The Relative Stability of German and American Industrial Growth, 1880-1913: a Comparative Analysis

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1. Introduction

The industrial expansion of the German economy between 1880 and 1913 was significantly more rapid than that of the United Kingdom, and substantially less volatile than that of the United States. Although economic historians have devoted considerable attention to explaining the differences in rates of growth between Germany and the U.K., only a very few scholars have addressed the differences in volatility between German and U.S. growth. In spite of the fact that it is primarily in comparison with the United States that the volatility of German industrial expansion appears so relatively mild, most suggested explanations for this stability, such as increased protection in Germany, or differences in financial structure or industrial organization, have not been developed as part of an explicitly comparative analysis that attempts to account both for the severity of fluctuations in the United States and for their relative absence in Germany. Within a comparative framework, an explanation for the relative stability of German growth should at the same time be an explanation for the instability of U.S. growth.

This paper argues that a substantial part of the explanation for these differences in relative stability may be found in differences in the relative importance and volatility of railroad investment in the two countries during these years. This hypothesis may also provide the key to understanding why German growth was so relatively stable in comparison with its own experience in the previous several decades, and perhaps also why the U.S. experience in the late nineteenth century appears historically to have been particularly unstable.

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2. The Problem

Although there are passages in the secondary literature which do suggest that the empirical proposition noted at the start of this essay is commonly accepted, only two economists have systematically examined both the rapidity and volatility of German industrial expansion in the late nineteenth and early twentieth centuries within a comparative framework[1]. In the final section of *Secular Movements in Production and Prices*[2], published in 1930, Simon Kuznets argued that the volatility of industrial expansion tended to be directly related to its rapidity: the faster an industry grew, the larger were its relative deviations from trend likely to be[3]. To support this generalization, Kuznets examined production and consumption series covering a variety of mining and manufacturing commodities in five different countries. He first examined different industrial series within the same countries, and then examined the same industries in different countries, in both cases calculating rank order correlation coefficients between measures of rapidity and measures of volatility. His second set of calculations provided somewhat less support for his proposition than the first, largely because of the anomalous position of Germany. After comparing series on coal output for the five countries, Kuznets noted that "The outstanding discrepancy is Germany, where there is very rapid growth with mild cycles"[4]. Similarly, he observed, after examining pig iron output series for the U.S., the U.K., Germany, France, and Belgium, that "The most important single discrepancy is for Germany ... in this comparison, as in the case of coal, Germany combines rapid development with mild cyclical fluctuations"[5]. Again, after examining the steel series, he remarked: "The most important exceptions ... include again Germany and the United Kingdom; the cyclical fluctuations being lower in the former than one would expect from its rate of growth and higher in the latter"[6].

But although he reported these results, Kuznets did not devote especial attention to their explanation, beyond some remarks in the case of steel that "We may surmise that this is due to the differences in the national organization of the country", and in the case of coal and copper that

> "The mildness of cycles in coal may be a result of the extremely efficient organization of the industry in the Rheinisch Westphalian Syndicate, while the copper disturbances may have been accelerated by the international character of the copper market. *But this is pretty much a matter of conjecture*"[7] (my emphasis).

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1 Walter G. Hoffmann's work, *The Growth of Industrial Economies*, trans. from German by W. O. Henderson and W. H. Chaloner, Manchester/England 1958 is excluded here because it is primarily concerned with changes in the composition of manufacturing output, not with the relative amplitude of deviations from trend growth rates.

2 Kuznets, Simon S., *Secular Movements in Production and Prices: Their Nature and Their Bearing Upon Cyclical Fluctuations*, Boston 1930; reprint ed., New York 1967.

3 Kuznets distinguished between cyclical fluctuations, on the one hand, and primary and secondary secular movements, on the other. The secondary secular movements represent longer term fluctuations above and below trend, and are the origin of the concept of long swings, which Kuznets and others later developed.

4 Kuznets, *Secular Movements*, p. 279.

5 Kuznets, *Secular Movements*, p. 280.

6 Ibid.

7 Kuznets, *Secular Movements*, p. 276.

It is perhaps not entirely surprising that Kuznets let the matter drop: the German case, after all, was a puzzling anomaly which partially weakened the empirical case linking volatility to rapidity that he was trying to establish.

The second economist who has systematically addressed questions of both rapidity and volatility is W. Arthur Lewis. In *Growth and Fluctuations, 1870–1913*[8], published in 1978, almost five decades after Kuznets' work, Lewis also noted the anomalous combination of growth and nonvolatility in the German series. After comparing the indices of industrial output he had constructed for Germany, France, the U.K., and the U.S., Lewis wrote that "Germany stands out for the mildness of its fluctuations. In the whole period 1882 to 1913 there is no year in which production actually falls, and the average gap between actual output and potential output is much lower than for any other country"[9]. After noting that this conclusion was supported by trade union statistics on unemployment[10], Lewis went on to examine the extent to which differences in the pattern of foreign trade might help explain the relative *rapidity* of growth. Curiously, however, he dropped the comparative discussion of volatility, never to return to it.

It is indeed puzzling that the two economists who have undertaken detailed comparative analyses of the rapidity and volatility of German expansion have both noted this peculiar combination of rapid growth and mild fluctuations, and yet have both declined to pursue an explanation of this phenomenon. In Kuznets' case this was probably because it was something of an anomaly. Less explicably (since the title of his book suggests an equal concern with fluctuations), Lewis appears to have ignored the issue because he was more interested in examining the extent to which German fluctuations were in or out of phase with expansions and contractions in the U.S. or U.K. economies. This concern with timing rather than amplitude reflects a continuation of interests evident in previous comparative analyses of U.K.-U.S. growth experiences[11].

Given the absence of explanations of this phenomenon in the work of Kuznets and of Lewis, it is perhaps not altogether unexpected that discussions of this issue in textbooks, where it is addressed at all, tend to be opaque. For example, J. H. Clapham, in his still widely read *Economic Development of France and Germany, 1815–1914* (published in 1921) stressed the rapidity of growth but did not emphasize nonvolatility, although he may be referring to it elliptically in the following passage if we interpret taking a lead "with ... decision" to imply relatively lower volatility in industrial production series:

> "The period 1890–1910 is shown to have been that in which Germany took the lead in Europe with a speed and decision which confirmed the most confident faith of her people in their industrial and political future. Only the U.S. – half a rich continent – was ahead of her as an iron and steel producer"[12].

8 Lewis, W. Arthur, *Growth and Fluctuations, 1870–1913*, London 1978.

9 Lewis, *Growth and Fluctuations*, p. 43.

10 There are problems with these data having to do with differential selectivity in the industries covered over time, and comparing the two countries. For what they are worth, these data show the U.K. with an average unemployment rate of 4.3 percent (standard deviation 1.83) as compared with 2.45 percent (standard deviation 1.52) for Germany over the years 1888–1913 inclusive.

11 See, for example, Thomas, Brinley, *Migration and Economic Growth: A Study of Great Britain and the Atlantic Economy*, 2nd ed., Cambridge/England 1972.

12 Clapham, J. H., *Economic Development of France and Germany 1815–1914*, Cambridge/England 1963, p. 285.

Similarly, David Landes' treatment of this question in his more recently published and also widely read text, *The Unbound Prometheus,* lacks precision:

> "... so that once the setback of the mid-1870's was behind her, Germany resumed her high rate of growth. And she had not yet exhausted this momentum when the new opportunities at the end of the century gave her economy another push. As the result one has the impression of an uninterrupted rise. For Germany, however, the 1890's were a watershed"[13].

Even if we resolve the ambiguities regarding Landes's periodization of the German growth experience (is he arguing that Germany grew more rapidly in the 1890's than the 1880's?), it is still striking that he includes here no discussion of relative nonvolatility. One finds the same lacuna in W.O. Henderson's comparative treatment of German, French, and Russian industrialization in the 1815–1914 period, a treatment that also fails to mention the relative nonvolatility of German expansion[14]. On the other hand, Alan Milward and S.B. Saul, in their *Development of the Economies of Continental Europe, 1850–1914,* do recognize both the speed and nonvolatility of German industrial expansion, but they do not really attempt to explain this absence of volatility beyond analyzing skeptically the hypothesis that it was due to cartels[15].

In summary, neither in detailed comparative examinations of industrial expansion, nor in secondary works intended primarily as texts, do we find, where the problem is addressed at all, systematic analysis of the relative nonvolatility of German industrial expansion. Before attempting some steps in the direction of such an analysis, however, it is incumbent upon us to examine in fairly close detail the statistical series upon which the comparative proposition advanced at the start of this essay is based.

