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ABSTRACT

The United States became a net exporter of manufactured goods around 1910 after a dramatic surge in iron and steel exports began in the mid-1890s. This paper argues that natural resource abundance fueled the expansion of iron and steel exports in part by enabling a sharp reduction in the price of U.S. exports relative to other competitors. The commercial exploitation of the Mesabi iron ore range, for example, reduced domestic ore prices by 60 percent in the mid-1890s and was equivalent to nearly 30 years of industry productivity growth in its effect on iron and steel export prices. The results are consistent with Wright's (1990) finding that U.S. manufactured exports were natural resource intensive at this time and have implications for recent work suggesting that resource abundance may be a curse rather than a blessing for economic development.

Douglas A. Irwin
Department of Economics
Dartmouth College
Hanover, NH 03755
and NBER
douglas.irwin@dartmouth.edu

1. Introduction

For most of the nineteenth century, the United States had a strong comparative advantage in cotton and agricultural goods and, as a result, was a substantial net importer of manufactured goods. From the antebellum period until the early 1890s, manufactured goods comprised about 20 percent of U.S. exports and roughly 50 percent of U.S. imports.

In the mid-1890s, however, exports of American manufactures surged. Manufactured goods jumped to 35 percent of U.S. exports by 1900 and nearly 50 percent by 1913. As Figure 1 illustrates, the United States suddenly and rapidly shifted from being a large net importer to a net exporter of manufactured goods between 1890 and 1913. In just two decades, the United States reversed a century-old trade pattern based on its specialization in agricultural products.

What accounts for this abrupt change in the structure of U.S. exports? Why was the 1890s the transitional decade for U.S. trade patterns rather than some earlier or later period? A shift in comparative advantage toward manufactured goods could be driven by changes in factor endowments or technological change, but at the aggregate level these explanations apparently fail to explain the striking discontinuity in U.S. exports after the early 1890s. America's growth in capital per worker and in total factor productivity in manufacturing was not unusually rapid during the 1890s, nor did agriculture experience a noticeable collapse.

Raw materials abundance has been proposed as an alternative explanation for America's export success during this period. Wright (1990) examines the factor content of U.S. net exports of manufactures from 1879 to 1940 and finds that they were intensive in non-reproducible natural resources. That the newly emergent U.S. comparative advantage in manufactures hinged on an abundance of such raw materials as iron, copper, and petroleum is supported by Lipsey's (1963, p. 59) observation that "the composition of manufactured exports has been changing ceaselessly since 1879 in a fairly consistent direction — away from products of animal or vegetable origin and toward those of mineral origin." Vanek (1963) also stresses the importance of natural resource abundance in shaping U.S. trade during this period. These works, however, do not explicitly link the changes in raw materials abundance to changes in the composition of U.S. exports.

This paper seeks to understand the rapid growth of manufactured exports by focusing on the driving force behind the dramatic change in the commodity composition of U.S. exports: the iron and steel industry. This industry demonstrates the link between the exploitation of natural resources and the expansion of manufactured exports: the initial surge of iron and steel exports during the 1890s can be traced to the opening of the Mesabi iron ore range in Minnesota, which resulted in a 60 percent decline in the domestic price of iron ore between 1894 and 1899. The lower domestic price of iron ore helped to reduce the relative price of U.S. iron and steel exports significantly and, according to results reported below, was equivalent to nearly 30 years of productivity improvements in the industry. Resource abundance provided not just a one-time improvement in the competitive position of American iron and steel producers, but also, it is argued, increased the elasticity of export supply such that growth in world demand would result in a larger U.S. share of the world market.

Understanding the basis for the U.S. export success during this pivotal period has implications for several related research questions. A recent literature (for example, Nelson and Wright 1992 and Broadberry 1997) takes an international comparative approach to exploring America's rise to industrial leadership, a clear manifestation of which is the change in trade pattern at the end of the nineteenth century. Yet with the exception of Wright (1990), most of this literature has focused on international comparisons of aggregate or sectoral output and productivity rather than addressing trade developments directly. In addition, Sachs and Warner (1995), Mikesell (1997), Anderson (1998), and others have considered whether raw materials abundance is a curse rather than a blessing in promoting economic development. This raises the question of why natural resource abundance was apparently beneficial in the U.S. case and how the situation may be different for developing countries today.

Section 2 of this paper provides details on the surge in U.S. manufactured exports from the mid-1890s and describes how natural resource developments helped propel this growth. Section 3 seeks to disentangle various demand- and supply-side hypotheses regarding the growth of U.S. exports. A system of equations representing world demand and supply of iron and steel products is estimated and then subjected to counterfactual analysis to gauge the relative contribution of raw materials prices, productivity improvements, and shifts in world demand to export growth. Section 4 summarizes the main findings.

2. The U.S. Export Boom after 1895

The explosion of U.S. manufactured exports in the mid-1890s, dubbed by European observers as the "American Commercial Invasion," followed several decades in which U.S. trade had been relatively stagnant and its commodity composition relatively stable. The volume of U.S. exports crept up only 30 percent in the fifteen years between 1880 and 1895 (Lipsey 1963, p. 144). Exports continued to be dominated by raw cotton and agricultural products, particularly meat and dairy products and grains, while manufactured goods comprised a stable 20 percent of total exports.

Starting around 1895, however, U.S. manufactured exports surged. The value of manufactured exports rose from $205 million in 1895 to $485 million in 1900, increasing its share of total exports from 25.8 percent to 35.3 percent (U.S. Bureau of the Census 1975, series U 213-218). In this five year period, the volume of manufactured exports rose an astonishing 90 percent (Lipsey 1963, p. 144). Export growth then virtually stopped between 1900 and 1908, when overall export volume was unchanged while that of manufactures crept up at a much slower pace. Between 1908 and 1913, manufactured exports surged again, rising in volume by 77 percent in those five years and bringing the manufactured share of total exports to nearly 50 percent. World War I and the 1920s propelled the U.S. net export position in manufactures to even higher levels, but the key transition for this development was clearly the two decades after 1895.

A. Factors Behind the Export Surge

Changes in aggregate factor endowments, such as a more rapid accumulation of capital and productivity improvements in comparison to one's trading partners, could be expected to expand a country's manufactured exports. To attribute the sharply discontinuous export surge from the mid-1890s to these factors, one would expect to see a pronounced rise in capital per worker or in productivity during this period compared with, for example, the United Kingdom, then the world's leading exporter of manufactured goods. Figure 2 depicts relative U.S.-U.K. output per worker, capital per worker, and total factor productivity in manufacturing during this period (taken from Broadberry 1997, p. 106). In the 1880s, a decade in which there was essentially no change in the commodity composition of U.S. trade, capital per worker in U.S. manufacturing rose rapidly compared to the United Kingdom. During the 1890s, a period in which U.S. exports of manufactures expanded rapidly, growth in capital per worker in U.S. manufacturing increased relative to Britain but at a much slower pace. The relative productivity performance of U.S. manufacturers was essentially unchanged throughout this period. Thus, in some sense, changes at the aggregate level fail to provide an obvious explanation for the timing of the export surge because there are no striking developments in the 1890s that would lead one to single out that decade as the one in which the structure of U.S. exports would undergo a sharp change.

