		0.78		0.03
Salt production		0.48		0.28
Gunpowder and explosives		0.41		0.32
Dyeing chemicals		0.14		0.13
Whalebone processing		0.05		0.02
Crude petroleum		—		1.90
Ordnance & Accessories	**0.34**		**0.24**	
Firearms		0.34		0.24
Food & Kindred Products	**10.87**		**13.12**	
Milled wheat flour		8.23		6.86
Refined sugar consumption		1.28		2.09
Hog packing		0.81		2.66
Beef packing		0.36		1.20
Salted mackerel		0.10		0.26
Cleaned rice		0.09		0.05
Textiles & Textile Products	**21.80**		**21.40**	
Cotton consumption		21.47		20.03
Wool stockings		0.15		0.36
Mixed cloth regalia		0.09		0.06
Raw silk imports		0.09		0.96
Lumber & Wood Products	**12.57**		**8.88**	
Lumber shipments		12.57		8.88
Printing & Publishing	**8.05**		**9.04**	
Newspapers		8.05		9.04
Leather & Leather Products	**13.12**		**8.04**	
Sole leather		8.95		5.10
Leather hides		4.14		2.93
Boots and shoes, U. S. troops		0.03		0.01
Metals & Metal Products	**12.93**		**13.07**	
Pig iron production		8.13		7.33
Gold mining		2.66		0.61
Tinsmithing		1.30		1.72
Coppersmithing		0.47		0.85
Lead smelting		0.21		0.26
Die-sinking		0.12		0.07
Copper mining		0.06		0.44
Bessemer and open-hearth steel		—		1.61
Zinc production		—		0.17
Transport Equipment & Machinery	**13.10**		**14.02**	
Merchant ships		5.40		2.70
Locomotives		3.62		4.71
Reaping machinery; steel plows		2.80		5.88
U. S. Navy vessels		1.15		0.58
Hand fire engines		0.13		0.01
Steam fire engines		—		0.15
Musical & Scientific Instruments	**0.85**		**1.16**	
Pipe organs		0.66		0.77
Telescopes		0.19		0.08
Pocket watches		—		0.30

Sources: Davis [2002] and Appendix E in Davis [2004a].
Components ranked by their relative importance in 1849/50 value added.

TABLE III
A NEW U. S. INDEX OF INDUSTRIAL PRODUCTION, 1790–1915

Year	Index	Year	Index	Year	Index
1790	4.291	**1832**	31.53	**1874**	300.7
1791	4.490	**1833**	35.15	**1875**	284.2
1792	4.881	**1834**	33.58	**1876**	294.0
1793	5.441	**1835**	37.57	**1877**	297.8
1794	6.014	**1836**	40.25	**1878**	314.0
1795	6.578	**1837**	39.68	**1879**	356.4
1796	6.699	**1838**	40.70	**1880**	400.9
1797	6.374	**1839**	46.06	**1881**	478.1
1798	6.213	**1840**	43.88	**1882**	509.5
1799	6.615	**1841**	46.35	**1883**	523.8
1800	7.273	**1842**	47.66	**1884**	505.3
1801	7.745	**1843**	53.10	**1885**	490.7
1802	8.210	**1844**	59.45	**1886**	550.5
1803	7.977	**1845**	65.36	**1887**	604.7
1804	8.077	**1846**	75.93	**1888**	656.7
1805	8.698	**1847**	87.37	**1889**	675.4
1806	9.283	**1848**	94.89	**1890**	781.0
1807	9.718	**1849**	98.33	**1891**	793.1
1808	8.063	**1850**	102.39	**1892**	852.0
1809	9.389	**1851**	106.05	**1893**	778.2
1810	10.258	**1852**	122.84	**1894**	722.0
1811	11.299	**1853**	139.98	**1895**	846.8
1812	11.252	**1854**	142.72	**1896**	820.9
1813	12.063	**1855**	143.44	**1897**	874.5
1814	13.172	**1856**	149.44	**1898**	1,030.3
1815	13.584	**1857**	146.17	**1899**	1,129.7
1816	12.595	**1858**	137.54	**1900**	1,182.2
1817	13.119	**1859**	156.39	**1901**	1,277.1
1818	13.838	**1860**	157.86	**1902**	1,369.3
1819	14.412	**1861**	156.47	**1903**	1,420.3
1820	14.834	**1862**	167.35	**1904**	1,353.2
1821	15.792	**1863**	187.31	**1905**	1,565.6
1822	17.291	**1864**	200.61	**1906**	1,644.9
1823	17.081	**1865**	190.11	**1907**	1,713.3
1824	18.559	**1866**	193.91	**1908**	1,446.5
1825	19.886	**1867**	210.05	**1909**	1,705.5
1826	20.535	**1868**	220.90	**1910**	1,783.9
1827	21.073	**1869**	237.47	**1911**	1,717.9
1828	21.391	**1870**	242.97	**1912**	1,899.1
1829	20.117	**1871**	255.29	**1913**	1,975.0
1830	23.801	**1872**	275.74	**1914**	1,774.1
1831	28.085	**1873**	302.17	**1915**	1,954.2

Sources: See the text. Index base year is census year 1849/1850 = 100.

ing industries has been aggregated and expressed as an index number from 1790 through 1915 with the base census year 1849/50.[7]

The index was constructed in several steps. First, each component series ip_{it} was indexed by expressing the physical quantity of output of series i for each year t, q_{it}, relative to the quantity produced for series i in base year $t = 0$, q_{i0}, equal to census year 1849/50. Next, the individually indexed components were weighted by their relative importance, or value added v_{i0}, in census year 1849/50 (see Table II) in order to arrive at an annual industrial production IP_t, using a standard Laspeyres fixed-weighted index formula:

$$(1) \qquad IP_t = \frac{\sum_{i=1}^{N} ip_{it} \cdot v_{i0}}{\sum_{i=1}^{N} v_{i0}}, \text{ where } v_{i0} = p_{i0} \cdot q_{i0} \text{ and } ip_{it} = \left(\frac{q_{it}}{q_{i0}}\right),$$

and where the weighted sum in (1) yielded a fixed-weighted index of industrial production based in census year 1849/50.

When certain series disappeared on account of data attrition, I followed the standard approach of computing the index as if the growth in the missing series equaled the growth in the weighted average of the remaining series in those years. This sequential linkage through ratio splices served to prevent discontinuous jump-offs when series dropped out of the sample.[8] Other industries died (e.g., hand-drawn fire engines), and new industries emerged (e.g., locomotives or pocket watches) over the course of the sample period. When a series disappeared because a good was not produced, the absent good still entered the index with a positive weight, multiplied by a quantity of zero. Likewise, observations before a good was actually first produced were recorded, by definition, as zero in the index. The indexing procedure above was then repeated for the 1879/80 census year using the last column of value-added weights in Table II.