3. The Data

For the major industrializing countries in the late nineteenth century we have reasonably accurate year-to-year records on output or consumption for only a few relatively homogenous commodities. Five of the most important of these are: iron ore, coal, pig iron, and steel output, and raw cotton consumption. These physical production series cover the two key sectoral complexes of early industrialization and, along with others, are the raw materials from which indices of industrial output (which in turn influence estimates of GNP or national income) are calculated. The fluctuations in these series, if they are collected accurately, reflect overall variations in economic activity from year to year; they remain some of the more important indicators of economic activity in an advanced economy. Figures 1–5 plot logged values of these physical production and consumption series for Germany, the U.K., and the U.S. for the years 1871–1913. The beginning and end points

13 Landes, David, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present,* Cambridge/England 1969, p.236.

14 Henderson, W.O., *The Industrial Revolution in Europe: Germany, France, Russia, 1815–1914,* Chicago 1961.

15 Milward, Alan, and Saul, S.B., *The Development of the Economies of Continental Europe, 1850–1914,* Cambridge/Massachusetts 1977, pp.52–53.

for these series reflect common historical benchmarks. By 1871 the disruptions of trade and cotton supply due to the American Civil War were several years in the past, Germany was politically unified under Prussian leadership, and Alsace-Lorraine had been ceded to the German Empire by France. 1913 is, of course, the final year before the outbreak of World War I.

Figures 1–4, especially 1, 3, and 4, provide striking visual confirmation of the empirical propositions advanced at the start of this essay. Both the German and the U.S. series appear to grow faster than the corresponding U.K. series, but the German series appear much less subject to fluctuations than those for the United States. Although the major problem addressed in this paper is the explanation of the relative nonvolatility of the German series after 1880, we are also interested in verifying that part of the proposition adduced in the introduction dealing with relative rates of growth. If we assume, as a simplification, that the underlying trend in each series results from a constant proportional or percent growth over the previous year's value, then logging the values of the series makes it possible to estimate the growth rate of the untransformed series using a simple linear regression of these logged values on a time trend and a constant. In other words, if growth is occurring at a constant proportional rate subject to fluctuations due to a variety of disturbing factors, then we have a process of exponential growth subject, if our OLS assumptions are to hold, to a multiplicative disturbance term which implies, reasonably, that the absolute values of disturbances are larger for later years or, alternatively, for larger values of the dependent variables in a growing series.

$$y_t = ke^{Bt}e^{v_t}, \qquad v \sim N(0,\sigma^2) \tag{3.1}$$

$$\ln Y_t = \ln k + Bt + v_t, \qquad v \sim N(0,\sigma^2). \tag{3.2}$$

Ordinary least square regressions can provide us not only with a more precise estimate of the annual growth rate ($\hat{B}$), but also with a summary measure of the extent to which the actual series deviates from the estimated trend: the sum of squared residuals (*see Table 1*). Plotting these series in logged form has several advantages. First of all, a decline of one centimeter is equivalent to an equal percentage decline, regardless of the position of the series. Second, the absolute values of deviations from trends will be independent of the metric of the dependent variable. Thus measuring one series in thousands of bales of cotton, and the other in metric tons, for example, will not affect a comparison of summed squared residuals.

Comparisons of volatility between two time series usually involve examining ratios of the variance of residuals remaining after all systematic components have been removed from these series. Comparisons of the variance of such "white noise" processes can be made using sums of squared residuals divided by degrees of freedom: the ratio of two such estimates, each distributed as chi, will be distributed as F, and standard F tests can be applied[16]. Because the term volatility is used here in a slightly less restrictive sense – to include all deviations from simple exponential growth – serial correlation in the error terms

16 See Brownlee, K. A., *Statistical Theory and Methodology in Science and Engineering*, New York 1965, pp. 283–285.

Table 1: Linear Regressions of Time Trends on Data in Figures 1–5 (1880–1913)

Dependent Variable	$\hat{\alpha}$	$\hat{\beta}$	R^2	SSR
Log of Output of Iron Ore Germany	-85.67 (3.012)	+.0500735 (.00158822)	.9688	.264151
Log of Output of Iron Ore U.K.	+13.44 (3.900)	-.002033 (.002057)	.0296	.442885
Log of Output of Iron Ore U.S.	-118.20 (5.371)	+.06755 (.002832)	.9468	.839829
Log of Coal Output Germany (nonlignite)	-65.11 (1.258)	+.04035 (.000663)	.9914	.04606
Log of Coal Output Germany (lignite)	-107.86 (2.426)	+.06231 (.001279)	.9867	.171309
Log of Coal Output U.K.	-25.57 (1.266)	+.01993 (.0006673)	.9654	.046629
Log of Coal Exports U.K.	-68.09 (1.843)	+.04144 (.0009719)	.9822	.098917
Log of Coal Output U.S. (bituminous)	-119.078 (2.546)	+.06917 (.001343)	.9881	.188851
Log of Coal Output U.S. (anthracite)	-48.054 (3.434)	+.03115 (.001811)	.9024	.343421
Log of Pig Iron Production Germany	-96.40 (2.344)	+.0554 (.001236)	.9843	.160004
Log of Pig Iron Production U.K.	-6.49 (2.696)	+.008199 (.001421)	.5099	.211469
Log of Pig Iron Production U.S.	-113.40 (5.100)	+.06474 (.002689)	.9477	.75727
Log of Steel Output Germany	-173.00 (3.370)	+.0956 (.001777)	.9891	.330611
Log of Steel Output U.K.	-75.68 (4.690)	+.04426 (.002473)	.9092	.64051
Log of Steel Output U.S.	-178.75 (5.593)	+.09902 (.002949)	.9724	.910898
Log of Raw Cotton Consumption, Germany	-69.26 (2.494)	+.03947 (.001315)	.9657	.181032
Log of Raw Cotton Consumption, U.K.	-12.478 (2.303)	+.01007 (.001214)	.6823	.154372
Log of Raw Cotton Consumption, U.S.	-64.74 (2.868)	+.03837 (.001512)	.9526	.239470

Sources: See Figures 1-5.

remains, and F tests of relative volatility (at least volatility defined in the traditional sense) are not appropriate[17].

Nevertheless, the sum of squared residuals does provide a convenient summary measure of deviations from trends: a measure independent of the metric of the series that can be used to confirm our visual impressions. Pairwise comparisons are reported in *Table 2,* although no formal tests of significance are made.

Table 2: Ratios of Sums of Squared Residuals U.S. vs. Germany: U.K. vs. Germany (1880–1913)

Commodity	Country Comparison	Ratio of SSR's
Iron Ore	U.S. vs. Germany	3.18
	U.K. vs. Germany	1.68
Coal	U.S. Anthracite vs. German Nonlignite	7.46
	U.S. Bituminous vs. German Nonlignite	4.10
	U.K. vs. German Nonlignite	1.10
	U.S. Anthracite vs. German Lignite	2.00
	U.S. Bituminous vs. German Lignite	1.10
	U.K. vs. German Lignite	.27
Pig Iron	U.S. vs. Germany	4.73
	U.K. vs. Germany	1.32
Steel	U.S. vs. Germany	2.75
	U.K. vs. Germany	1.94
Raw Cotton	U.S. vs. Germany	1.32
	U.K. vs. Germany	.85

Sources: Figures 1-5.

17 Note that this broader definition of volatility includes both what Kuznets called "secondary secular movements" (eventually, long swings) and what he called cyclical variation. Both of these types of variations represent deviation from exponential growth, and are included in the sum of squared residuals. The use of an exponential form, rather than a more complex logistic or Gompertz curve is justified on the grounds that we are examining a relatively short period (34 years inclusive). Kuznets' series, by comparison, extend back as early as 1782 and as late as 1925. Note also that the listings of troughs in the text in general covers only the 1880–1913 period.

Let us examine these figures and tables more closely. *Figure 1* graphs logged values of iron ore output. After a boom and collapse in the first half of the 1870's, the German series grew steadily over the period 1880–1913 at an annual rate of just over 5 percent, experiencing minor downturns in 1886, 1891, 1901, and 1908. The U.K. series stagnates, perhaps suggesting a slight downward trend, although the regression on the 1880–1913 data reveals a statistically insignificant negative trend. Marked downturns are reflected in troughs in 1887, 1893, 1901, 1909, and 1912. The U.S. series grows very rapidly (at an estimated rate of over 6.7 percent a year after 1880), but appears substantially more volatile than the German series, an impression confirmed by the comparison in *Table 2*. Troughs appear in 1885, 1891, 1893, 1904, 1908, and 1911.