Yet capital accumulation and technological change almost surely contributed to the export surge in some way, so perhaps these aggregate movements mask important changes at the industry level. Indeed, the export boom was not broadly-based across manufacturing industries but concentrated in iron and steel products. Table 1 presents the leading U.S. exports between 1890 and 1913 and shows that iron and steel was the largest category of manufactured exports. Iron and steel exports jumped from 4.0 percent of all exports in 1895 to 9.0 percent in 1900. In these five years, the volume of iron and steel exports rose by a factor of more than six, as shown on Figure 3 (Lipsey 1963, p. 257).[1] The ratio of iron and steel exports to production rose from 4.4 percent in 1889 to 11.7 percent in 1899 (Statistical Abstract of the United States 1904, pp. 218, 522).

Exports of all iron and steel products increased sharply in these five years. The largest single category was machinery, which included engines, electrical machines, sewing machines, typewriters,

[1] Lipsey presents two series for iron and steel exports, one for semimanufactured exports (069) and another for manufactured exports (070). This paper uses a value-weighted average of these two series to represent overall iron and steel exports (the weights are from Lipsey 1963, pp. 168-69).

cash registers, printing presses, etc. Other prominent categories included steel rails, pipes and fittings, wire, tools, locks and hinges, billets, and structural iron and steel. Europe and North America were the most important destinations for these exports. Iron and steel exports to Europe grew from $8.5 million in 1895 to $45.8 million in 1900, while exports to North America (mainly structural steel to Canada and steel rails to Mexico) grew from $14.1 million in 1895 to $42.4 million in 1900. Much of this export growth took place in what had been traditional British export markets; in fact, exports of iron and steel to the United Kingdom rose from $4.6 million in 1895 to $21.2 million in 1900 (U.S. Department of Commerce and Labor 1907, p. 41).

As shown in Figure 3, however, export growth slammed to a halt between 1900 and 1908. The export volume of iron and steel products was even slightly lower in 1908 compared with 1900. After 1908, these exports surged again: the iron and steel export volume rose by a factor of more than two in the five years to 1913. In this second surge, the iron and steel share of total exports rose from 10.0 percent in 1908 to 12.5 percent in 1913, but this time export growth matched the growth in domestic production as the ratio of iron and steel exports to production fell from 11.7 percent in 1899 to 10.5 percent in 1909 (Statistical Abstract of the United States 1915, pp. 436, 452, 192).

The key to understanding the changing composition of U.S. exports, therefore, involves an explanation of why American iron and steel products suddenly became competitive on world markets in two distinct phases after 1895.

B. Explaining the Iron and Steel Export Surge

Various explanations for the dramatic rise in American iron and steel exports during the 1890s have been proposed. Some economists have embraced a "demand-side" explanation for the post-1895 export surge. One demand-side story suggests a growing preference for U.S. products rather than a sudden increase in demand for U.S. goods. In the case of agricultural implements, McLean (1976) argues that U.S. products were ingeniously designed and marketed and therefore increasingly attractive to farmers overseas. Yet McLean quotes foreign observers in the 1870s who were favorably impressed with American products, suggesting that U.S. firms were producing ingenious products throughout this period. This hypothesis fails to explain the post-1895 export surge unless there was an identifiable burst of ingenuity around the turn of the century. Exports of new and innovative goods (such as automobiles, phonographs, and electrical products) increased rapidly, but started from such a small base such that they constituted a minute part of the overall export growth.

In reference to U.S. machinery exports to the United Kingdom, Nicholas (1980) proposes an alternative demand-side explanation. He suggests that U.S. exports rose as a result of the inability of capacity-constrained British producers to fill a sudden increase in orders. In Nicholas's (pp. 588, 583) view, "the experience of the American engineering exports to Britain provides little support for the view that American manufactured exports in the 1890s were becoming price competitive on a world scale. . . . The trend in relative prices, which shows a slight rise in U.S. machinery prices relative to U.K. prices in the 1890s, is inconsistent with a sharp outward movement in supply." Yet Figure 4 (to be discussed further below) shows that both surges were associated with a sharp decline in the price of U.S. iron and steel exports relative to those of the United Kingdom, then the world's leading exporter of such products.[2]

Others have proposed supply-side explanations that focus on the improved competitive position of U.S. producers. Contrary to Nicholas (1980) but consistent with Figure 4, Floud (1974) presents evidence that the export surge in machinery in the late 1890s was associated with a pronounced fall in the relative price of U.S. machinery, the source of which was not clearly identified. Such a shift in supply was less likely the result of capital accumulation than productivity advances. Capital accumulation was not particularly rapid in the iron and steel industry: during the 1890s, the average annual increase in the total (real) capital stock was 3.3 percent for iron and steel products compared with 5.3 percent for total manufacturing (Creamer, Dobrovolsky, and Borenstein 1960, p. 25). Productivity growth, however, was much more rapid in iron and steel than in other manufacturing industries: between 1899 and 1909, total factor productivity increased 2.7 percent annually in the primary metals industry and 2.3 percent in the fabricated metals industry, compared with just 0.7 percent in manufacturing overall (Kendrick 1961, p. 136). The improved technological efficiency of U.S. producers may explain why the export growth was so concentrated in one particular manufacturing sector rather than being broadly based.

Allen's (1979, p. 931) study of international iron and steel competition in the late nineteenth century supports this view. He concludes that "America's competitive strength [in iron and steel around 1910] was not the result of low input prices" but rather greater efficiency that led to lower costs.[3]

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[2] The relative price decline during 1887-1890 was associated with a doubling of iron and steel exports, but from a very small base.

[3] Allen (1979, p. 915) states in the introduction to the paper, however, that "By 1913, . . . American costs had fallen below British costs, party due to Britain's relative inefficiency, but more

Between 1889 and 1902, for example, Allen (1981) calculates that the unit cost of U.S. steel rails declined 19 percent, almost entirely due to productivity improvements that reduced costs by 21 percent, while his calculated input costs rose 2 percent. Between 1902 and 1910, he finds that input prices rose 5 percent while productivity increased 7 percent, thereby reducing unit costs 3 percent.

Other supply-side explanations emphasize America's natural resource abundance and the access of U.S. producers to cheap raw materials. "A fundamental strength of the American industry was its supply of rich iron ores," write Carr and Taplin (1962, p. 246).[4] This factor, which is obvious at one level, has been relatively neglected by economic historians but deserves elaboration in light of Wright's (1990) finding that the factor content of U.S. net exports indicates intensive use of non-renewable natural resources. Arguably the most important development in the iron and steel industry in the 1890s was the commercial exploitation of iron ore in the Mesabi range of Minnesota. Mussey (1905, pp. 378-79) called it the "most remarkable deposit of high-grade iron-ore known to-day. . . . its reserves are supposed to be twice as great as those of all the old ranges combined, and the Lake Superior mines led the world even before the Mesabi was discovered." Even more remarkable than its enormous size was the ore's location close to the earth's surface, which made strip mining a viable and extremely inexpensive extraction technology.

The Mesabi opening in 1892 had dramatic consequences. Minnesota accounted for just 6 percent of U.S. iron ore production in 1890, but 24 percent in 1895 and 51 percent in 1905 (Warren

importantly to lower input prices in America . . ."

[4] As the American Iron and Steel Association (1901, p. 4) put it, "No country in the world possesses the raw materials for the manufacture of iron and steel in such abundance as the United States."