7. Seventh Census returns embrace parts of two calendar years. Census year 1849/50 (two years, separated by a slash, henceforth refers to a census year) pertains to production over the twelve-month period beginning June 1, 1849. To better correspond with 1849/50 value-added weights, each calendar-year product index was converted in its final form to a census-year equivalent base using the geometric-mean approximation:

$$IP_{i1849/50} = \lfloor((IP_{i1849})^{7/12}) \cdot ((IP_{i1850})^{5/12})\rfloor,$$

where IP_{it} represents the physical volume of series i in year t. This procedure was repeated for 1879/80.

8. For instance, the index possesses complete industry coverage in 1827, but loses three series in 1826. Following the procedure described in Romer [1994] and the U. S. Board of Governors of the Federal Reserve System [1986], I ratio-spliced the full-coverage index in 1827 to a reweighted index excluding the terminated series in 1826 in order to extend back the final index.

Armed with two overlapping indexes based in 1849/50 and 1879/80 value-added weights, the two series were linked in chronological segments. The percentage changes in the final index of Table III reflect the fixed-weight index with the 1849/50 base from 1790 through 1850, and reflect the other with the 1879/80 base from 1879 through 1915. For the intercensal observations from 1851 through 1878, I used a linear time-weighted average of the annual percentage changes of two indexes. This last step was chosen because it more effectively captured the emergence of new industries during the 1850s than would have an arbitrary splicing of the two overlapping series at the period's midpoint centered the end of the Civil War.[9]

The resulting U. S. index covers the 1790–1915 period. The index commences with the calendar year in which the last of the thirteen original colonies ratified the Constitution. With the power to regulate commerce transferred from those colonies to the U. S. government, the American economy was officially "national" beginning in 1790. The index has been carried through 1915 (the standard terminus of the prewar period) in light of the deficiencies and comparability concerns that characterize earlier indexes constructed for the post-Civil War years, in particular the Frickey index.

My index terminates in 1915 due primarily to data constraints. Since several data sources are interrupted or degrade on account of World War I, the onset of the Great Depression, or changes in reporting procedures and data-collecting bodies, I could not reliably extend the annual index past 1919, the year in which the Federal Reserve Board's monthly industrial production index begins. However, for situations where controlling for secular U. S. economic trends is necessary, my index may be linked to other data to create an annual industrial production index that runs from 1790 through 2000 and beyond. Specifically, I suggest the following two-step approach. First, ratio-splice the new annual index to the Miron-Romer index of industrial production in 1916. Second, ratio-splice this series in 1919 to the Federal Reserve Board's index of industrial production. That said, I strenu-

9. Specifically, let $x_t^{1849/50} = \ln(IP_t^{1849/50}) - \ln(IP_{t-1}^{1849/50})$ and $x_t^{1879/80} = \ln(IP_t^{1879/80}) - \ln(IP_{t-1}^{1879/80})$ represent the logarithmic growth rates in the two overlapping indexes. We can then define the growth rate x_t^{final} that pertains to the *final* industrial production index as a $x_t^{final} = (1 \times w_t)x_t^{1849/50} + w_t x_t^{1979/80}$, where $w_t = 0 \forall t \leq 1850$, $w_t = 1 \forall t \geq 1880$, and, to link the indexes, $w_t = ((t - 1850)/30) \forall 1850 < t < 1880$. Thus, the final industrial production index as presented in Table III reflects the accumulation of x_t^{final} to $IP_{1850}^{1849/50}$ forward from 1850.

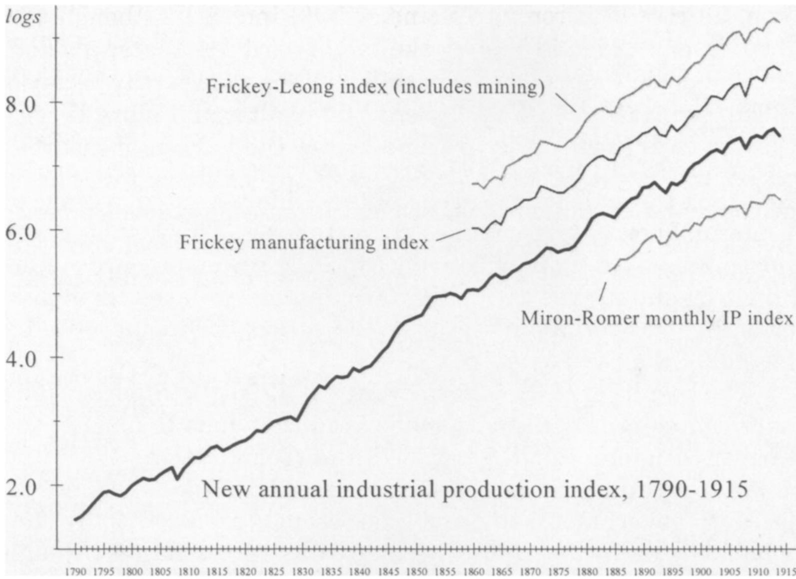

FIGURE II
Comparison with Conventional Postbellum U. S. Industrial Production Indexes
Sources: See the text.
Conventional series rescaled to base year 1899 and expressed in logarithms. For clarity, 1.50 has been added throughout to the logarithm of the Miron-Romer index, 3.25 to the Frickey index, and 4.00 to the Frickey-Leong, or Nutter, index.

ously warn that conducting statistical tests on the business-cycle properties (i.e., structural breaks in volatility) of this spliced series before and after 1915 is *inappropriate under any context.* This is primarily because the constituent series and data reliability of the three linked industrial production indexes varies considerably over time, and so, as Romer [1986, 1989] has demonstrated, any potential evidence of structural breaks in the extended spliced series may simply reflect changes in data quality rather than genuine regime shifts in the U. S. economy's cyclical properties.

II.E. Comparison with Existing Postbellum Industrial Production Indexes

To visually assess its creditability and reliability, Figure II traces the new index alongside three previously published post-Civil War measures of industrial production: the Frickey manufacturing index, an augmented version of the Frickey series, and the more recent Miron and Romer [1990] index.[10] Although the Miron-Romer index is heavily skewed toward raw materials and semi-finished products, the monthly series is noteworthy because its thirteen components are essentially unaltered. Figure II conveys the close agreement in trend across the various measures. Indeed, the new index does not depart in any significant way from our conventional notions of post-Civil War secular development. This degree of uniformity stems in part from the fact that the indexes share several common components, most notably cotton textiles and pig iron.