Figure 1: Log of Iron Ore Output: 1871–1913; U.K., U.S. (metric tons)

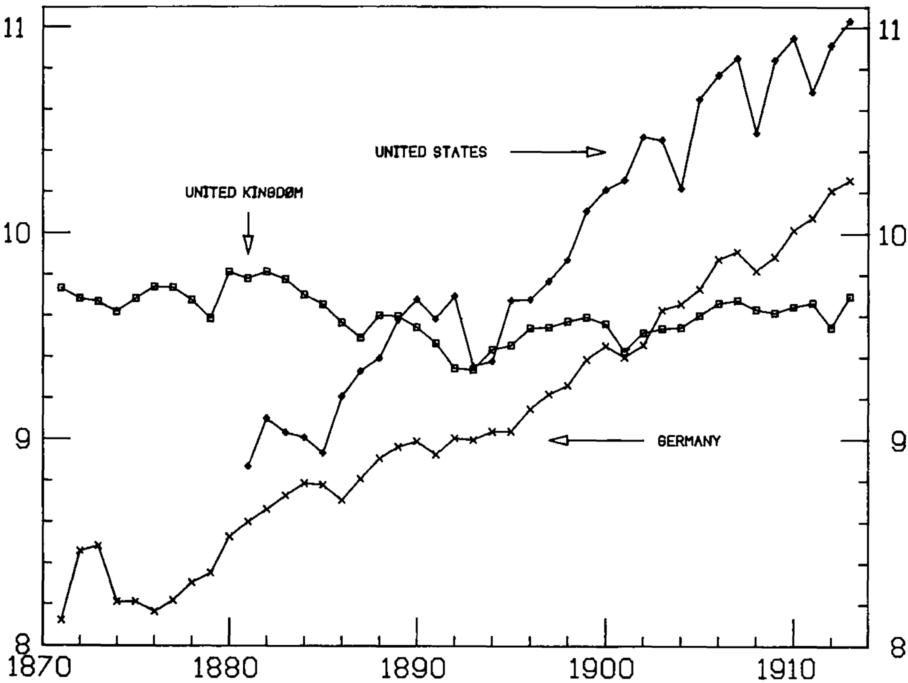


Figure 2 reports a variety of series on coal output. The German nonlignite series grows fairly steadily after 1876, experiencing slight retardations in 1892 and 1900/02. The German lignite series also grows steadily after 1871, at a slightly faster rate, estimated from the post-1880 data at about 6.2 percent a year, vs. a little over 4 percent a year for the nonlignite series. Post-1880 troughs include 1886, 1893, 1901, and 1910. U.K. coal output is growing very slowly (just under 2 percent a year), with slight downturns in 1886, 1893, 1901, 1908, and 1912. U.K. coal exports grow faster than output (over 4 percent a year), indicating that U.K. consumption was increasing even more slowly than U.K. coal output. The U.S. bituminous series grows very rapidly (almost 7 percent a year); the anthracite series more slowly (a little over 3 percent a year), but both appear substantially more volatile than either of the German series, the U.S. bituminous series evidencing troughs in 1889, 1894, 1904, 1908, and 1911, the anthracite series in 1894, 1897, 1900, 1902 (the year of a bitter coal strike), 1906, 1909, and 1912.

Figure 2: Log of Coal Output: 1871–1913; Germany, U.K., U.S. (metric tons)

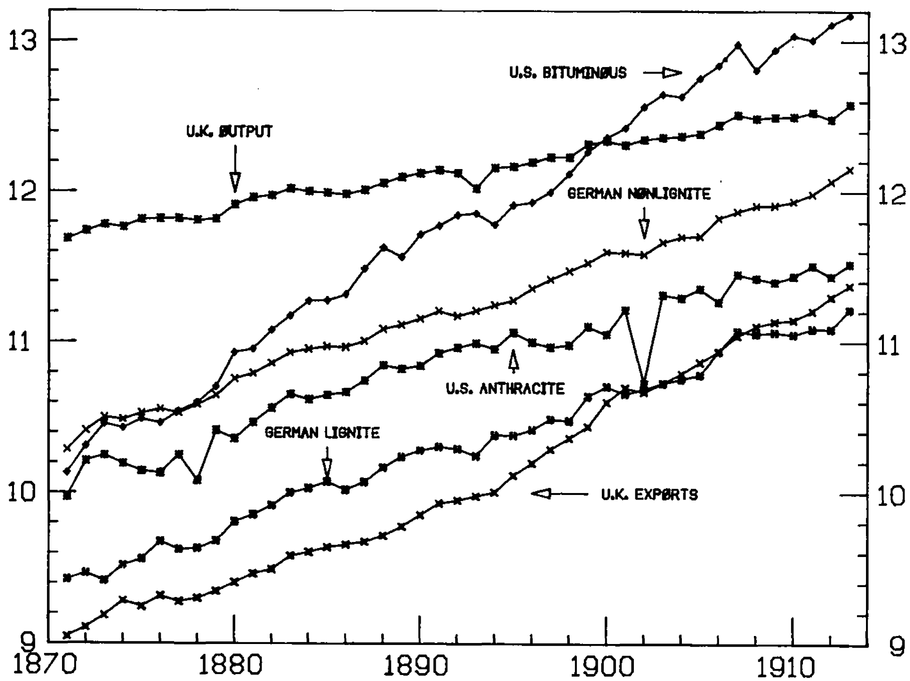


Figure 3, reporting pig iron output, reflects, as we might expect, some of the same patterns as *Figure 1*. Both the U.S. and the German series collapse in the middle 1870's. After this collapse, both series grow very rapidly (5.5 percent for Germany, 6.5 percent for the United States over the 1880–1913 period), but the relative magnitude of the downturns in the German series appears to be much smaller than those in the U.S. series. Distinct German troughs, for example, appear only in 1886, 1901, and 1908, whereas in the American case, we find troughs in 1885, 1891, 1894, 1896, 1904, 1908, and 1911. The U.K. series grows slowly (less than 1 percent a year) and appears to be intermediate between the U.S. and Germany in its volatility, distinct post-1880 troughs observable in 1886, 1892, 1898, 1901, 1904, 1908, and 1912. Note that the U.S. surpasses U.K. pig iron output for the first time in 1889; Germany does so in 1904.

Figure 3: Log of Pig Iron Output: 1871–1913; Germany, U.K., U.S. (metric tons)

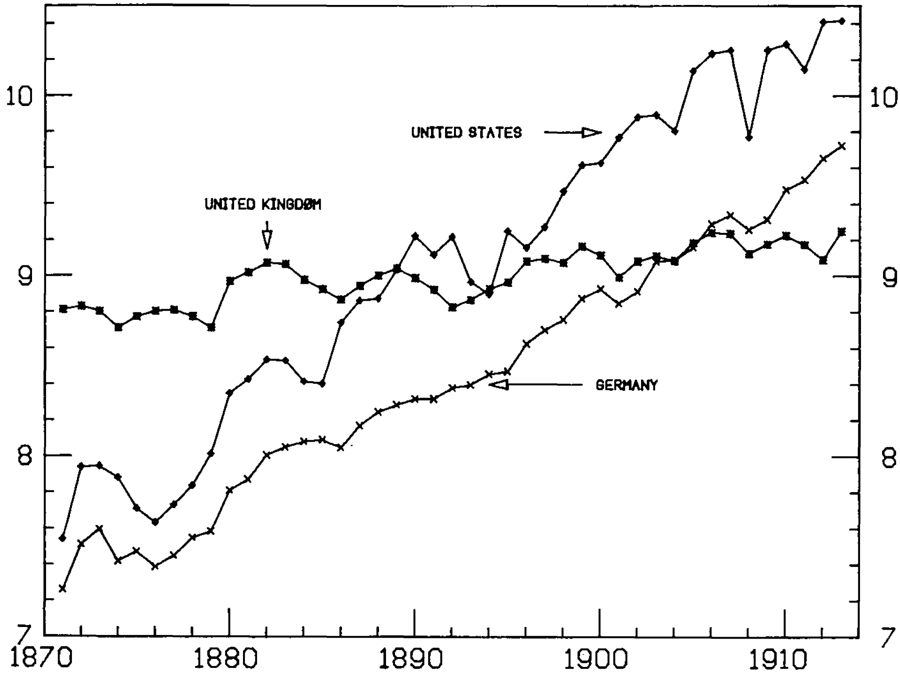
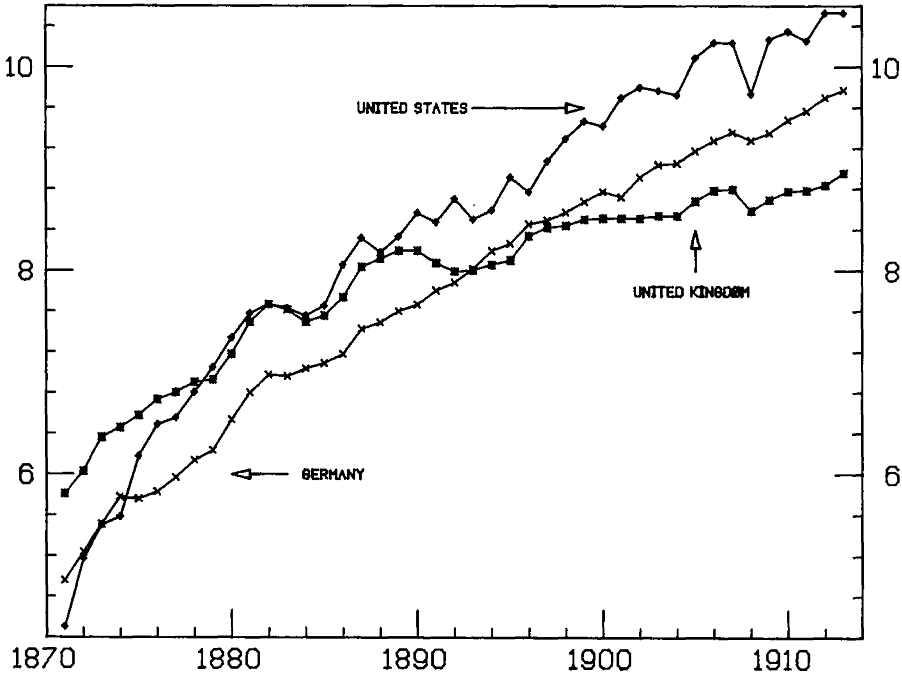