1973, p. 116). As Figure 5 illustrates, the price of iron ore plunged by about 60 percent when the Mesabi shipments hit the market, from about $5 to $6 per ton in the early 1890s to about $2 to $3 per ton by the mid-1890s (Mussey 1905, p. 166; Lake Superior Iron Ore Association 1938, p. 322).

This steep fall in the price of iron ore significantly reduced the prices of final iron and steel products. Table 2 presents the cost structure of U.S. blast furnaces and shows that iron ore comprised nearly 60 percent of the materials costs of producing blast furnace products (mainly pig iron) in 1890. A 60 percent decline in the price of iron ore, if fully passed through to the value of products, would imply a 34 percent reduction in the material costs of producing pig iron, or a 26 percent reduction in its price (assuming a constant markup). Pig iron, in turn, comprised 50 percent of the materials costs (and 32 percent of the value) of steel works and rolling mills, including various products such as steel rails and wire. If a vertically-integrated firm simply passed on the lower ore prices through to costs, then the 34 percent reduction in materials costs would imply a 17 percent reduction in the material costs of rolling mill products. Thus, in an extremely short period of time, the lower ore price could translate into a 15 to 20 percent cost reduction for a range of iron and steel products.

As Figure 4 shows, such dramatic reductions are clearly evident in the export prices of U.S. iron and steel products around this time. Between 1892 and 1898, when overall export prices fell 16 percent, the export price of iron and steel products fell 24 percent (Lipsey 1963, p. 252). This price reduction significantly improved the comparative cost position of domestic producers because British iron and steel export prices were essentially flat during this period, falling 5.3 percent between 1892 and 1898 but rising 1.1 percent between 1893 and 1898 (Silverman 1930, p. 147).

The sharp fall in the relative price of U.S. iron and steel exports shocked their British rivals, who sought to determine if this development was temporary or permanent.[5] As a result of a June 1898 visit to the United States, the authors of one British report concluded "that Lake Superior iron ores are likely to have a considerable and permanent effect in cheapening iron and steel and all goods made therefrom through the markets of the world; and that they will tend to encourage the production of such goods, and especially of ocean going ships and engines at United States ports to a hitherto unprecedented extent" (Head and Head 1899, p. 646). The British Iron Trade Association later concurred, stating that the Mesabi region "has been, for several years past, the main factor in determining the cost and the conditions of supply of Lake Superior ores, has practically revolutionized the circumstances of the iron ore industry of the United States during that period, and may be regarding as mainly responsible for the low prices since prevailing" (Jeans 1902, p. 32).

After plummeting in the mid-1890s, however, the domestic price of iron ore rose sharply around 1900 and subsequently remained at a higher level.[6] Several factors account for the higher price of ore. A "corner" on the Lake freights in 1900 succeeded in doubling freight rates and increased delivered ore prices by 12 percent in that year (U.S. Commissioner of Corporations 1912, p. 139). The "concentration of ownership of Lake iron-ore properties in the hands of very few concerns, and particularly in the hands of the [U.S.] Steel Corporation" was an even more important factor, according

[5] "The recent unexpected invasion by American competitors of market which had hitherto been considered exclusively British has naturally somewhat disturbed home producers, among whom there are those who question the allegation that the mineral resources of American iron and steel masters are superior to those available here," began one report (Head and Head 1899, p. 624).

[6] The average quoted prices at lower Lake ports for Mesabi Bessemer ore rose 56 percent from its 1898-99 average to its 1902-1906 average (U.S. Commissioner of Corporations 1912, p. 139).

to a government report investigating anti-competitive practices by that company (Commissioner of Corporations 1912, pp. 139-140). Andrew Carnegie began purchasing many of the iron ore-producing districts around Lake Superior in 1894 and by 1907 U.S. Steel owned 75 percent of total ore deposits of Minnesota (U.S. Commissioner of Corporations 1911, p. 58). "It may be stated here, . . . as a notorious and incontrovertible fact, that the price of Lake Superior ore during the greater part of 1902 to 1906 . . . has been established in large measure by agreement among the principal ore-producing interests" (p. 140). The government believed that it had found "convincing evidence that the present profits on Lake Superior ore are noncompetitive as well as excessive" and reported a 33 percent profit margin on Bessemer ores over 1902-06 period (U.S. Commissioner of Corporations 1912, p. 43).

These higher prices helped bring the export boom to an abrupt halt at the turn of the century. But iron and steel exports surged once again after 1908 as world demand soared. U.S. producers were aided by a dramatic rise in British export prices in 1912, when a national coal strike, compounded by a railwayman's strike, stopped production at U.K. ore mines for nearly two months. British pig iron prices rose about 30 percent in that year partly due to the coal shortage. While still feeling the effects of "unusually high coke prices," British producers also sought to set prices collectively to undermine a growing secondary market, a scheme that "resulted in widely fluctuating but generally artificially inflated prices" (Carr and Taplin 1962, pp. 238, 236). Thus, British producers missed the opportunity to capitalize on the sharply higher world demand for iron and steel products during this period, while high domestic prices led to increasing U.K. imports of such products. Meanwhile, U.S. producers filled the gap cause by Britain's difficulties and saw their exports expand rapidly at virtually unchanged export prices.

The United States, therefore, became a net exporter of manufactured goods largely on the strength of two incredible five-year export surges, between 1895 and 1900 and between 1908 and 1913, in iron and steel products. Figure 4 strikingly illustrates that both export booms were associated with a sharp decline in the price of U.S. iron and steel exports relative to those of the United Kingdom. The next section attempts to determine the contribution of various factors — lower raw materials prices, a shift in demand toward U.S. products, more rapid technological change by U.S. producers — to the U.S. export expansion during this period.

3. Sources of U.S. Export Success in Iron and Steel

This section develops an econometric model of iron and steel exports from the United States and United Kingdom to evaluate the contribution of changes in raw materials prices, productivity, and world demand on U.S. export growth. A complete model would take into account the many sources of world supply, but the analysis is simplified here to focus on U.S. exports relative to those of the United Kingdom, then the world's leading exporter of iron and steel. Most U.S. and U.K. exports were sold to third markets (that is, outside of each others's market to such destinations as Canada, Australia, Mexico, and elsewhere) in which they were competing against one another.

The model has two sources of export supply, the United States and the United Kingdom, which are imperfect substitutes for one another in satisfying the rest-of-world demand. Conceptually, an increase in world demand for iron and steel products would lift the export prices and volumes of both countries, although the country with the higher export supply elasticity would see its exports increase by a greater proportion. Alternatively, a shift in U.S. export supply, the result of either lower materials prices or productivity improvements, would increase U.S. exports, drive down the world price, and reduce U.K. exports. An imperfect substitutes model based on this general framework can be estimated and then used to determine the relative contributions of shifts in export supply and world demand to the expansion of U.S. exports.