A perhaps less obvious feature of Figure II is the new index's lower year-to-year variation, as defined by the standard deviation in logarithmic growth rates. Despite the strong growth-rate correlation between the new and old indexes, the new series is systematically less volatile than its postbellum counterparts.[11] The severity of cyclical swings in the new index is approximately 20 percent lower than the Frickey series and nearly 10 percent lower than Nutter's chain-linked index. These margins hold whether or not one includes the Civil War years. Under the hypothesis that the variances of the present index and the previously constructed data are identical, traditional variance ratio tests indicate that the volatility differences are statistically significant at the 10 percent level with respect to the Frickey manufacturing index but only at the 30 percent level vis-à-vis the Nutter industrial index.[12]

The reduced volatility in the new data is noteworthy and reassuring because the older series has been criticized for overstating business-cycle fluctuations. In particular, Romer [1986, p. 331] stresses that the Frickey manufacturing data are "excessively volatile" on the order of 26 percent when artificially extended and compared with the post-WWII Federal Reserve Board index. Incidentally, the Frickey index disports a similar volatility gap in the *postbellum* period in relation to my new index. In fact, this variance differential is likely understated on account of sev-

10. The augmented Frickey index comes from Nutter [1962], who affixes Leong's [1950] index of mineral production to the Frickey data to better approximate an industrial production index. I have abstracted from other postbellum indexes on grounds of availability and comparability. See Davis [2002] for details.

11. For log growth rates over the 1866–1914 period, the Spearman rank correlation coefficient is 0.79 with the Frickey series and 0.79 with the Nutter series.

12. Typical caveats apply regarding the Gaussian assumptions of the underlying distribution.

TABLE IV
POSTBELLUM INDEXES: COMPARISON OF COMPONENT MARKET STRUCTURE

Index:	New annual index		Frickey	Miron-Romer
Value-added base:	1849/50	1879/80	1899	1899
Panel A. Component share (%) of index, by value added				
Final products	35.1	34.7	11.7	15.4
Intermediates	21.5	17.8	23.5	9.3
Raw materials	43.4	47.6	64.9	75.4
Panel B. Component share (%) of index, by number of series				
Final products	55.3	53.5	25.0	23.1
Intermediates	13.2	14.0	15.0	7.7
Raw materials	31.6	32.6	60.0	69.2

Sources: Author's calculations based on information in Frickey [1947], Miron and Romer [1990], and Davis [2002, 2004a]. Components classified according to historical Federal Reserve market groups as defined in U. S. Board of Governors of the Federal Reserve System [1986].

eral artificially "smoothed" components present in the Frickey and Nutter series.[13]

The reduced volatility observed in the new index can be attributed to the range of commodities specified.[14] To see why this is true, the product mix of the new index can be contrasted with those of previously constructed post-Civil War indexes using a standard classification scheme. Table IV summarizes the product mixes for the new and previously constructed indexes based upon more contemporary Federal Reserve market groups.[15] The critical feature of Table IV is that the product sample of the new index differs qualitatively from the conventional post-Civil War series. Indeed, it is reasonable to conclude that the new index is systematically less volatile than the Frickey-Nutter data precisely because the paper's database is not replete with raw materials and intermediate products. Despite a focus on long-span data, a salient feature of the new index is that the sample possesses *a share* of final goods similar to the currently released Federal Reserve industrial production index. Taken together, the new quantity-based series represent a major

13. See Davis [2002] for further details.
14. Unless component variations are highly correlated, differences in year-to-year volatility could simply reflect differences in the number of components. However, closer inspection reveals that this is not the case. The new and old indexes consist of approximately 40 annual series from the 1870s (minor attrition across samples alters the exact count at any time).
15. While post-World War II industry designations are admittedly imperfect, the Federal Reserve classifications provide a convenient standard with which to evaluate the degree of processing embodied across diverse manufactures.

TABLE V
NEW INDEX CONSISTENT WITH FRAGMENTARY EARLY U. S. OUTPUT BENCHMARKS

	A. Existing antebellum industrial benchmarks			*B. New data*
	Real manufacturing value added			
Census year	Range estimate	Point estimate	Real industrial value added	**Industrial production index**
1810	(7.6–12.8)	9.8		10.52
1820	(9.2–15.6)	12.0		14.59
1830				21.58
1840	(33.9–46.0)	39.6	40.7	45.10
1845			60.9	61.84
1850	**100.0**	**100.0**	**100.0**	**100.00**

Sources: Davis [2002].
Figures were indexed to 1849/50 census-year equivalents using a geometric mean formula. Census years 1810 and 1840 encompass the calendar years 1809–1812 and 1840–1941, respectively, to accord with when those surveys were actually conducted.

contribution to the present study because they ameliorate what would otherwise be an overreliance on primary commodities. Moreover, these freshly assembled time-series data cover many of the most sophisticated and complex wares made during the nineteenth century. Economists widely cite many of the new component series in their case studies of the American system of manufactures for their utilization of a wide range of machine tools, interchangeable parts, and basic materials.

III. INDEX IMPLICATIONS

III.A. Antebellum Industrial Development

The new index can speak directly to our conventional notions of early secular growth. At the same time, independently derived output benchmarks for the pre-Civil War era can serve to evaluate the reliability in the trend of the index. Table V compares the secular trend of the new index with the best set of output benchmarks that exist for the pre-Civil War period. The benchmarks represent constant-dollar industrial estimates adapted from disparate sources and incomplete manufacturing censuses; all figures in Table V have been indexed to the 1850 census year.

The wide ranges in the earliest output benchmarks attest to the considerable uncertainty surrounding America's formative economic development. The main implication of Table V, however, is that conventional views on the secular development of the American economy are generally consistent with the newer data set.

The index also tells a more nuanced story involving important events in the early American economy, including exactly when the antebellum U. S. economy experienced a watershed acceleration in its long-run rate of output growth. Considerable debate still surrounds the approximate date of America's "takeoff" and its emergence from industrial infancy. Given that pre-1840 estimates of real output per capita are available at only ten-year intervals, the timing and relative magnitude of a secular acceleration have been difficult to ascertain. Rostow's [1971] *takeoff* hypothesis stipulates that U. S. industrial productivity growth accelerated only with the "railroadization" of the economy during the 1840s and early 1850s. Conversely, other scholars (e.g., David [1967], Sokoloff [1986], and Weiss [1994]) contend that industrial productivity may have accelerated a decade or so earlier with the increasing adoption of the factory system.

Using the new index, Figure III presents a crude proxy for industrial productivity growth: average five-year growth rates in annual industrial production per capita. An interesting implication of Figure III is that the new data lend defensibility of both camps in the "takeoff" debate. That is, while gains were most accentuated during the 1840s and 1850s, productivity gains were not unique to this period in the Rostovian sense.