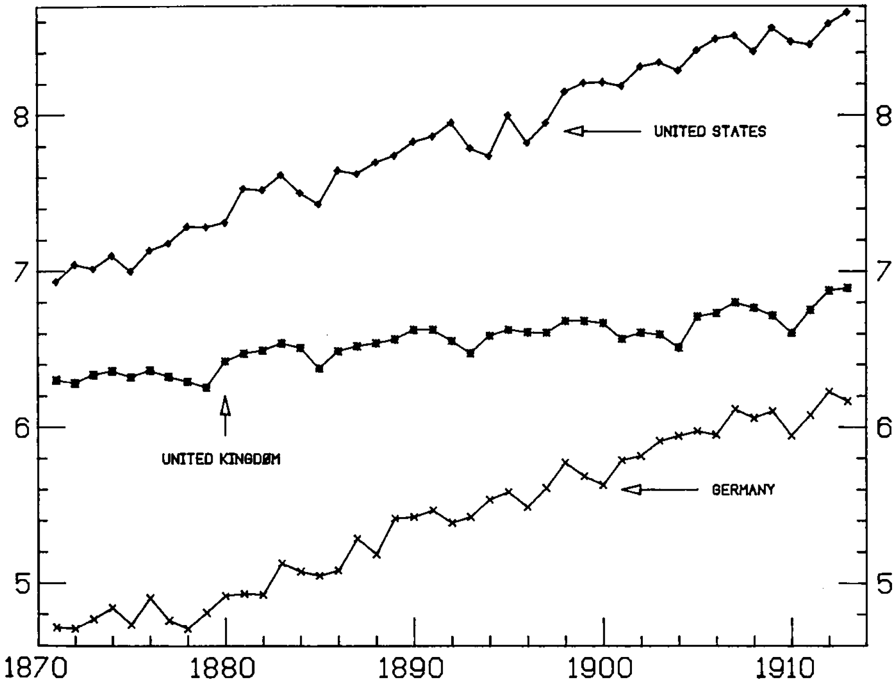
Figure 4 presents the steel series, which are particularly interesting, because we are here dealing with a product which is essentially new for all three countries. Although steel had certainly been available before the nineteenth century, *cheap* steel was the direct result of the development of the Bessemer converter, the Siemens-Martin open hearth, and the Gilchrist-Thomas basic processes which were only beginning to have their impact in the 1870's. For some of the other series we might argue that for the U.S. and Germany, we witness the middle section of a logistics curve, whereas in the U.K., a more mature economy, we see the righthand portion of such a curve as growth tapers off. In the case of steel, it is harder to make this argument, since it is a new product. All three series start off rapidly; both the U.S. and Germany starting behind Britain, but the U.S. clearly overtaking Germany in 1875 and the U.K. in 1879. Germany overtakes the U.K. in 1893. Both Germany and the U.S. grow at rates of over 9 percent a year; the U.K. figure is closer to 4.5 percent. But once again, the U.S. series appears significantly more volatile than the German (or the U.K.), with distinguishable troughs in 1884, 1888, 1891, 1893, 1896, 1900, 1904, 1908, and 1911, as compared with only 1901 and 1908 for Germany and 1884, 1893, and 1908 for the U.K.

Figure 4: Log of Steel Output: 1871–1913; Germany, U.K., U.S. (metric tons)



Finally, *Figure 5* graphs the series on raw cotton consumption. Both the U.S. and Germany grow at a rate of a little under 4 percent (vs. about 1 percent for the U.K.), but in this industry, the German series does not seem to be distinguished by its relative nonvolatility. In sum, with the possible exception of the cotton series, the proposition that German industrial expansion over the years 1880 to 1913 was significantly more rapid than the U.K. expansion, and substantially less volatile than that of the United States seems to be empirically justified by these data.

Figure 5: Log of Raw Cotton Consumption: 1871–1913; Germany, U.K. (metric tons); U.S. (1000 bales)



Of course, one can never entirely dismiss the possibility that these results are statistical artifacts. Perhaps the coverage of the German statistical apparatus was more limited or selective when compared with that of the United States. Perhaps the German data are, if not biased, simply less accurate. A couple of considerations may partially dispel the unease which comes from considering such possibilities. First of all, J. D. Clapham, writing at the conclusion of the period we are examining, and basing much of his work on the published statistical volumes of the German government, was impressed with the overall quality of these statistics. He observed, for example, that "The excellent German industrial statistics allow the development (of large scale manufacturing) to be studied with a precision impossible for France, England, or any other country"[18]. Second, the statistical apparatus was apparently not incapable of picking up serious downturns, as evidenced by the collapses or downturns reported in the iron ore, coal, pig iron, and cotton consumption series in the mid-1870's. Finally, post-1880 physical production and consumption series are probably more reliable than series that involve prices and values, and are also probably more reliable than production data for earlier periods in the nineteenth century. These observations give us some reason to have confidence that the phenomenon we have isolated is not a statistical artifact, but as Kuznets and Lewis both concluded, a real one. It is also in need of investigation.

4. Explanations

The economic history literature, as we have already seen, is not totally devoid of suggestions as to why German industrial output was relatively stable from 1880 to 1913, in comparison with the expansion of the United States during the same years, and in comparison with its own volatility in the pre-1880 period, especially the 1870's. Kuznets thought that this relative nonvolatility might be due to the influence of cartels. Cartel agreements were, of course, much more widespread in Germany than in the United States, and were legally enforceable in courts of law, reflecting a different legal environment than that which prevailed in the United States, especially after the passage of the Sherman Antitrust Act.

Although cartels may have been partially effective in smoothing out fluctuations, there are two reasons for questioning the overall importance of their contribution to the stability of the German industrial series. First, the number of industries that were effectively cartelized was relatively small: according to Milward and Saul, only in mining, paper-making and somewhat later, dyestuffs and organic chemicals, was more than 75 percent of output effectively controlled[19]. Second, *ceteris paribus,* the ability of a cartel to continue in operation diminishes with the severity of changes in demand or supply conditions which confront it. For example, in coal mining, one of the most effectively cartelized industries, "There is clear evidence that the control of markets and production still left the industry open to fluctuations of trade ..."[20]. In noting the growth of the cartel movement, and the relatively stable growth of German industrial output after 1880, we must beware of the *post*

18 Clapham, *Economic Development,* p. 287.
19 Milward and Saul, *Development,* p. 52.
20 Ibid., pp. 52–53.

hoc ergo propter hoc fallacy. To the extent that cartels appear to have been successful in reducing volatility in individual industries, this may have been, paradoxically, because the economic disturbances that had led to their formation did not reappear with the same severity after 1880.