A. Model Specification and Estimation

The empirical specification is similar to Head (1994) and will focus on the aggregate quantity of iron and steel exports rather than on a specific product such as pig iron, steel rails, machinery, structural steel, or wire and nails. The relative rest-of-the-world demand for U.S. and U.K. exports is specified as:

$$Q_{US}/Q_{UK} = (\alpha_{US}/\alpha_{UK})(P_{US}/P_{UK})^{-\beta}$$

where Q is the quantity and P is the price of iron and steel exports (the subscripts indicate the United States and the United Kingdom). U.S. export volume relative to that of the United Kingdom depends upon the ratio of export prices and α_{US}/α_{UK}, which allows for an asymmetry in demand if $\alpha_{US}/\alpha_{UK}= \exp(\alpha_0/\alpha_1 t + \varepsilon_t)$, where α_0 captures the fixed and α_1 the time-varying (t) components of demand while ε_t is a disturbance. Taking logs, we have:

$$\log (Q_{US}/Q_{UK})_t = \alpha_0 + \alpha_1 t - \beta \log (P_{US}/P_{UK})_t + \varepsilon_t,$$

where β represents the elasticity of substitution between U.S. and U.K. exports in world demand. This specification is standard in econometric efforts to estimate the elasticity of substitution between competing products (see Reinert and Roland-Holst 1992), although in this case the relative price will be endogenously specified.

Inverse U.S. export supply is represented by a similarly log-linear equation:

$$\log (P_{US})_t = \gamma_0 + \gamma_1 t + \gamma_2 \log (P_{ORE})_t + \gamma_3 \log(P_{COAL})_t + \delta \text{ (U.S. Steel)}_t + \omega_t$$

where P_{ORE} is the domestic price of iron ore, P_{COAL} is the domestic price of coal, and U.S. Steel is a dummy variable representing the formation of the U.S. Steel Corporation (which takes the value of 1 from the year 1901). This allows us to test the hypothesis that the U.S. Steel consolidation resulted in a higher markup of prices above materials costs; the above specification implicitly assumes a fixed and a time-varying markup except for the U.S. Steel formation. The time trend captures the changes in export prices that cannot be attributed to the other independent variables and will be taken as indicating technological progress. The inverse export supply equation of the United Kingdom is similarly specified and includes a dummy variable for period of producer collusion in 1912-13, as discussed above.

Table 3 presents the results of estimating the relative demand and two supply equations by three-stage least squares, which allows for contemporaneous correlation between the three error terms. The elasticity of substitution between U.S. and U.K. iron and steel exports is estimated to be -1.9. This elasticity of substitution is slightly lower than that found in contemporary estimates of the elasticity for more disaggregated categories of iron and steel products (as in Reinert and Roland-Holst 1992). The imperfect substitutability of the products of the two countries may be due to the dissimilar product mix in the characteristic, quality, or delivery aspects of the products. While there was initially a preference for British products as indicated by the negative constant term (α_0), the coefficient on time (α_1) suggests that this eroded significantly over time (8.6 percent per year).

Turning to the supply equation for the United States, the coefficient on time (taken to reflect the productivity growth of domestic producers) indicates that export prices experienced an annual reduction of 0.8 percent, on average, after controlling for other factors affecting prices. The elasticity of iron and steel prices with respect to ore prices and coal prices was 0.34 and 0.10, respectively. This implies that a 60 percent decline in the price of ore, as experienced in the mid-1890s, should reduce the price of final iron and steel products by 20 percent, consistent with the earlier calculation. The coefficient on the U.S. Steel dummy variable indicates that, after controlling for input prices, iron and steel export prices were, on average, 23 percent higher after the industry consolidation in 1901. This is similar to Allen's (1981, pp. 522-23) finding that markups in the steel rail industry rose 18 percent between 1889 and 1902.

The export supply equation of the United Kingdom indicates that prices were sensitive to changes in iron ore prices and less sensitive to coal prices. The coefficient on time is suggestive of much slower annual technological progress (at 0.4 percent per year) relative to the United States, consistent with Allen's (1977) work. Wald tests reject the hypothesis that the coefficients on iron ore and on time (productivity) are equal for the two countries, suggesting potentially important differences in the effects of productivity growth and iron ore prices on the respective export prices.

The appendix reports results for two other specifications that serve as robustness checks on the coefficients found here. A first-difference specification has little impact on the key parameters of interest, the elasticity of substitution and the coefficients on the price of iron ore. Another specification includes wages and lagged cumulative production experience (from 1880) as explanatory variables in the export supply equations. Wages were a small part of production costs for the U.S. industry (about 10 percent of the value of output in 1890, according to Table 2) and although the estimated coefficient in the U.S. case is 0.11, it is statistically insignificant. Lagged cumulative production experience captures the effects of any price reductions that might be due to country-specific learning-by-doing. The coefficients are roughly the same magnitude in both the United Kingdom and the United States, but are also statistically insignificant. Such effects might be present at the product level, as Head (1994) finds is the case for steel rails, but they do not appear at the aggregate level.

B. Counterfactual Implications and Assessment

The parameter estimates for the demand and supply equations can be used in conjunction with different counterfactual paths for the raw materials prices and technological progress to determine the relative contribution of supply and demand factors behind the U.S. export surge. Table 4 shows the export and import volumes of the United States and the United Kingdom. U.S. exports were just 1 percent of U.K. exports in 1890, but they jumped to 25 percent by 1900 and to 38 percent by 1913. How did this enormous relative growth occur?

Three counterfactual scenarios are considered for two different time periods, 1892-1899 and 1892-1913. The first counterfactual is the impact of the Mesabi iron ore shipments on U.S. iron and steel exports. The previous section observed that iron ore prices fell about 60 percent immediately after the opening of the mine in 1892, so the counterfactual scenario is that this price reduction is eliminated. The second counterfactual scenario is the absence of productivity growth in the U.S. industry after 1892. The third scenario is the absence of a demand shift toward U.S. products after 1892 (i.e., no change in "$_1$ after that date).

The bottom panel of Table 4 gives the percentage contribution of each factor to the growth in U.S. iron and steel exports relative to those of the United Kingdom, specifically, the U.S. market share, or U.S. exports over the sum of U.S. and U.K. exports. For the first surge, from 1892 to 1899, the decline in the price of iron ore accounts for about 30 percent of the increase in relative U.S. iron and steel exports. The demand shift is a slightly larger factor while productivity is less important over this short horizon. Other factors, such as a decline in the relative U.S. price of coal, shown in Figure 7, also account for a large proportion of the U.S. increase.

For the entire period, 1892 to 1913, the contribution of lower iron ore prices is slightly larger than that of productivity growth, although they are roughly comparable. This result can be explained as follows. The Mesabi opening is assumed to be a once-and-for-all 60 percent drop in the price of iron ore. Using the 0.34 coefficient from the Table 3 regression, this translates into an immediate 20 percent fall in U.S. iron and steel export prices. The coefficient on time indicates that there is a 0.8 percent annual decline in export prices that is being attributed to productivity improvements. Over a 21 year horizon, these productivity improvements translate into a 15.5 percent decline in the price of iron and steel exports. Stated differently, the opening of the Mesabi range had an effect on export prices that was economically equivalent to that of 29 years of productivity improvements in the iron and steel industry.

In both periods, the direct effect of iron ore prices and productivity improvements appear to be swamped by the growth in world demand for U.S. products, as indicated by the magnitude of "$_1$. But this coefficient may not represent “demand” at all, in the sense of a shift towards U.S. goods, because it merely picks up the greater expansion of U.S. exports over time that cannot be explained by a decline in the relative price of U.S. goods. The coefficient instead could reflect the greater elasticity of U.S. export supply than that from the United Kingdom, which itself may be due to America’s resource abundance.