Productivity growth appears to have surged in twin-peaked waves before the Civil War. According to the new index, the first significant surge above trend occurred in the 1820s and early 1830s. The first peak agrees with Weiss's revised trend-growth estimates of decennial U. S. GDP. The second, more vigorous productivity boom (*point B*) coincides graphically with the timing of Rostow's *takeoff* hypothesis, although the figure indicates that the magnitude of its acceleration was not entirely unprecedented. And yet despite the twin-peaked booms witnessed before 1860, industrial productivity advanced at a more rapid pace following the Civil War. Slight but palpable growth-rate differentials before and after the Civil War validate the progressive industrialization of the nineteenth-century U. S. macroeconomy.

III.B. Antebellum-Postbellum Comparisons in Industrial Volatility

The new index also permits unresolved questions to be answered with respect to the cyclical properties of the nine-

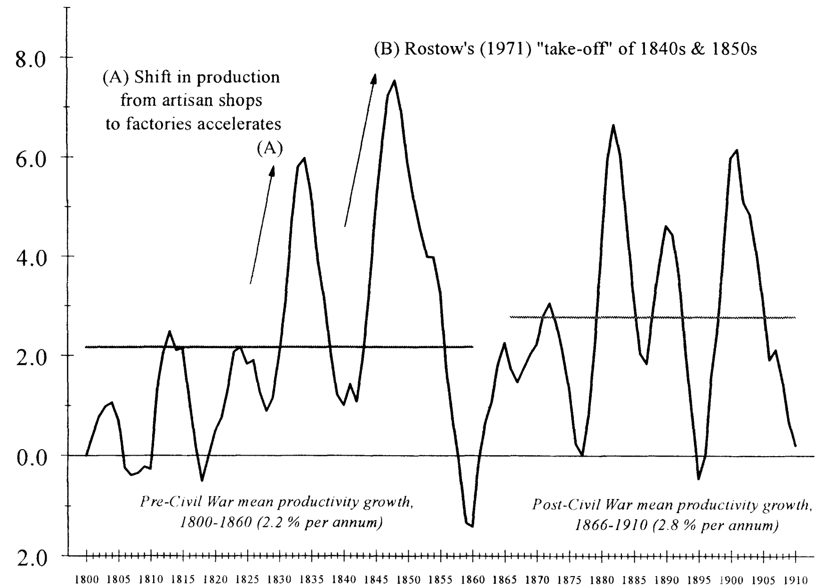

FIGURE III

Waves in Nineteenth-Century U. S. Industrial Productivity Growth

Plot represents running five-year centered moving averages of five-year annualized log growth rates in per capita industrial production. Productivity is defined on a per capita basis because annual labor-force estimates are unavailable.

teenth-century U. S. economy. Specifically, did significant changes in aggregate business-cycle volatility occur before and after the Civil War? Due primarily to a lack of reliable output data, antecedent studies that have looked into the issue of antebellum-postbellum volatility have reached somewhat contradictory conclusions. James [1993] finds that the cyclical severity in economic fluctuations *increased* over the course of the nineteenth century. Unfortunately, the annual pre-Civil War data set on which James bases his conclusions are widely considered inappropriate for business-cycle analysis.[16] In the other study, Calomiris and Hanes [1994] evaluate differences

16. James [1993] constructs an artificial series of antebellum GNP by linking Berry's "consensus" estimates (1790–1833) to Gallman's extrapolations (1834–1859 census years). James then tests whether annual changes in these spliced data differ systematically from revised postbellum estimates (e.g., Balke and Gordon [1989] and Romer [1989]). Unfortunately, the value of the spliced Berry-Gallman data is quite limited in this context and hence casts considerable doubt on the reliability of his conclusions.

in the volatility of U. S. industrial production between the antebellum (1840–1859) and postbellum (1870–1913) years. From a set of six consistently defined manufacturing and mining products, Calomiris and Hanes [p. 420] tentatively conclude that "cyclical movements in industrial production were no larger, and were probably smaller, in the postbellum period than in the last two decades of the antebellum period."

By design, however, their methodology precludes direct inference of antebellum-postbellum volatility changes because Calomiris and Hanes [1994] artificially construct the antebellum data that best replicate Frickey's postbellum manufacturing index. Since postbellum productive relationships are imposed upon the antebellum economy, Dick [1998] remarks that it is unclear whether structural changes, or more inclusive industrial data, would validate or nullify the outcome.[17] Indeed, even Calomiris and Hanes [p. 410] stress that their study represents the *initial* step toward building "an annual series covering both the antebellum and postbellum years through 1914, consistent and comparable throughout," for the primary purpose of testing whether the amplitude of business cycles changed from the antebellum to the postbellum period.

The new index allows us to examine with more confidence the properties of annual fluctuations of U. S. industrial production over the 1790–1915 period. Of particular interest is a comparison of industrial volatility before and after the Civil War, which we can confidently treat as a known break-point given that the Civil War was, as Williamson [1974, p. 5] describes, a "source of profound disequilibrium" and regime change along several dimensions.

Table VI presents summary statistics of annual logarithmic growth rates in the new index. As a baseline case, I have defined business-cycle volatility as the standard deviation in index logarithmic growth rates. Contrary to detrending methods, business-cycle movements are precisely measured because growth rates map absolute expansions and contractions in the level of industrial production. Table VI presents test statistics and affiliated p-values on the null hypothesis that the mean and variance of the index's growth rates are the same between the antebellum and

17. Calomiris and Hanes [1994] individually regress trend-adjusted deviations in the six series on trend-adjusted deviations in the Frickey index, which is based on 1899 value-added weights. The subsequent regression coefficients act as a surrogate for value-added weights in an artificial extrapolation of Frickey's index over the twenty-year antebellum sample.

TABLE VI
ANTEBELLUM-POSTBELLUM INDEX VOLATILITY COMPARISONS

Index comparison		Antebellum period	Postbellum period	Equal means hypothesis: *T*-test	Equal means hypothesis: *p*-value	Equal variance hypothesis: **Brown-Forsythe median W**	Equal variance hypothesis: *p*-value
		Panel A. Logarithmic growth rates, benchmark sample					
1791–1860 vs. 1866–1915	**s.d.**	**6.64**	**7.39**	0.40	0.69	0.53	0.59
(*excludes War of 1812*)	mean	5.18	4.66				
		Panel B. Alternative sample periods					
1791–1860 vs. 1866–1915	**s.d.**	**6.50**	**7.39**	0.38	0.70	0.41	0.52
(*includes War of 1812*)	mean	5.15	4.66				
1800–1849 vs. 1850–1899	**s.d.**	**6.71**	**6.59**	0.39	0.70	0.19	0.66
(*19th century only*)	mean	5.40	4.88				
		Panel C. Alternative index construction					
Attrition-free index (*2 variants*)							
Years with all series	**s.d.**	**7.35**	**6.70**	0.03	0.98	0.11	0.90
	mean	*5.87*	*5.82*				
Series with all years	**s.d.**	**7.06**	**7.05**	0.06	0.95	0.08	0.78
	mean	*5.08*	*4.99*				
Calomiris-Hanes (A)	**s.d.**	**14.94**	**10.97**	(0.08)	0.94	**2.62**	**0.11***
(*Replication*)	*mean*	*6.25*	*6.52*				
Calomiris-Hanes (B)	**s.d.**	**10.90**	**10.95**	0.00	1.00	1.05	0.35
(*Extension*)	*mean*	*6.19*	*6.19*				