Often associated with the emphasis on cartels is a discussion of the relatively greater role which investment banks played in Germany as compared with the United States or with England. Members of German investment banks often organized the placement of a company's equity issues, made direct loans to firms, and frequently sat on company boards[21]. Possibly these banks provided a more efficient mechanism of financial intermediation than existed in the United States: these institutions may have been more effective in channelling funds from savers who had surpluses to investors who had worthwhile projects. On the other hand, economic historians who have examined the workings of the U.S. financial system in the nineteenth century speak very highly of its efficiency[22]. But whereas it may have been relatively efficient in allocating loanable funds between regions, it may not have been terribly efficient in preventing periodic financial crises. Certainly it was the perception of a historically unstable financial structure that motivated the creators of the Federal Reserve system. The role of the United States financial system in contributing to instability in investment behavior cannot be dismissed out of hand.

Another familiar explanation is the rise of protectionist sentiment and policy in Germany. The great movement toward trade liberalization rationalized by the writings of Adam Smith and David Ricardo, and reflected in the 1786 Eden treaty and the 1860 Cobden-Chevalier treaty between England and France, and the complete elimination of the duty on foreign pig iron in Germany in the early 1870's was reversed in Germany by the collapse of the German iron industry in the mid-1870's and the growing influx of cheap agricultural commodities from outside of Europe. This shift from free trade to protection happens to coincide with the beginnings of very rapid and stable growth in the late 1870's and early 1880's. But one must be skeptical here as well. The German tariffs were not exclusionary: Clapham argues that the tariff, at least that on manufacturers, "was never excessive and compared favorably, from the point of view of an exporting manufacturer in another country, with that of most great powers"[23]. Furthermore, effective levels of protection in the U.S. were far greater throughout this period than those in Germany, making it difficult to use the presence of increasing protection in Germany after 1880 as a simple explanation of the differences between the stability of the industrial expansions of these two countries.

Some writers have suggested that export performance may help explain the relative rapidity of German growth as compared with England. In addition to her efficient iron and steel sector, Germany developed internationally competitive engineering, electrical machinery and chemical industries, and competed effectively against British manufacturers in markets, especially Continental markets, that England had formally dominated[24].

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21 For a study based on archival and econometric evidence of the role of private banks and Kreditbanken in facilitating industrial investment, see Neuberger, Hugh, *German Banks and German Economic Growth from Unification to World War I*, New York 1977.

22 Davis, Lance, u. a., *American Economic Growth: An Economist's History of the United States*, New York 1972, Chapter 10.

23 Clapham, *Economic Development*, p. 322.

24 Hoffman, Ross, J.S., *Great Britain and the German Trade Rivalary 1875–1914*, Philadelphia 1933.

Is it possible that the key to the nonvolatility of her expansion is also to be found in the export structure? Was Germany, because of its strategic geophysical situation, facing both toward Central Europe and toward the Atlantic, perhaps insulated from shocks peculiar to one or the other region? Some economic historians have indeed argued, at least implicitly, that the greater relative volatility of demand for U.S. exports, particularly cotton and wheat, may have been associated with the relative severity of fluctuations in its industrial sector. On the other hand, Germany was not a small country industrializing primarily as the result of export-led growth (although in *absolute* terms, Germany had, by the start of the First World War, become the world's second largest exporter). With a relatively affluent population of almost 65 million in 1910, Germany had a very large internal market. Henderson, for example, remarks that the growth of the German iron industry was based primarily on the internal market[25]. An explanation of the relative nonvolatility of the German vs. the U.S. industrial series based on export structure would have to argue (a) that volatility in export demand had a significant impact on the volatility of domestic production, and (b) that the demands for German exports were, on balance, relatively more stable than those for exports from the United States.

This discussion of exports, generally considered a component of autonomous expenditure, is an appropriate point to ask from a theoretical perspective where we should *expect* to find the sources of instability in an industrializing economy. Suppose we consider a very simple Keynesian model of income determination, in which aggregate demand is a function of consumption expenditures, investment, government expenditure, and exports less imports, with consumption and imports each a linear function of income:

$$Y = C + I + G + X - M \tag{4.1}$$

$$C = a + \beta Y \tag{4.2}$$

$$M = \gamma + \delta Y \tag{4.3}$$

which reduces to

$$Y = \frac{(a - \gamma + I + G + X)}{(1 - \beta + \delta)}. \tag{4.4}$$

The fundamental distinction in this simple model is between variables which are exogenous, or autonomous (I, G, X), and those which are not (C, M, and Y). Of course, I, G and X are never totally independent of the level of domestic economic activity, past and present. But as a first approximation, it may be helpful to assume that they are, which implies that the sources of instability in aggregate demand are to be located in one or some combination of the three components of autonomous expenditure: I, G, or X. In comparison with the twentieth century, G was relatively unimportant at this time. As indicated above, export behavior does warrant scrutiny. But for the moment, let us focus on the third component of autonomous expenditure, investment.

In the late nineteenth and early twentieth centuries, two of the most important components of gross and net investment were expenditures on residential construction and expenditures on the construction of railroads. Between 1879 and 1908, U. S. Gross New

25 Henderson, *Industrial Revolution in Europe*, p. 68.

Construction totalled over 14 percent of GNP – almost two thirds of total Gross Capital Formation (21.6 percent of GNP). Housing and railroads, in turn, were a large fraction of total construction: Between 1880 and 1899 non-farm residential construction averaged 41 percent of all gross new construction and expenditures on railroad construction averaged 19.4 percent[26]. The large and often extremely volatile residential housing cycle has indeed played an important part in our understanding of cyclical fluctuations in advanced economies[27]. W. Arthur Lewis, in *Growth and Fluctuations*, reports graphically two series for each of the four core industrial economies he studied: one is a series of industrial output indices, the other a series of deviations from trend in indices of construction activity[28]. After the 1870's, the German construction plot hugs the horizontal axis, in comparison with the corresponding series for the other core countries. Simply examining these graphs, one might conclude that the relative stability of the growth of German industrial output was due to or at least associated with the relative nonvolatility of its construction sector.

Lewis refers to upswings in these series sometimes as building booms and sometimes as construction booms. The usage is confusing: a building boom might mean a boom in one component of construction (structures) or it might mean a boom in all construction activity. This confusion is not clarified by looking behind Lewis's German construction series, which consists before 1890 solely of Hoffmann's series on timber production, and after 1890, solely of timber and bricks[29]. If the hypothesis one derives from Lewis's graphs is that the German residential construction cycle was less volatile than that of the U.S., one would have to object on the basis of work by Manuel Gottlieb. Gottlieb has attempted to document long swings in German residential construction using tax, building permit, and insurance data, and his data show that there are cycles within German residential construction expenditure that are as important as those which characterize the American building series[30].

Railroad construction, by contrast, is not emphasized by Lewis. Although post-1880 expenditures on railroad construction in both countries are generally less than those for residential construction, there is a long tradition in American economic history that emphasizes the importance of the railroad in nineteenth century economic development. Fifteen years ago Robert Fogel challenged that tradition, citing critically Herman Kroos's general description of the railroad as "the principal single determinant of the levels of investment, national income, and employment in the nineteenth century"[31]. More specifical-

26 Abramovitz, Moses, *Evidence of Long Swings in Aggregate Construction Since the Civil War*, NBER Occasional Paper No. 90, New York 1964, pp. 13–14. The first calculation is based on current prices. The second uses 1919 prices.

27 See, for example, Long, Clarence D., Jr., *Building Cycles and the Theory of Investment*, Princeton 1940; Hickman, Bert G., *Growth and Stability of the Postwar Economy*, Washington 1960, pp. 306ff.

28 Lewis, *Growth and Fluctuations*, pp. 18, 23.

29 Lewis, *Growth and Fluctuations*, pp. 270–271.

30 Gottlieb, Manuel, *Long Swings in Urban Development*, New York 1976, p. 325.

31 See Fogel, Robert W., *Railroads and American Economic Growth: Essays in Econometric History*, Baltimore 1964, pp. 9, 129–206; Kroos, Herman E., *American Economic Development*, Englewood Cliffs 1959, p. 439. Indeed, Fogel's finding that the backward linkages were relatively *weak* in the United States between 1840 and 1860 combined with Fremdling's finding that the linkages in Germany were relatively *strong* over a similiar period in one sense nicely complements my hypothesis that the relative importance of the linkages in the post-1880 period in the two countries was reversed. It also suggests that, *ceteris paribus*, if we compare the growth experience of the countries in the 1880–1913 period with, let us say, the 1840–1860 or 1840–1880

ly, Fogel challenged Walt Rostow's emphasis on the railroad as a leading sector in the economic growth of the United States, by attempting to estimate the strength of the backward linkages from the railroad to the coal, iron, machinery, transport equipment, and lumber sectors during the years 1840 to 1860. This is a legitimate procedure since Rostow does identify the takeoff in the United States with the years 1843 to 1860. Nevertheless, Fogel's work does not examine backward linkages in the post-Civil War pre-World War I period, in spite of the fact that his social savings calculations apply to 1890. Even the limited amount of data surveyed in this essay suggest that at least for the 1880-1913 period, Kroos's statement cannot be dismissed out of hand.