A more elastic export supply would result in a growing market share for U.S. exporters — above and beyond that due to factors that would reduce the relative price of U.S. exports — if there was a secular increase in demand (which there was because both countries's exports were much greater in 1913 than they had been a decade or two earlier). Resource abundance could have contributed to this greater export supply elasticity through a high elasticity of input supply.[7] The abundance of domestic supplies of iron ore, in particular the ease with which the enormous Mesabi deposits could be strip mined in great quantity, implies that U.S. iron and steel producers faced a highly elastic domestic supply of iron ore. Between 1895 and 1913, U.S. production of iron ore increased from 15,958 tons to 61,980 tons – in other words, the domestic supply of ore easily kept pace with the soaring domestic production of iron and steel products. In Britain, however, producers faced the increasing scarcity of acquiring iron ore at home: between 1895 and 1913, U.K. production of iron ore increased from 12,615 tons to only 15,997 tons (Burnham and Hoskins 1943, p. 107). To expand output and exports, British producers were forced to search abroad for cheaper ore: by 1913, about 43 percent of U.K. iron and steel production used imported (mainly Spanish) iron ore, a percentage that had been 1.2 percent in 1869 (Flinn 1955, p. 86).

[7] The relationship between the elasticity of output supply and the elasticities of input supplies can be written as: $, = 1/G(2_i/s_i)$, where , is the elasticity of supply, 2_i is the share of input i in costs, and s_i is the elasticity of supply of input i for a production function that is linearly homogenous of degree 1, such that any increase in the elasticity of input supply will translate into an increase in the output supply elasticity. As an example, suppose that the elasticity of iron ore supply facing U.S. producers was 3 and that facing British producers was 1 (with a common cost share of 0.5), while the elasticity of non-ore inputs was 1 in both countries. Then the U.K. export supply elasticity of iron and steel would be 1.0 while the U.S. supply elasticity would be 1.5. For a given demand shock, the U.S. export supply response would be 50 percent greater than that from the United Kingdom as a result of the higher input supply elasticity.

The econometric specification in Table 3 precludes a direct test of the hypothesis that the U.S. export supply elasticity exceeds that of the United Kingdom, but there is additional indirect evidence in favor of this interpretation.[8] After increasing at 6.7 percent annually from 1870-1880, world demand for iron and steel (measured by the exports of the United Kingdom, Germany, the United States, Belgium and France) grew sluggishly in the 1880-1890 and 1890-1900 periods (at 1.0 and 1.6 percent annual) before rising rapidly again in 1900-1910 at 6.6 percent annually (Burnham and Hoskins 1943, pp. 276-277). Although world demand growth was not strong during the 1892-1899 export surge, there was a structural shift in the α_1 "demand" coefficient after 1892: when interacted with a post-1892 dummy variable, the coefficient on time falls to 0.02 (with a standard error of 0.02) while the coefficient on the interaction of time and the post-1892 dummy variable is 0.05 (with a standard error of 0.02). In other words, the increase in Q_{US}/Q_{UK} occurs after the Mesabi discoveries but before the large increase in world demand for iron and steel. This is consistent with a change in U.S. supply possibilities during this time, but also brings into question the partitioning of export growth into strictly distinct categories as in Table 4; i.e., the contribution of demand may be overstated and the contribution of Mesabi may be understated. Thus, resource abundance appears to have contributed to U.S. export growth directly, by lowering the prices of key material inputs, and indirectly, by reducing the scarcity constraints on domestic production through a high elasticity of input supply that brought about a high elasticity of export supply. This raises the question of why U.S. natural resource abundance did not affect

[8] The relative demand equation makes it inappropriate to include variables such as world income that might serve as instruments for the inclusion of export quantity in the inverse supply equations.

conditions of input supply in the United Kingdom as well, as one would expect if the world market for iron ore was perfectly integrated. Surprisingly, the Lake Superior iron ores were essentially a non-traded intermediate good for the United States due to transportation costs as well as the industry's high degree of vertical integration within the U.S. Steel Corporation. A sophisticated transportation network linked the mines in Minnesota to the Great Lake ports to the furnaces of Ohio and Pennsylvania, a network that was an essential part of the lower cost of the Mesabi ores despite the long distance they were hauled (see Parsons and Ray 1975). By 1901, the iron ore mines, the lake and rail transport system, and the blast furnaces were largely owned and operated by a single entity, U.S. Steel. In fact, not only were the Lake Superior iron ores almost fully utilized by U.S. Steel and therefore not exported, but the United States was consistently a net importer of iron ore throughout this period.[9] Iron ore from Cuba was purchased by iron and steel producers in the southern United States, where transportation costs made Lake Superior ores uneconomic (or unavailable if the plants were not part of U.S. Steel).

The role of natural resources has not always been emphasized by economic historians in examining international iron and steel competition during this period. While acknowledging the low iron ore costs as a result of the Mesabi discoveries, Allen (1979, p. 931) concludes that "America's competitive strength [in iron and steel around 1910] was not the result of low input prices" but rather the greater efficiency of U.S. producers. Allen (1981) uses cost data from 1889, 1902, and 1910 to

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[9] In 1913 the United States exported 1.2 million tons of iron ore valued at $3.7 million, but imported 2.2 million tons valued at $7.0 million. (The same is true earlier; in 1899, ore exports were worth $66,400 while ore imports were $401,595.) Data from the Statistical Abstract of the United States.

disentangle the components of price reductions of U.S. steel rails. These benchmark years unfortunately overlook the dramatic reduction in ore costs between 1892 and 1899 and its impact of the competitive position of U.S. producers. These years miss the cyclical pattern in which lower ore costs helped to drive exports to a much higher level between 1895 and 1899, after which ore prices rose sharply. The focus on the components of cost also misses the effect of natural resource abundance in fostering the rapid growth of exports by relieving any input supply constraints.

Yet Allen (1977) makes the fascinating point that productivity changes and natural resources endowments may have been complementary for the industry. The initially lower productivity in the U.S. pig iron industry (compared to that in the United Kingdom) was due largely to higher fuel-use per ton of pig iron produced. This gap closed rapidly in the 1880s when there was a significant reduction in the amount of limestone used in U.S. blast furnaces. Limestone itself was not costly, but the eastern iron ores were much richer in silica than the Midwestern ores and consequently took much more limestone to melt. According to Allen (1977, p. 631), "The shift from eastern to Lake [Superior] ores thus accounts for the decline in limestone charged into the blast furnaces and consequently for the half of productivity growth after the 1870s that was due to the rise in the average product of fuel."

The situation describe here in reference to iron and steel appears to be similar to that in other resource-based manufacturing. The example of copper manufactures is equally striking. Electrification prompted much greater demand for a host of copper-related manufactured products, particularly copper wire. Exports of copper manufactures rose from 0.3 percent of exports in 1890 to become the fifth largest export category at nearly 6 percent of exports in 1913, as shown on Table 1. This growth was facilitated by massive copper extraction in the West, but despite this the United States remained a small net importer of raw copper through this period (see Hyde 1998).[10]

A recent literature, cited in the introduction, has analyzed the effects of natural resource abundance on economic performance in the late twentieth century, often reaching a negative assessment on the impact of such abundance. Unlike many developing countries that currently export unprocessed raw materials, the turn-of-the-century United States differed in that it did not so much export the raw materials as the final products in which they were embodied. This may be due to the large size of the U.S. market with the existence of domestic users of those inputs that could, through vertical integration or contracts, absorb much of the domestic supply. Yet some raw materials clearly were tradable: unlike iron and copper ore, raw cotton was more amenable to bulk trade than minerals and was exported in great quantities from the United States. As a result, the domestic cotton textile industry had no particular cost advantage in having local production of cotton and in fact never became a net exporter, perhaps because high U.S. wages hampered the much more labor-intensive cotton textile industry than the materials-intensive iron and copper manufacturing industries. (Wages accounted for 25 to 30 percent of value of cotton textile products, for example, but only about 10 percent in iron and steel, according to the Census of Manufactures of 1890.)