Unless otherwise noted, summary statistics represent log first differences of index, expressed in percentages.

postbellum periods. The Brown-Forsythe median equality-of-variance test is a more robust test than traditional variance-ratio tests when the distribution is independent but not identically distributed.[18] The benchmark sample is presented in Panel A. The benchmark case includes all pre-World War I observations save for those traversing the Civil War and the War of 1812 as periods of major armed conflicts (fought on domestic soil) are treated as atypical occurrences. Alternative sample periods (in Panel B) and index construction methods (in Panel C) are considered in order to assess the robustness of the results in Panel A.

It is quite reasonable to conclude from Table VI that fluctuations in U. S. industrial production were not markedly different in the periods before and after the Civil War. This outcome appears resilient to tenable changes in sample periods, volatility measurements, and data coverage. When antebellum deviations are compared with their postbellum counterparts, the variance comparison tests in Table VI fail to reject the hypothesis of equality in growth-rate volatility. Standard deviations tend to be slightly lower in the pre-Civil War years, but antebellum-postbellum differences not are statistically significant.[19]

As shown in Panel C, these conclusions are robust to how one constructs the index. Potentially, modest index attrition or data adjustments could have important business-cycle implications. For instance, component attrition would be a concern if the series that drop out of the index further back in time behave quite differently over the business cycle than remaining constituents. This is certainly the case for the Frickey index and the early segments of the Federal Reserve industrial production index.

To explore this possibility, Panel C presents variance-equality tests for several alternatives to the benchmark index in Table III. Specifically, two different no-attrition indexes have been compiled. The first no-attrition index considers only those years (1827–1900) in the final index unaffected by end-point component attrition. The second no-attrition index draws volatility comparisons from an index comprised of only those disaggregate series whose annual coverage commences from 1800 or earlier. Consequently, the latter no-attrition series reflects approximately 70 percent of the value-added in the final index, while the former

18. A Shapiro-Wilk test rejects the null hypothesis of normality in the first-differenced data at the 10 percent significance level. However, a nonparametric runs test fails to detect serial correlation in the first-differenced data.

19. Similar results are obtained when volatility is defined in terms of detrended data using a band-pass filter.

reflects complete value-added coverage for an abridged sample. Panel C demonstrates that the core results are insensitive to the minor attrition and adjustment embedded in the benchmark version of the new index. Neither attrition-free index displays significant changes in either trend growth or cyclical volatility between the antebellum and postbellum periods.[20]

Finally, Panel C revisits the results of Calomiris and Hanes [1994], who tentatively conclude that cyclical swings in industrial production likely fell in the post-Civil War period. I first create a near replica of their artificial index for antebellum (1840–1859) and postbellum (1870–1913) samples by accessing five of their six annual series using fixed 1880 value-added weights (labeled Calomiris-Hanes (A) "replication" in Table VI).[21] I then link the same five annual series using the methodology described in Section II, extending the analysis to include the pre-1840 period (labeled Calomiris-Hanes (B) in Table VI). These calculations provide some important insights. First, a replication of the Calomiris-Hanes study yields the only case of significant reduction in postbellum volatility. The standard deviations in annual fluctuations fall approximately 30 percent after the Civil War, a reduction statistically significant at the 15 percent level. However, this replication does not appear representative of broader trends. When one explicitly allows for structural change or for a longer antebellum representation (as is done here), the indications of cyclical moderation vanish. A logical explanation for this revision is that the Calomiris-Hanes group accounts for less than 30 percent of the value added specified in the new index.[22]

III.C. Ranking the Severity of Prewar Business Cycles

The new index also allows us to quantify the relative severity of U. S. business cycles both before and after the Civil War. This should be of interest for several reasons. For one, most of our current views regarding the occurrence and magnitude of prewar recessions are based on an NBER chronology whose annual peaks

20. Similar results obtain for an "adjustment-free" index, which excludes three index components whose coverage gaps were in-filled on a related annual proxy (see the Data Appendix for details).

21. The "study replication" for the *Calomiris-Hanes group* in Table VI includes data for five manufacturing and mining industries (anthracite coal, bituminous coal, cotton consumption, lead, and pig iron) but omits the sixth series in the original study (coffee imports) on account of reporting changes in U. S. trade statistics. Inclusion of the imports would not substantially alter the findings since coffee roasting would receive by far the smallest weight.

22. The sensitivity of the replication underscores why Calomiris and Hanes emphasized that their results were preliminary.

and troughs rest heavily on nominal data—particularly commodity prices—and the qualitative assessments of contemporary observers (see Davis [2004b]). Since an important advantage of an index of industrial production is that it traces only changes in physical quantities, the new index may shed new light on relative recession severity. Second, it could be argued that business-cycle severity did in fact moderate after the Civil War, yet just along dimensions other than annual volatility. For instance, a pre-Civil War economy characterized by small booms and large busts could have gradually shifted toward an economy with larger booms and smaller busts.

Following Romer [1994], one sensible and direct welfare approximation of a business contraction's severity is the absolute decline in real output realized over the business cycle. Indeed, we can quantify a recession's cumulative output loss as the summation of the log differences between industrial production and its previous peak level, with the sum taken over the years when output is below that previous peak level. This is the most straightforward approach to calculate a recession's severity when using annual data.

Table VII ranks cumulative index losses for contractions in the antebellum and postbellum periods, respectively, in descending order of severity. Given that the data in Table VII are calculated in logarithms, output losses represent the sum of the deviations (in percentage points) from the peak level of industrial production during a given contraction. The bottom of Table VII presents the mean output loss and its standard deviation for antebellum and postbellum recessions, as well as nonparametric Wilcoxon rank-sum test statistics. Under the null hypothesis of the Wilcoxon test, the average rank of severity for an antebellum recession should equal the average rank of severity of a postbellum recession. The Wilcoxon test excludes from its mean-loss comparisons the three marginal pre-Civil War recessions (indicated by *) whose losses are subjacent to the minimum loss observed for the post-Civil War era. The motivation for this so-called *cutoff loss rule* is to adequately ensure that an average profile of antebellum cyclical severity takes into account the economy's secular industrialization by excluding all cumulative losses that do not exceed the minimum postbellum index loss (see Romer [1994] for a similar approach).