In contrast to Fogel, Rainer Fremdling has resurrected Rostow's argument that railroad investment acted as an important leading sector in nineteenth century economic development, by arguing on the one hand that for Germany Rostow's characterization is eminently reasonable, and on the other hand that Fogel and Hawke have dismissed too lightly Rostow's case for, respectively, the U.S. and U.K. economies[32]. Similarly, Carl Holtfrerich, examining the 1851–1892 period, concluded that it was railroads, rather than coal, that qualify for designation as a leading sector in Germany[33]. Reinhard Spree's work on German growth and cycles between 1840 and 1880 also emphasizes the very influential role of railroad investment in determining the level of overall economic activity during these years[34].

However, the time periods covered in all three of these analyses tend to precede the tremendous expansion of industrial output in Germany in the decades before the First World War. It may well be that the relative importance of German railway investment between 1840 and 1880 precluded its playing as influential a role in the period after 1880, at least in comparison with the situation in the United States. If one examines a map of the German railway network, even as early as 1850, one is struck by the extent to which the main elements of that net are already in place[35]. The U.S. was a very much larger country. Even though the U.S. population was only 42 percent greater than the German population in 1910 (92.4 vs. 64.9 million), the entire German empire, including Alsace Lorraine, and the territories which are now part of Poland and the Soviet Union, could comfortably have been squeezed into the single American state of Texas. Partly because of its larger size and relatively lower population density, American railway investment tended to be much larger absolutely and in comparison to total population or total industrial output.

U.S. railway trackage peaked in 1916 with a little over a quarter million miles (410,268 kilometers) of railway track owned. The German trackage peaked in 1913 at 63,378 kilometers. Therefore, although U.S. population was only a little more than 1.4 times German population in 1910, its peak rail trackage was almost 6.5 times that of Germany. If we

period, U.S. growth should have been more uneven in the latter period than the earlier period, whereas in Germany, the reverse should have been true.

32 Fremdling, Rainer, *Railroads and German Economic Growth: A Leading Sector Analysis with a Comparison to the United States and Great Britain*, in: Journal of Economic History, Vol. 37 (1977), 3, pp. 583–604.

33 Holtfrerich, Carl-L., *Quantitative Wirtschaftsgeschichte des Ruhrkohlenbergbaus im 19. Jahrhundert*, Dortmund 1973, p. 184.

34 Spree, Reinhard, *Die Wachstumszyklen der deutschen Wirtschaft von 1840 bis 1880*, Berlin 1977, pp. 261–330.

35 Kobschätzky, Hans, *Streckenatlas der Deutschen Eisenbahnen, 1834–1892*, Düsseldorf 1971.

take these figures as indicating the high water marks for the diffusion of this revolutionary transportation innovation, we can work backward and ask what percent of the "final" rail net was in place in various years. Performing this calculation for 1880 (*Table 3*), we find, somewhat unexpectedly, that the final U.S. rail net was only a little more than a third complete at that date, whereas the German net was already more than half in place. The U.K. net, by comparison, was more than three-quarters complete.

Table 3: Percent of Final Railway Net Complete, 1880

	1880 Trackage	Peak Trackage	% Complete
U.K.[a]	25,060	32,349 (1928)	76.3
Germany[a]	33,838	63,378 (1913)	53.4
U.S.[b]	148,385	410,268 (1916)	36.2

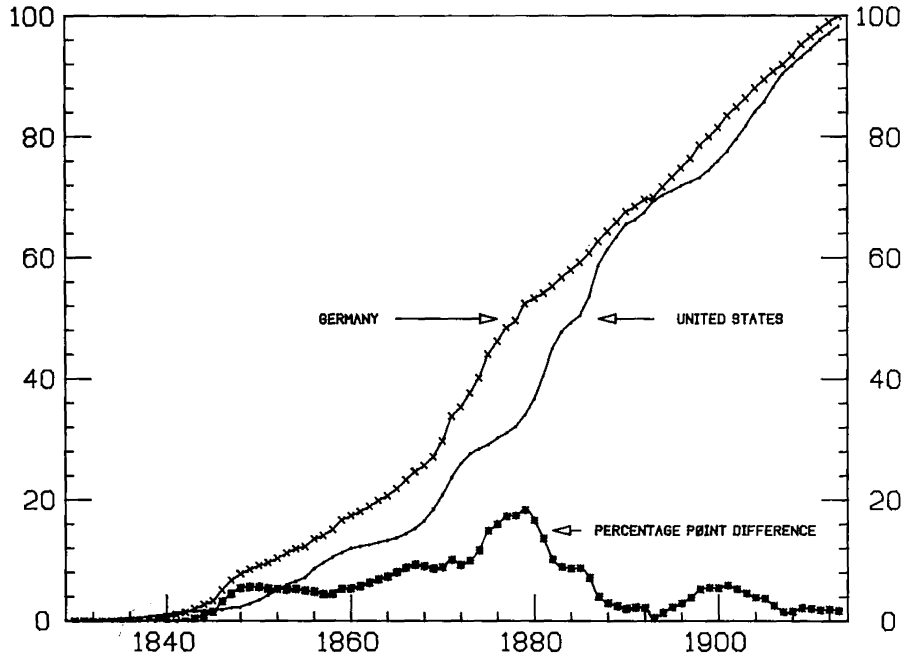
[a] Length of railway line open as reported in Mitchell (1976), pp. 583-584 (kilometers).

[b] 1880: Road owned, as reported in Historical Statistics II (1975), Series Q-322, p. 731 (converted to kilometers).

1916: Road owned, as reported in Historical Statistics II (1975), Series Q-287, p. 728 (converted to kilometers).

Figure 6 plots the percent of the final rail net in place against time from 1830 to 1913 for both the U.S. and for Germany. Although the U.S. is actually ahead of Germany in 1841, after 1845, a decisive gap opens up between the two countries, a gap which is underestimated slightly for the pre-1871 figures because the German data do not include Alsace-Lorraine trackage. The graph also contains a plot of the percentage point difference between the completion levels of the rail net in the two countries, a gap which peaks in 1879. The American percentage completed then rises rapidly, almost to meet the German figure in 1893, but then falls back again, rising again toward the German figure in 1908. In comparison with Germany, it is clear that the U.S. had, in 1880, a substantially larger fraction of its rail net still to be laid down.

Figure 6: Percent of Final Rail Net Complete; Germany and the U.S.: 1830–1913

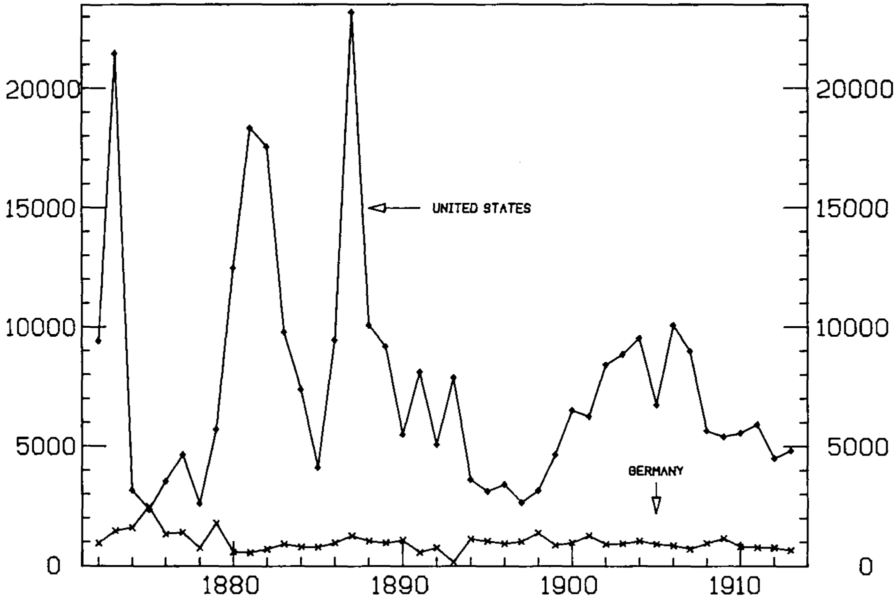


If one calculates the first differences in cumulated track length, one has a rough proxy for net investment in railroads[36]. It is only a proxy because it does not capture the increasing importance of investment in double tracking, switching yards, more complex rolling stock, stronger bridges, curve straightening, and so forth, which causes the net investment figures in the U.S., for example, to peak in 1910, substantially after the annual additions to track miles peaks[37]. Nevertheless, the turning points of the investment or rail consumption series do correspond roughly with turning points of the net additions to trackage series[38]. *Figure 7* plots the values of these annual net additions for Germany and the United States. Not only are these increments substantially larger on average in the U.S. than in Germany, but the

36 Spree, *Die Wachstumszyklen,* p. 270.
37 Kuznets, Simon, *Capital in the American Economy: Its Formation and Financing,* Princeton 1961, p. 328.
38 Abramovitz, *Evidence of Long Swings,* p. 28.