The dramatic shift in the U.S. export position in manufactures also stimulated changes in underlying economic interests that were a precondition for a change in U.S. trade policy away from protectionism toward reciprocity. President William McKinley, who as the Republican chair of the House Ways and Means Committee gave his name to a high protective tariff in 1890, announced in

[10] In 1913, the United States exported $3.0 million of raw copper while importing $13.7 million (Statistical Abstract of the United States 1915, pp. 424, 380).

1901 that “reciprocity is the natural outgrowth of our wonderful industrial development . . . The period of exclusiveness is past. The expansion of our trade and commerce is the pressing problem. . . . If perchance some of our tariffs are no longer needed for revenue or to encourage and protect our industries at home, why should they not be employed to extend and promote our markets abroad?” (Hogan 1971, p. 777). The Republican party took nearly half a century, however, to endorse the policy of reciprocal tariff reductions (Irwin and Kroszner 1999).

4. Conclusions

This paper has sought to determine the underlying factors behind the incredible growth of U.S. manufactured exports, particularly concentrated in iron and steel, in the two decades after the 1890s. This paper has stressed that natural resources, particularly the opening of the Mesabi iron ore range, lay the groundwork for a striking change in the composition of U.S. exports by fundamentally altering industry conditions in the mid-1890s. Resource abundance formed the basis for the U.S. export success around the turn of the century directly, by lowering the price of key material inputs in a way that turned to the domestic advantage because those materials were not exported, and indirectly, by translating into higher elasticity of final goods supply that enabled U.S. exporters to capture a larger share of the international market as world demand for iron and steel expanded. The perspective developed here aims to deepen our understanding of this pivotal period by binding together many elements of the story that have been present in previous works: the sharp improvement in the relative price of U.S. exports during the periods of export surge (as in Floud 1974), the large increase in world demand that British producers were apparently constrained from meeting (as in Nicholas 1980), the more rapid productivity improvements by U.S. producers compared with their foreign rivals (as in Allen 1977), and natural resource abundance as a general factor behind manufactured exports (as in Wright 1990).

Table 1: Leading U.S. Exports, Selected Years between 1890 and 1913

(figures in millions of dollars, percent of total exports in parenthesis)

	1890		1895		1900		1913	
1.	Cotton	$250.9 (29.7%)	Cotton	$204.9 (25.8%)	Grains	$262.7 (19.2%)	Cotton	$546.3 (22.5%)
2.	Grains	$154.9 (18.3%)	Meat & Dairy	$135.2 (16.8%)	Cotton	$241.8 (17.6%)	Iron & Steel	$304.6 (12.5%)
3.	Meat & Dairy	$136.2 (16.1%)	Grains	$114.6 (14.4%)	Meat & Dairy	$184.5 (13.5%)	Grains	$211.1 (8.7%)
4.	Petroleum	$51.4 (6.1%)	Petroleum	$46.7 (5.9%)	Iron & Steel	$121.9 (9.0%)	Meat & Dairy	$153.9 (6.3%)
5.	Animals	$33.6 (3.9%)	Animals	$35.7 (4.5%)	Petroleum	$75.6 (5.5%)	Copper & Mfgs.	$140.2 (5.8%)
6.	Wood & Mfgs.	$28.3 (3.3%)	Iron & Steel	$32.0 (4.0%)	Copper & Mfgs.	$58.9 (4.3%)	Petroleum	$129.7 (5.3%)
7.	Iron & Steel	$25.5 (3.0%)	Tobacco & Mfgs.	$29.8 (3.8%)	Wood & Mfgs.	$50.6 (3.7%)	Wood & Mfgs.	$115.7 (4.8%)

Source: Statistical Abstract of the United States, various years.

Table 2: Cost Structure of Blast Furnaces in 1890

(Figures in millions of dollars)

Value of Blast Furnace Products	$145.6	Percent of Value	Percent of Materials Costs
Cost of Materials	$110.1	76	
Iron Ore	$63.5	44	58
Coke	$27.4	19	25
Coal	$ 5.9	4	5
Wages	$14.6	10	

Source: Census Office, Department of the Interior, Report on Manufacturing Industry in the United States, 11th Census, 1890, Part III: Selected Industries (Washington, D.C.: Government Printing Office, 1895), pp. 395, 398.

Table 3: Parameter Estimates for U.S. and U.K. Iron and Steel Exports

Sample period: 1880-1913. Estimated by three-stage least squares with AR(1) correction. Instruments include all exogenous variables, total expenditures on U.S. and U.K. exports, and the dollar sterling exchange rate.

Dependent Variable:	$\log(Q_{US}/Q_{UK})$	$\log(P_{US})$	$\log(P_{UK})$
Constant	-3.00 (0.10)	4.09 (0.09)	1.72 (0.21)
Relative Price	-1.92 (0.38)	--	--
Time	0.086 (0.006)	-0.008 (0.002)	-0.004 (0.001)
Log of Iron Ore Price	--	0.34 (0.06)	0.83 (0.08)
Log of Coal Price	--	0.10 (0.10)	0.30 (0.08)
U.S. Steel Dummy (1901-1913)	--	0.23 (0.05)	--
U.K. Producer Collusion (1912-1913)	--	--	0.21 (0.04)
Adj. R^2	0.94	0.88	0.84
Standard Error	0.25	0.06	0.06

Data Sources: Price of U.S. iron and steel exports: Lipsey (1963, p. 252). Quantity of U.S. iron and steel exports: Lipsey (1963, p. 257). Price of U.K. iron and steel exports: Silverman (1930, p. 147). Quantity of U.K. iron and steel exports: Mitchell (1988, p. 301). U.S. iron ore price: Lake Superior Iron Ore Association (1938), p. 322. U.K. iron ore price: import price, Abstract of Statistics for the United Kingdom (various years). U.S. bituminous coal price: Statistical Abstract of the United States (1915, p. 519). U.K. coal price: Mitchell (1984, p. 54). Exchange Rate: Mitchell (1988, pp. 702-703).

Table 4: Impact of Counterfactual Scenarios on U.S. Iron and Steel Exports

Actual Export Volumes:
(thousands of tons)

	United States		United Kingdom	
	Exports	Imports	Exports	Imports
1890	50	665	4,001	386
1895	89	309	2,738	406
1900	1,154	210	3,447	800
1913	2,907	253	4,934	2,231

Source: Burnham and Hoskins (1943), pp. 276-79.

Percentage Contribution to Change in Relative U.S. Exports (U.S. Exports/U.S.+U.K. Exports)

	1892-1899	1892-1913
Contribution of:		
Mesabi ore discovery	30	14
Post-1892 Productivity Growth	7	12
Post-1892 Demand Shift	35	65
Other Factors	28	8
Explained	100	100

Note: Mesabi ore discovery is taken as a one-time decline the price of iron ore of 60 percent (from 1892). Post-1892 productivity growth assumes no U.S. productivity growth after 1892. Post-1892 demand shift implies no change in relative demand toward U.S. products after 1892.