The Wilcoxon test in Table VII does not reject the null hypothesis of commensurate severity. In terms of industrial activity, the severity of a generic contraction increased approximately

TABLE VII
SEVERITY OF AMERICAN PREWAR RECESSIONS: CUMULATIVE OUTPUT LOSS

Antebellum recessions			Postbellum recessions		
Peak	Trough	Cumulative index loss	Peak	Trough	Cumulative index loss
1807	1808	22.12	1892	1897	29.97
1796	1798	13.77	1907	1908	17.38
1815	1816	11.05	1913	1914	11.79
1856	1858	10.50	1873	1875	10.83
1828	1829	6.14	1883	1885	10.13
1839	1840	4.84	1903	1904	4.85
1833	1834	4.57	1910	1911	3.77
1802	1803	4.51			
1836	1837	1.43*			
1822	1823	1.22*			
1811	1812	0.41*			

Subsample output losses: Summary statistics and significance tests

All Antebellum recessions		All Postbellum recessions	
Mean output loss	7.32	Mean output loss	12.67
Mean loss (*no * losses*)	9.69	Mean output loss	12.67
		Wilcoxon rank-sum equality-of-mean statistic	59.0
		p-value	0.56

Cumulative loss represents sum of percentage-point shortfalls in the logarithm of the index between peak and subsequent years below the peak. * losses indicate contractions that do not exceed the minimum cumulative postbellum loss. Two Civil War cycles (1861 and 1865 troughs) are omitted, although their inclusion would not meaningfully affect calculations. p-values are for the null hypothesis of no mean-loss distribution change before and after the Civil War.

three percentage points after the Civil War. However, business contractions did not become shallower over the course of the nineteenth century, nor did they become more uniform. Another interesting feature of Table VII is that the three most severe output losses for the postbellum period fall under the 30-year sample (*1886–1916*) analyzed by Romer [1994], who then concluded that pre-World War I recessions are only marginally more severe than post-World War II recessions.

In addition, the new index may radically change our views on individual American business cycles. According to the NBER business-cycle chronology, the recessions of 1873–1878 and 1839–1843 are the longest contractions on record and are typically characterized as periods of profound depression and deflation. Yet some economic historians (e.g., Friedman and Schwartz

[1963] and Temin [1974]) have long suspected that these episodes may be an artifact of the NBER's heavy reliance on nominal variables in the selection of the early reference years.

Table VII illustrates in either instance that the quantity-based production data display shallower losses relative to their qualitative assessment portrayed by the contemporary press and wholesale price indexes. One plausible explanation for the disparity may be that the media confused commercial crises with financial ones, because the latter were characteristic of falling commodity and security prices (see Kindleberger [2000]). Indeed, Peter Temin and others have hypothesized that the duration and severity of the cyclical contractions that followed the 1839 and 1873 panics were exceedingly more severe in nominal than real economic data because precipitate price deflation for final goods essentially substituted for marked declines in production. The new output data series employed here indicates that downturns did occur following the financial crises of 1839 and 1873, but they were shorter-lived than described by contemporary accounts. My assessment is bolstered not only by the mild depth of these recessions, but also their breadth: *All 43* index components in my data set reach their trough before the official NBER troughs during the 1839 and 1873 downturns.

IV. Conclusion

This study was motivated by the lack of a reliable annual measure of nineteenth-century American economic activity. As a significant step toward rectifying the so-called "statistical dark age," this paper offers an annual index of industrial production that spans the entire pre-World War I U. S. economy. Index construction parallels that of the Federal Reserve Board's canonical post-1919 series in assembling base data on 43 distinct manufactures and minerals from official and private sources. In light of the criticisms lodged by Romer [1986, 1989] and others against previously constructed macroeconomic series for the post-Civil War years, primacy has been placed on long-span data to reasonably ensure index consistency. Indeed, the strongest attribute of the index is that its components are expressed entirely in physical quantities. Despite rigorous selection criteria, the index is not overpopulated with basic commodities conveniently published elsewhere. Rather, compilations from ignored and recently unearthed source materials have yielded more than two dozen new physical-output series that encompass a broad spectrum of consumer goods and industrial machinery.

This study's provision of an annual measure of prewar industrial activity should be of keen interest to economic historians and business-cycle analysts. Since our knowledge of American production before (and, indeed, after) the Civil War is severely limited, this new annual index of industrial production may provide economists and historians alike new insights into old questions, and should even allow new questions to be answered. As just an example, what were the impacts of profound events such as the Embargo of 1807, the War of 1812, and the Civil War on America's path toward industrialization?

The new index also has implications for our limited understanding on the magnitude, frequency, and duration of prewar U. S. business cycles, both on an individual basis and across eras. Scanty pre-Civil War macroeconomic data have dulled the efficacy of antecedent studies that examine possible differences in annual volatility before and after the watershed events of the Civil War. One implication of the new index is that antebellum-postbellum differences in volatility are not statistically significant when the Civil War is treated as the sample break. This study also demonstrates that the differences in the average severity of contractions before and after the Civil War are immaterial, a strong indication that pre-World War I contractions did not become shallower or more uniform over time. Going forward, this new index could be used to create an alternative set of business cycle peaks and troughs to the NBER chronology. How would these new data alter our comparisons with the characteristics of postwar recessions and expansions?

Appendix 1: Brief Description of the Index Components

This appendix briefly documents (in alphabetical order) the initial coverage, physical units, and source types of the 43 physical-volume series underlying the new U. S. industrial production index. The reader is referred to the unpublished companion Technical Data Appendix [Davis 2004a], available from the author upon request, for more copious details and a complete list of citations. Unless stated otherwise, the reader can assume that no significant adjustments were made to the time-series data. In all cases, overlapping or separate data sources were checked for consistency and transcription errors.

Series 1: Anthracite coal
Initial Coverage: 1790
Details: Direct measure. Pennsylvania anthracite coal, in net tons, from published U. S. government sources and independent research. Comprehensive industry coverage.

Series 2: Army boots & shoes
Initial Coverage: 1808
Details: Direct measure. Pairs of leather boots and shoes made by private contractors (including those on the putting-out system) and at U. S. Quartermaster depots for the U. S. Army. Author's tabulations from U. S. government archives. Comprehensive industry coverage.

Series 3: Beef cattle receipts
Initial Coverage: 1827
Details: Indirect measure. Head of beef cattle received during the calendar year at Brighton market and at Chicago stockyards. Author's tabulations from contemporary newspapers, trade journals, and published research.

Series 4: Bituminous coal
Initial Coverage: 1790
Details: Direct measure. In net tons, from sources identical to anthracite coal. Quantities have been extended back from 1800 through 1790 by ratio-splicing national states, a fair linkage since the three absentee states accounted for less than 3 percent of 1800 national output.

Series 5: Cloth regalia
Initial Coverage: 1808
Details: Direct measure. Units of wool and silk regalia made by private contractors (including those on the putting-out system), private factories, and federal clothing depots. Author's tabulations from U. S. government archives. Comprehensive industry coverage.