US. series is more volatile. At the peak of the rail boom in 1887, U.S. steel output was a little more than 2.4 times that of Germany, but the U.S. net increment to trackage was more than 18.4 times the German increment. By contrast, in the railroad trough in 1897, U.S. net additions to trackage were only 2.6 times the German, and the steel multiple had dropped to 1.8. To some degree the relative stability of the German increments to trackage series may reflect the nationalization of the Prussian railroads after 1880[39]. But a more obvious factor is simply that a significantly larger fraction of the German rail net had already been completed as of 1880.

Figure 7: Net Increments to Trackage (kilometers); Germany and the U.S.: 1872–1913



39 Fremdling, Rainer, *Freight Rates and State Budget: The Role of the Nationalized Prussian Railways 1880–1913*, in: Journal of European Economic History (forthcoming).

If one views the volatility of the investment sector (and perforce, the economy as a whole) as largely due to a combination of a residential housing sector in Germany as volatile as that in the U.S. (24 million more people lived in German cities of more than 2,000 in 1910 than had in 1870, and they all had to be housed)[40] and a railroad component which was (a) correlated with the construction cycle in both countries, (b) much more volatile in the U.S., and (c) much larger and relatively more important in the U.S. than in Germany[41], one may begin to understand why the volatility that appears in the U.S. iron ore, coal, pig iron, and steel (but not cotton) series is substantially greater than that apparent in the corresponding German industrial output series. For railroad construction had a dual influence on the demand for iron and steel and related products. In addition to a direct demand for rails, locomotives and other equipment, there were indirect multiplier effects resulting from the armies of railway construction workers assembled. When these were laid off, not only did direct demand for rails and locomotives drop, but so too did demand for consumer iron and steel using durables.

Let us go back to *Figure 7*. The U.S. additions to trackage series bottoms out nine times between 1880 and 1913: in 1885, 1890, 1892, 1895, 1897, 1901, 1905, 1909, and 1912. Now turn back to *Figure 4*. The U.S. output of steel also bottoms out nine times during these same years: in 1884, 1888, 1891, 1893, 1896, 1900, 1904, 1908, and 1911, exactly one year in each case (except for 1888 and 1893 which lead by two years) before additions to track mileage bottoms out. This is not to suggest that fluctuations in iron and steel output were causing fluctuations in the railroad series; rather, that the additions to trackage represent the coming onstream of projects which had had their impact on the steel industries somewhat earlier. Similar, but somewhat less striking relationships exist between the pig iron/iron ore and coal troughs and the additions to trackage series.

What about Germany? The German additions to trackage series also bottoms out nine times over this 34 year period – in 1881, 1889, 1891, 1893, 1896, 1899, 1902/3, 1907, and 1913. By contrast, these fluctuations appear to have had very little effect on any of the German industrial series, which bottom out, in general, much less frequently than the comparable U.S. series. The decline in additions to trackage in 1893 appears to have had no effect on any of the German industrial series. On the other hand, the 1896 trough in German iron ore and pig iron output is not echoed in the railroad figures at all.

More systematically, equations 4.5 and 4.6 attempt to explain changes in logged steel output by logged increases in railroad trackage for the *subsequent* year. We also include in these regressions a time trend (YR) and a YR^2 term to take account of the curvature of these series, and reduce somewhat the serial correlation in the error terms. Results indicate a statistically significant elasticity of .19 for the United States, and a small and statistically insignificant elasticity in the German case (t statistics are in parentheses)[42]. Roughly speak-

40 Clapham, *Economic Development*, p. 278. Between 1871 and 1910 German rural population remained constant at about 26 million, but the urban population grew from a little under 15 million to almost 39 million.

41 Lewis, for example, when combining his indices of mining and manufacturing with the construction index, uses weights of 9 and 1 in Germany, vs. .857 and .142 for the United States. See Lewis, *Growth and Fluctuations*, pp. 271, 274.

42 If one runs the U.S. regression including a YR^3 and a YR^4 variable, the Durbin Watson statistic rises to 1.46 (still in the grey area), the estimate on the trackage variable drops to .165, with a t statistic of 3.52. In an unpublished memorandum, J. Krengel has questioned the method of constructing the steel series reported in Mitchell. However, these regression results are not modified if one uses as a dependent variable in the German case Krengel's series for steel production.

ing, this means that if the U.S. increment to trackage is to go up 100 percent next year, we would predict that U.S. steel output would go up by about 19 percent this year, based on the estimates from these regressions.

United States*

$$\ln STEEL = \underset{(3.645)}{0.1924} \ln TRACK\Delta_{+1} + \underset{(7.747)}{6.937} YR - \underset{(-7.613)}{.0018} YR^2 - \underset{(-7.873)}{6668.7} \qquad (4.5)$$

$R^2 = .9845$ D.W. = 1.1316

Germany*

$$\ln STEEL = \underset{(.8009)}{.0256} \ln TRACK\Delta_{+1} + \underset{(12.30)}{4.768} YR - \underset{(-12.03)}{.0012} YR^2 - \underset{(-12.55)}{4604.81} \qquad (4.6)$$

$R^2 = .9966$ D.W. = 1.0346

The final figure in this paper, *Figure 8,* plots Hoffmann's series on investment in German railroads and investment in nonagricultural residential construction in current prices for the years 1851–1913. This table shows that the relative importance of German railroad investment in comparison with investment in residential housing declined dramatically in the early 1880's. Railroad investment in Germany averaged only about 26 percent of investment in residential construction between 1880 and 1913, and after 1884, rose above 33 percent (slightly) in only 5 years. By contrast, in the United States, railroad investment averaged 47 percent of investment in residential housing between 1880 and 1899 and over 53 percent between 1890 and 1913[43]. These data provide further support for the proposition that because of the relatively early completion of a substantial fraction of the final German rail net, the relative importance and volatility of German railway investment declined in the late nineteenth century. The relative unimportance of this traditionally volatile component of investment may provide a partial explanation both for the relative stability of industrial growth in Germany after 1880, and for its relative stability vis-a-vis the industrial expansion of the United States, a much larger, less densely settled country, that still had a very large fraction of its rail net to lay down. That process, in retrospect, was not a smooth or continuous one.

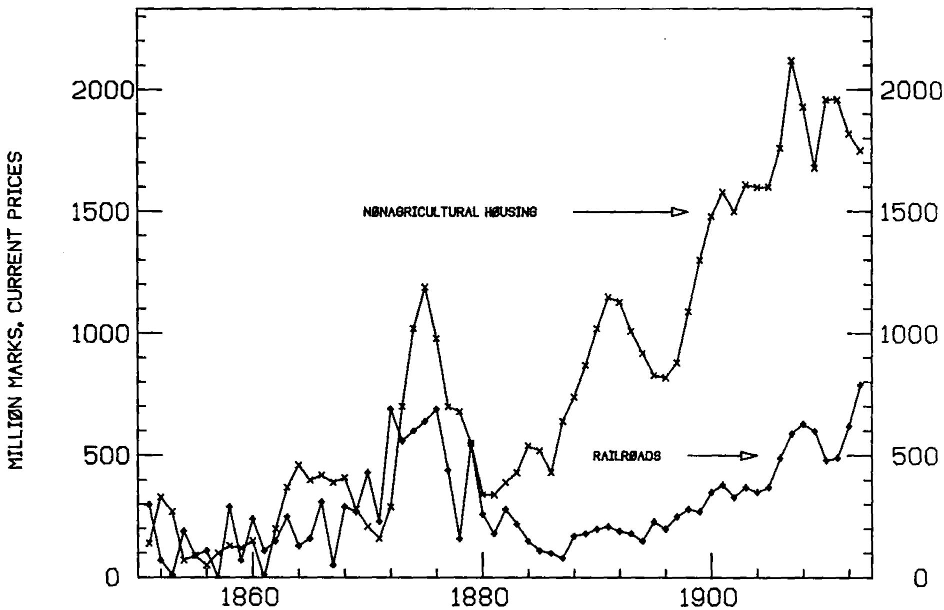
5. Conclusion

The argument that fluctuations in industrial output in the United States were related to fluctuations in U.S. railroad investment leaves open the question of why U.S. rail investment was so volatile. Moses Abramovitz has suggested that railroad booms may in

*n = 41 (1872–1912); the method of estimation was ordinary least squares.