Table 3A: Parameter Estimates for U.S. and U.K. Iron and Steel Exports

Sample period: 1880-1913. Estimated by three-stage least squares with AR(1) correction. Instruments include all exogenous variables, total expenditures on U.S. and U.K. exports, and the dollar sterling exchange rate.

Dependent Variable:	log (Q_{US}/Q_{UK})	log (P_{US})	log (P_{UK})
Constant	-2.96 (0.09)	4.11 (0.08)	1.70 (0.21)
Relative Price	-2.62 (0.39)	--	--
Time	0.086 (0.005)	-0.003 (0.005)	-0.001 (0.007)
Log of Iron Ore Price	--	0.32 (0.08)	0.67 (0.15)
Log of Coal Price	--	0.03 (0.10)	0.26 (0.07)
Log of Iron & Steel Wage	--	0.11 (0.10)	0.32 (0.57)
Lagged Cumulative Production Experience	--	-0.05 (0.04)	-0.05 (0.05)
U.S. Steel Dummy (1901-1913)	--	0.19 (0.05)	--
U.K. Producer Collusion (1912-13)	–	–	0.15 (0.04)
Adj. R^2	0.94	0.88	0.81
Standard Error	0.25	0.06	0.06

Data Sources: See Table 3. British iron wages: from engineering and shipbuilding, Bowley (1937, p. 8). U.S. iron and steel wages: U.S. Bureau of Labor Statistics (1934, section F on iron and steel industry). Total U.S. and U.K. iron and steel production: Burnham and Hoskins (1943, pp. 272-274).

Table 3B: Parameter Estimates for U.S. and U.K. Iron and Steel Exports

Sample period: 1880-1913. Estimated in first differences by three-stage least squares with AR(1) correction. Instruments include all exogenous variables, total expenditures on U.S. and U.K. exports, and the dollar sterling exchange rate.

Dependent Variable:	) log (Q_{US}/Q_{UK})	) log (P_{US})	) log (P_{UK})
) Relative Price	-2.02 (0.52)	--	--
) Log of Iron Ore Price	--	0.29 (0.08)	0.96 (0.33)
) Log of Coal Price	--	0.14 (0.09)	0.15 (0.16)
) U.S. Steel Dummy	--	0.24 (0.10)	--
) U.K. Collusion Dummy	–	–	0.18 (0.09)
Adj. R^2	0.48	0.31	0.60
Standard Error	0.23	0.06	0.07