Series 6: Copper consumption
Initial Coverage: 1806
Details: Indirect measure. Domestic smelter output, plus imports of all unwrought copper exported from all British ports, in long tons. Author's tabulations from British and U. S. government records.

Series 7: Copper smelting
Initial Coverage: 1790 (Product first commercially mined in the United States on a large scale in 1845; earlier observations are recorded, by definition, as zero in the index).
Details: Direct measure. Smelter production, recoverable

content, in short tons, obtained from U. S. government publications. Complete industry coverage.

Series 8: Cotton consumption

Initial Coverage: 1790

Details: Indirect measure. 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 500-pound bales (gross weight) as reported by the U. S. Census Bureau, and account for cotton consumed at textile mills and by households under the putting-out contract system. Annual cotton consumption figures are available 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. Confidence in the estimated observations is high for several reasons, including the fact that approximately 99 percent of cotton grown in the specified crop year was returned as ginned after the marketing year, and that growth rates in the extended series track closely with the establishment and output of New England cotton textile mills. See Davis [2004a] for further details.

Series 9: Crude tin imports

Initial Coverage: 1815

Details: Indirect measure. Unwrought tin from mines of the United Kingdom, British colonies, and foreign countries, exported to the United States by all vessels from all British ports, in long tons, from the *Sessional Papers.*

Series 10: Die-sinking

Initial Coverage: 1793

Details: Direct measure. U. S. coin production of all denominations, in grams (weight; not face value). Author's tabulations from price guides, based on U. S. government records and private research.

Series 11: Dyeing chemicals

Initial Coverage: 1790 (Product first commercially produced in the United States in 1834; earlier observations are recorded, by definition, as zero in the index).

Details: Direct measure. Pounds of prussiate of potash (potassium ferrocyanide) made by Carter & Scattergood and Henry Bower Chemical Manufacturing Company. Author's tabulations from firm archives. The Philadelphia chemical firm of Carter & Scattergood was the first and largest American manufacturer of yellow and red prussiate of potash, which were industrial dyeing agents utilized in calico printing, fabric-making, blueprinting, etc. Series possesses survivorship bias.

Series 12: Farm machinery

Initial Coverage: 1790 (Product first commercially produced in the United States in 1833; earlier observations are recorded, by definition, as zero in the index).

Details: Direct measure. Units of reaping and harvesting machinery, including rakers, mowers, droppers, harvesters, binders; and steel plows. Author's tabulations from firm archives, published firm case studies, and private correspondence. Series records the output of four pioneer and primary farm-implement manufacturers: Obed Hussey, McCormick, International Harvester Company, and John Deere. Series possesses survivorship bias.

Series 13: Firearms

Initial Coverage: 1790 (Product first commercially produced in the United States in 1793; earlier observations are recorded, by definition, as zero in the index).

Details: Direct measure. Military and commercial small arms made (all models), by federal and state armories, contractors, and private firms. Author's tabulations from published and unpublished U. S. government records, firm archives, and published firm studies. Gunsmiths and firearm manufacturers represented in the component series account for approximately one-half of total U. S. firearm production.

Series 14: Fish curing

Initial Coverage: 1804

Details: Direct measure. Salted mackerel barrels inspected in Massachusetts (until 1877) and New England (thereafter), as reported in U. S. government publications. Nearly complete industry coverage.

Series 15: Gold mining

Initial Coverage: 1804

Details: Direct measure. Mined output at refinery stage, in fine ounces, as reported in U. S. government publications. Complete industry coverage.

Series 16: Gunpowder

Initial Coverage: 1804

Details: Direct measure. Pounds of gunpowder and explosives produced by interests of E.I. du Pont de Nemours Powder Company, tabulated from firm archives. Series overstate the secular industry growth and possess survivorship bias.

Series 17: Hand-operated fire engines

Initial Coverage: 1790

Details: Direct measure. Units constructed. Author's tabulations of more than 2,000 fire engines from various builder lists, historical society records, fire museum archives, and fire department histories. The series captures the "death" of the domestic industry in 1914, and an estimated two-thirds of nineteenth-century domestic production.

Series 18: Hide receipts

Initial Coverage: 1827

Details: Indirect proxy for leather tanning and curing. Receipts of domestic and foreign dried & green hides at New York City and Chicago, the premiere leather-tanning centers of the nineteenth century. Author's tabulations from contemporary newspapers and trade journals.

Series 19: Hog packing

Initial Coverage: 1790 (First commercial shipment made in 1809; earlier observations are recorded, by definition, as zero in the index).

Details: Direct measure. Quantities of hogs packed in Cincinnati, Chicago, Indianapolis, and Omaha. Author's tabulations from contemporary newspapers, trade journals, and published research. Minor data adjustments were necessary.

Series 20: Lead smelting

Initial Coverage: 1821

Details: Direct measure. Primary smelter production, in short tons until 1885; refined output thereafter, as reported in U. S. government publications. Complete industry coverage.

Series 21: Locomotives

Initial Coverage: 1790 (Product first commercially produced in the United States in 1825; earlier observations are recorded, by definition, as zero in the index).

Details: Direct measure. Author's tabulations of more than 120,000 engines manufactured from various builder lists, railroad historical society records, firm archives, and published railroad-company histories. For a complete description, refer to Appendix B of Davis [2004a].

Series 22: Lumber shipments

Initial Coverage: 1827

Details: Direct measure. Shipments in feet board measure (b.f.) from ten distinct river booms, seaside ports, and wholesale districts that represent virtually all of the principal lumber-producing regions of the nineteenth century. Author's tabulations from contemporary trade journals and various published studies.

Series 23: Merchant shipbuilding
Initial Coverage: 1790
Details: Direct measure. Gross tonnage (Old Custom House Measurement basis) of all types of domestically constructed merchant rigs, including the four major specialty classes (clippers, packets, steamers, and whalers). Author's tabulations from published and unpublished U. S. government records, historical society archives, and published ship registries. The new series rests on a database of approximately 100,000 merchant vessels, or more than two-thirds of the American merchant fleet built before World War I. For a complete description, refer to Appendix C of Davis [2004a].

Series 24: Milled wheat flour
Initial Coverage: 1798
Details: Direct measure. Barrels received or manufactured in Baltimore, Buffalo, Chicago, and Minneapolis. Author's tabulations from contemporary trade journals and various published studies.

Series 25: Naval shipbuilding
Initial Coverage: 1790
Details: Direct measure. Author's tabulations from U. S. government publications and ship registries of every U. S. Navy vessel constructed at private and government yards, in displacement tonnage.

Series 26: Newspaper publishing
Initial Coverage: 1790
Details: Indirect measure. Number of daily newspapers in circulation. Author's tabulations from numerous bibliographic lists and trade journals.