43 Abramovitz, Moses, *Evidence of Long Swings in Aggregate Construction Since the Civil War*, NBER Occasional Paper No. 90, New York 1964, p. 15. These statistics are derived from Abramovitz' table of the composition of gross new construction in 1919 prices in various years.

Figure 8: Investment in Railroads and Housing; Germany: 1851–1913



part have been related to booms in demand for U.S. exports such as wheat and cotton. As a result of these booms and the operation of the gold standard, argues Abramovitz, nominal income increased in the U.S., and railway profits soared, since the marginal costs of the traffic increases associated with the export booms were relatively low. The increased cash flow not only made possible increased finance by retained earnings, but also made it easier to float equity issues by buoying share prices, and made it easier to float loans (issue bonds) by improving credit ratings. The undertaking of large lumpy construction projects, in turn, sustained an industrial boom well beyond the period in which it would have faltered in the absence of the projects until eventually, as immigration slowed, housing construction faltered, and imports of British financial capital tapered off, the boom collapsed[44].

44 Abramovitz, Moses, *The Passing of the Kuznets Cycle*, in: Economica (1968), pp. 349–367; *The Monetary Side of Long Swings in U.S. Growth*, CREG Memorandum No. 146, Stanford/California (1973).

Although Abramovitz carefully qualifies all of these propositions, his analysis does suggest that, on balance, railroad investment responded to revivals in commercial conditions. By contrast, John Partington examined the 1870–1926 period, and concluded that "in a majority of business revivals ... railroad buying revived some months before commercial and industrial activity appears to have begun its recovery"[45]. This difference in emphasis indicates that the factors lying behind the volatility of the U.S. rail trackage series are in need of further investigation. In understanding the volatility of U.S. rail investment, it is also of some importance to investigate the proportion of such investment that involved extensions of lines into previously unserved agricultural hinderland, as opposed to the construction of new trunk lines. In the case of the latter, there would presumably have been a much greater incentive to continue building to completion regardless of business conditions, whereas in the former case, one might have been more willing to stop in midstream, since a partially completed project could still generate income.

Although more research is needed on the determinants of the volatility of U.S. rail investment, an initial step in explaining the differences in volatility of industrial output series in the U.S. and Germany is the recognition of the critical importance of the relative size and volatility of rail investment in these two countries after 1880 and before World War I. In his work on the United States, Simon Kuznets identified both railroads and residential construction as "population sensitive" in the sense that they were associated with "long swings" in migration[46]. Although investment in residential construction does appear to have been sensitive to swings in migration in both countries, investment in German railroads, at least after 1880, does not, especially in comparison with the United States[47].

Comparative analyses often reveal problems which may not be apparent when one focusses solely on one country. In the 1970's, German economists have viewed single digit annual rates of price increase as evidence of rampant inflation, which seems exaggerated from the standpoint of American or British observers. Similarly, many scholars, in focussing on the absolute levels of late nineteenth century German fluctuations, may have failed adequately to consider what is really the more striking phenomenon: the relative absence of fluctuations when compared with other rapidly growing industrial economies, especially that of the United States. This paper has tried to remedy this situation by focussing within a comparative framework on some of the characteristics of the German economy which may have been associated with its record, after 1880 and before World War I, of rapid growth with mild fluctuations.

45 Partington, John E., *Railroad Purchasing and the Business Cycle,* Washington/D.C. 1929.

46 Kuznets, Simon, *Capital in the American Economy: Its Formation and Financing,* Princeton 1961.

47 Indeed, according to many historians, it was the rail net itself that stimulated much of the German migration by lowering transport costs and speeding the diffusion of information on employment opportunities in the industrial and mining areas. Clapham quotes Treitschke: "It was the railways which first dragged the nation from its economic stagnation; they ended what the Zollverein had only begun; with such power did they break in upon all the old habits of work, that already in the forties the aspect of Germany was completely changed." Clapham, *Economic Development,* p. 150.

6. Summary

German industrial expansion in the period 1880–1913 was significantly more rapid than that of the United Kingdom, and substantially less volatile than that of the United States. A partial explanation for the relatively stable growth path of the German economy during these years may be found in the greater relative importance and volatility of the railroad construction component of net investment in the United States. By 1880 only a little over one-third of the U.S. final rail net was in place, compared with over half in the case of Germany. Compared to Germany, railroad investment in the United States between 1880 and World War I was, on average, much larger absolutely. It was also much larger in comparison to total population, total industrial output, and in comparison to expenditures on residential construction. In addition, it was more volatile. The lesser importance and volatility of this component of autonomous expenditure in the German case partially accounts for the relative nonvolatility of the German industrial output series.

Zusammenfassung: Vergleichende Analyse der relativen Stabilität des industriellen Wachstums in Deutschland und den USA, 1880–1913

Die deutsche Industrie wuchs von 1880 bis 1913 deutlich rascher als die Großbritanniens und unter geringeren Schwankungen als die der USA. Hier wird folgender Erklärungsansatz vorgeschlagen: Im Jahre 1880 war in den USA erst etwas mehr als ein Drittel des endgültigen Eisenbahnnetzes fertiggestellt, in Deutschland dagegen schon mehr als die Hälfte. Zwischen 1880 und 1913 war der Umfang der Eisenbahnbau-Investitionen in den USA durchschnittlich erheblich größer als in Deutschland. Diese besaßen auch ein stärkeres Gewicht, z.B. im Vergleich zur Gesamtbevölkerung, zur industriellen Produktion und zu den Wohnungsbau-Investitionen. Noch bedeutsamer aber war vielleicht ihre starke Fluktuation. Die größere Stabilität der deutschen Eisenbahnbau-Investitionen und ihr kleiner Anteil am gesamtwirtschaftlichen Investitionsvolumen erklären zum Teil, warum das Wachstum der deutschen Industrie während des Untersuchungszeitraums relativ geringe Schwankungen aufwies.

Appendix: Sources of Figures

Figure 1:
Germany: B.R. Mitchell, *European Historical Statistics, 1750–1970*, New York 1976, p.388; based on W.G. Hoffmann, u.a., *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*, Berlin usw. 1965, based in turn primarily on *Statistisches Jahrbuch für das Deutsche Reich* (1880–1914) and *Statistik des Deutschen Reichs* (1873–1914).
U.K.: Mitchell (1976), based on *Statistical Abstract of the United Kingdom* (1871–1914).
U.S.: U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970*, Washington 1975, Part 1, pp. 599–600, Series M-205. Yearly data available commencing in 1881.

Figure 2:
Germany: Mitchell (1976), p.362, based on Hoffmann (1965).
U.K.: Mitchell (1976), pp.364, 411.
U.S.: U.S. Bureau of the Census (1975) I, pp.589–90, 592–93; Series M-93 and M-123.

Figure 3:
Germany: Mitchell (1976), p.393.
U.K.: Mitchell (1976), p.393.
U.S.: U.S. Bureau of the Census (1975) I, pp.599–600, Series M-217.

Figure 4:
Germany, U.K.: Mitchell (1976), pp.399–400.
U.S.: U.S. Bureau of the Census (1975) II, pp.693–94, Series P-265.

Figure 5:
Germany: Mitchell (1976), pp.429–30 (Net Imports of Raw Cotton).
U.K.: Mitchell (1976), pp.429–30 (Estimated Raw Cotton Consumption).
U.S.: U.S. Bureau of the Census (1975) II, p.689, Series P-228 (Raw Cotton Used in Textiles).

Figures 6, 7:
Germany: Mitchell (1976), Series G-1, pp.583–584.
U.S.: U.S. Bureau of the Census, *Historical Statistics* II (1975). 1830–1870: Road operated, Series Q-321; 1871–1890: Road owned, Series Q-322; 1891–1913: Road owned, Series Q-287 (pp.728–731).

Figure 8:
W.G. Hoffmann, *Das Wachstum der deutschen Wirtschaft*, Table 42, pp.259–260.