Figure 1: U.S. Trade in Manufactured Goods, 1850-1913

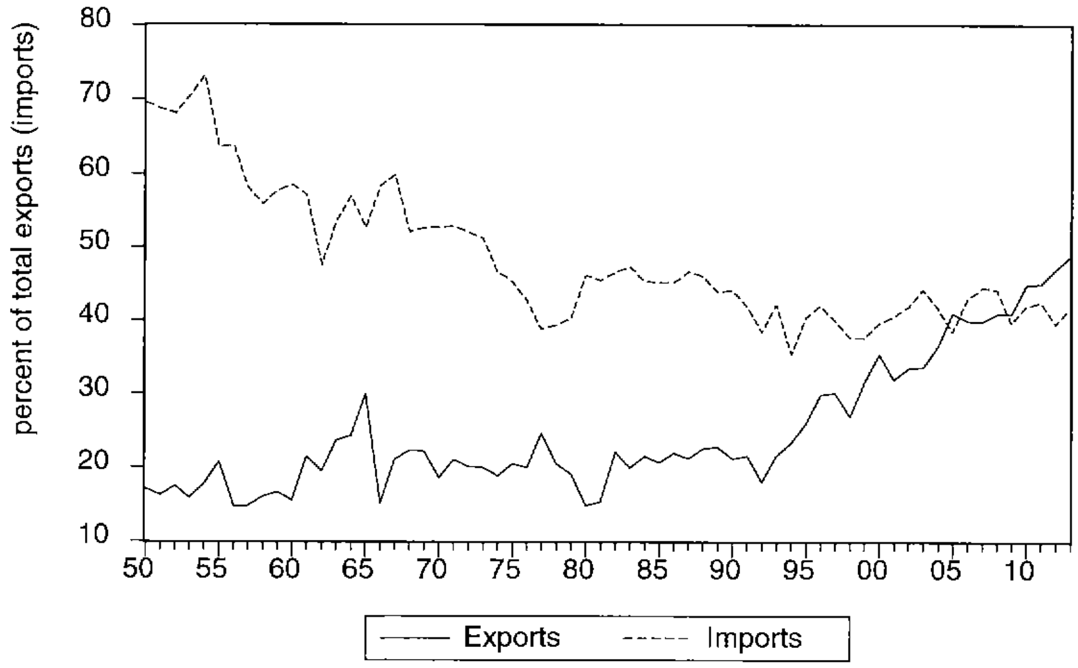


Figure 2: Comparative U.S.-U.K. Performance in Manufacturing

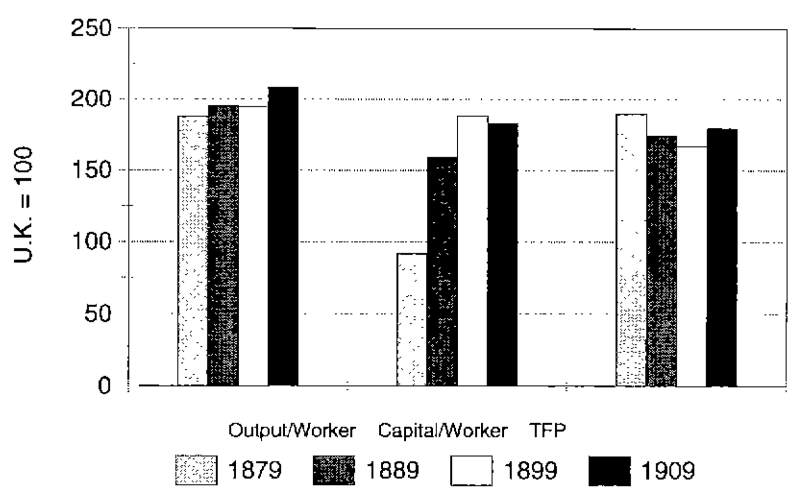


Figure 3: Volume of U.S. Iron and Steel Exports, 1880-1913

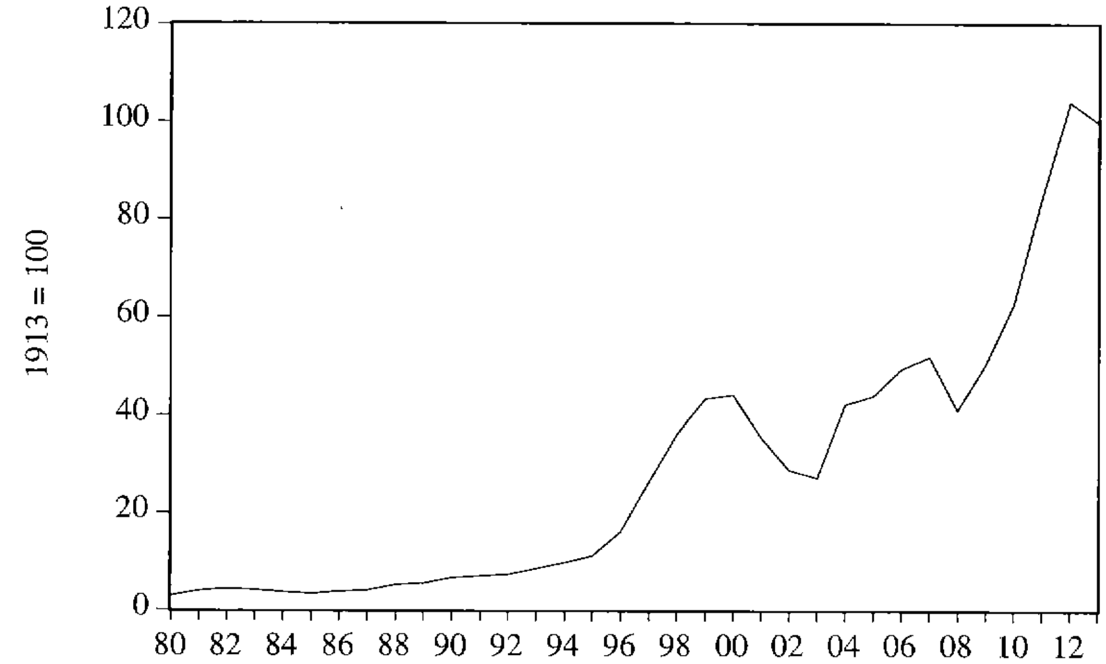


Figure 4: Relative U.S./U.K. Price of Iron and Steel Exports, 1880-1913

Figure 5: U.S. Iron Ore Prices, 1883-1913

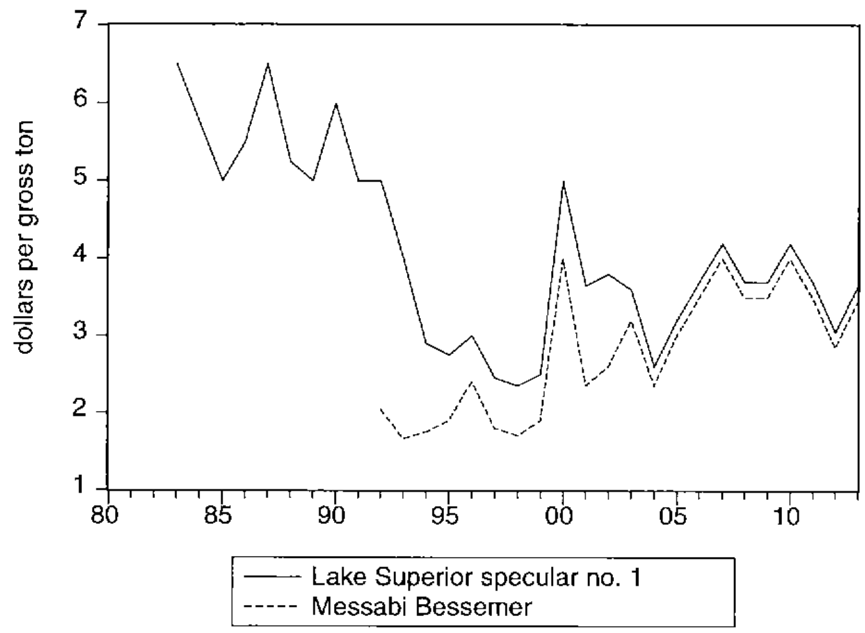


Figure 6: Relative Price of U.S. Iron Ore, 1880-1913

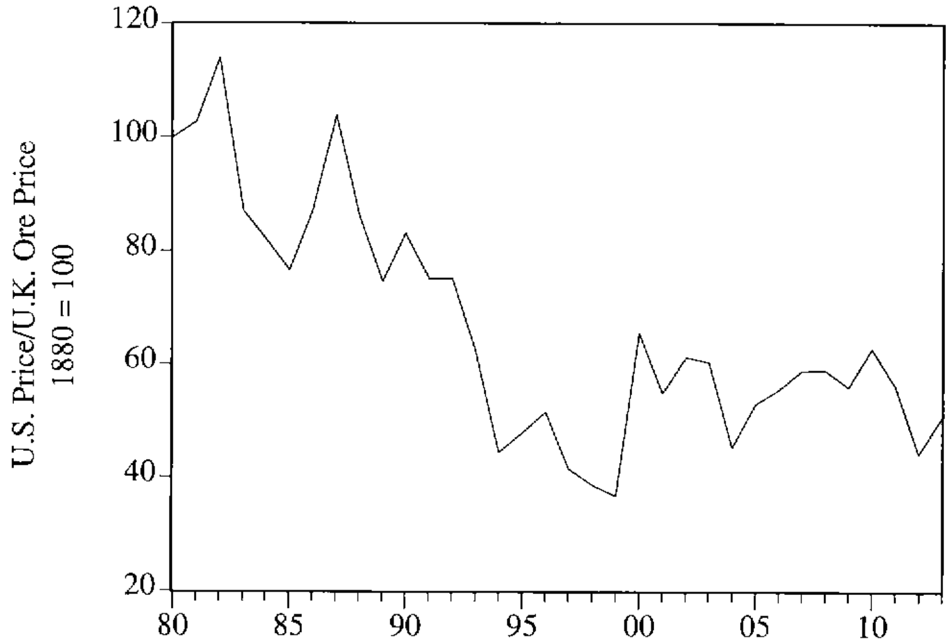
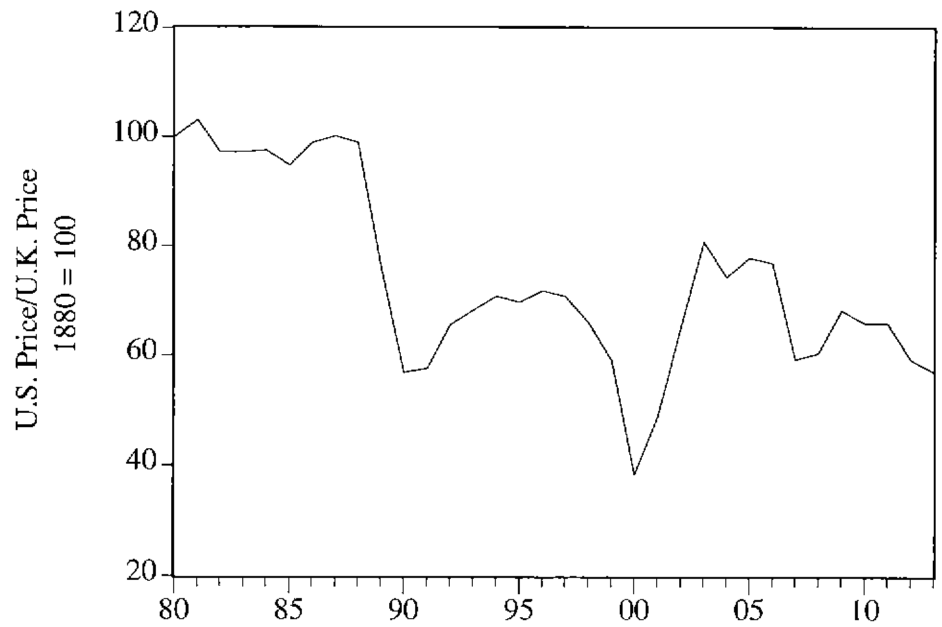


Figure 7: Relative Price of Coal, 1880-1913



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