Series 27: Petroleum refining
Initial Coverage: 1790 (Product first commercially mined in the United States in 1859; earlier observations are recorded, by definition, as zero in the index; component receives only 1880 value-added weight in the index).
Details: Direct measure. Crude petroleum produced, in 42-gallon barrels, from series M-318 of *Historical Statistics* [1975]. Complete industry coverage.

Series 28: Pig iron production
Initial Coverage: 1827
Details: Direct measure. Gross tons produced. Author's tabulations from various published and unpublished sources. For complete details, see Section D of the companion Technical Data Appendix.

Series 29: Pipe organs

Initial Coverage: 1790

Details: Direct measure. Author's tabulations of more than 22,000 units constructed from various published and unpublished sources. Comprehensive industry coverage.

Series 30: Pocket watches

Initial Coverage: 1790 (Product first commercially mined in the United States in 1851; earlier observations are recorded, by definition, as zero in the index; component receives only 1880 value-added weight in the index).

Details: Direct measure. Author's tabulations of more than 80 percent of movements produced from various unpublished historical society records and published studies.

Series 31: Raw silk imports

Initial Coverage: 1814

Details: Indirect measure of silk consumption. Raw, thrown, and waste silk of the United Kingdom, British colonies, and foreign countries (including China and India), exported to the United States by all vessels from all British ports, in pounds, from the *Sessional Papers*.

Series 32: Rice milling

Initial Coverage: 1819

Details: Direct measure. Cleaned rice equivalent, rough rice crop, in pounds, adjusted from U. S. government publications. Several errors were corrected in the U. S. Department of Agriculture estimates.

Series 33: Salt production

Initial Coverage: 1797

Details: Direct measure. Inspected 56-pound bushels of processed salt (all types), at all New York salt wells and reservations, and from all Michigan salt producers. Author's tabulations from state government records. New York and Michigan were the preeminent salt-producing states during the nineteenth century.

Series 34: Sole leather receipts

Initial Coverage: 1827

Details: Direct measure. Inspected receipts of sole leather sides, including hemlock sole, union sole, and oak sole, in New York (prior to Boston consignment). Author's tabulations from contemporary reports and trade journals. New York City's receipts of domestic heavy sole leather offer a reasonable measure of the output of civilian shoes and other finished leather products because New York City was the largest leather market at this time, and because sole leather was the primary component in boots and shoes.

Series 35: Sperm oil refining

Initial Coverage: 1793

Details: Indirect measure. Barrels of sperm oil returned to port by American whaling fleet. Author's tabulations from various published sources. Nearly universal industry coverage.

Series 36: Steam fire engines

Initial Coverage: 1790 (Product first commercially produced in the United States in 1852; earlier observations are recorded, by definition, as zero in the index; component receives only 1880 value-added weight in the index).

Details: Direct measure. Units delivered, expressed in engine capacity of gallons per minute. I obtained construction and specification information on over 4,000 engines from builder and fire department records. The series is comprehensive, and captures the birth and death of the domestic industry.

Series 37: Steel production

Initial Coverage: 1790 (Product first commercially mined in the United States in 1866; earlier observations are recorded, by definition, as zero in the index; component receives only 1880 value-added weight in the index).

Details: Direct measure. Thousands of net tons produced through open-hearth and Bessemer processes, as reported in contemporary trade journals. Nearly universal industry coverage.

Series 38: Sugar refining

Initial Coverage: 1790

Details: Indirect measure. Domestic production of refined sugar consumption, converted to pounds. Author's tabulations from U. S. government publications. Related series spliced in 1822. Nearly universal industry coverage.

Series 39: Telescopes

Initial Coverage: 1790 (Product first commercially produced in the United States in 1830; earlier observations are recorded, by definition, as zero in the index).

Details: Direct measure. Refractors and reflectors, in inches of objective. Author's tabulations from published and unpublished records of historical societies and its members. Comprehensive industry coverage.

Series 40: Whalebone

Initial Coverage: 1804

Details: Indirect measure. Baleen whalebone, in pounds, from sources identical to sperm oil refining. Nearly universal industry coverage.

Series 41: Whale oil refining

Initial Coverage: 1793

Details: Indirect measure. Barrels of whale oil returned to port by American whaling fleet, from sources identical to sperm oil refining. Nearly universal industry coverage.

Series 42: Wool stockings

Initial Coverage: 1808

Details: Direct measure. Pairs of woolen stockings and half stockings made. Author's tabulations from U. S. government archives. Fairly comprehensive industry coverage.

Series 43: Zinc smelting

Initial Coverage: 1790 (Product first commercially mined in the United States in 1858; earlier observations are recorded, by definition, as zero in the index; component receives only 1880 value-added weight in the index).

Details: Direct measure. Primary smelter production, in short tons until 1906; mine recoverable content thereafter, as reported in U. S. government publications. Minor data corrections. Complete industry coverage.

Appendix 2: Data Limitations

Despite its aforementioned strengths, the new U. S. industrial production index possesses definite limitations and potential biases. To be sure, the index possesses a higher degree of measurement error vis-à-vis modern-day series since the antiquated base data are not completely devoid of adjustments or attrition. Generally speaking, series that I have created retrospectively may be most susceptible to survivorship bias because the base data rest partially on extant records. Everything else equal, retrospective canvasses will be less accurate than a contemporaneous producer survey because the latter are more inclined to capture smaller-scale or since-defunct businesses. Substituting the production of a sample of firms for the output of an entire industry is also susceptible to measurement error. Consequently, survivorship bias will tend to understate data volatility because business failures rise during recessions. While these biases should not apply to the series on locomotives or navy vessels given the completeness of the raw data, it is unclear exactly how survivorship bias affects the novel data sets for dyeing chemicals, firearms, fire engines, farm machinery, and gunpowder.

Data attrition could also potentially distort the historical time series. In this case, however, component attrition in the new index actually occurs at a slower and lower rate back in time relative to the Frickey and Federal Reserve indexes, two well-known industrial production indexes that measure more recent economic activity. Occasional reporting errors and gaps in data coverage also necessitated the adjustment to several index components. In many cases, data adjustments arose simply from conflicting observations. Presumably due to typographical errors or subsequent revisions, source data did not always correspond when cross-referencing antiquated publications. Most discrepancies were minor. In the case of contradictions, government and most recent publications received preference.

While missing observations were generally confined to one or two years (again, see the companion Technical Data Appendix for specifics), slightly longer gaps were encountered in three of the 43 product series. I adopted a fairly strict rule in estimating the missing observations: an alternative annual series available for the coverage gap had to possess similar cyclical turning points and volatility to the component data. Prevailing evidence in each of the three cases indicated that an available proxy was a suitable interpolator.

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