EXPLAINING AMERICA'S SURGE IN MANUFACTURED EXPORTS, 1880–1913

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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 50% in the mid-1890s and was equivalent to over a decade's worth of industry productivity improvement in its effect on iron and steel export prices. The nontradability of American ore resulted in its distinctive impact on the pattern of U.S. trade. The results are consistent with Wright's (1990) finding that U.S. manufactured exports were natural-resource-intensive at this time.

I. Introduction

FOR most of the nineteenth century, the United States had a strong comparative advantage in agricultural goods and exported mainly raw cotton, grains, and meat products. In the mid-1890s, however, America's exports of manufactures surged. Manufactured goods jumped from 20% of U.S. exports in 1890 to 35% by 1900 and nearly 50% 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 were 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 result from changes in factor endowments or technological improvements, 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 agricultural exports experience a noticeable collapse.

Raw-materials abundance has been proposed as an alternative explanation for America's export success during this period. Wright (1990) examined the factor content of U.S. trade in manufactured goods from 1879 to 1940 and found that net exports were intensive in nonreproducible 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 studies, however, do not explicitly link the changes in raw-material abundance to changes in the composition of U.S. exports; for example, Wright found that net exports of manufactures were consistently intensive in natural resources, both before and after the 1890s.

This paper seeks to understand the rapid growth of U.S. manufactured exports by focusing on the iron and steel industry, which was the driving force behind the dramatic change in the commodity composition of exports. The paper uncovers 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 cut the domestic price of iron ore in half during that decade. The lower domestic price of iron ore led to significant reduction in the relative price of U.S. iron and steel exports and, according to results reported below, was equivalent to more than a decade's worth of productivity improvements in the industry.

Understanding the basis for the U.S. export success during this pivotal period has implications for several related research questions. A recent literature 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 (see, for example, Nelson and Wright, 1992; Abramovitz and David, 1996; and Broadberry, 1997). 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. Another recent literature examines whether natural-resource abundance is a blessing or a curse for economic development (see, for example, Sachs and Warner, 1999, 2001). The present case raises the question of how the United States avoided the *Dutch disease* wherein resource abundance crowds out exports of manufactured goods. As will be discussed below, the nontradability of iron ore resources helped to "crowd in" manufactured exports, thereby avoiding some of the adverse consequences of resource abundance in the U.S. case.

Section II 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 III seeks to disentangle various demand- and supply-side hypotheses regarding the growth of

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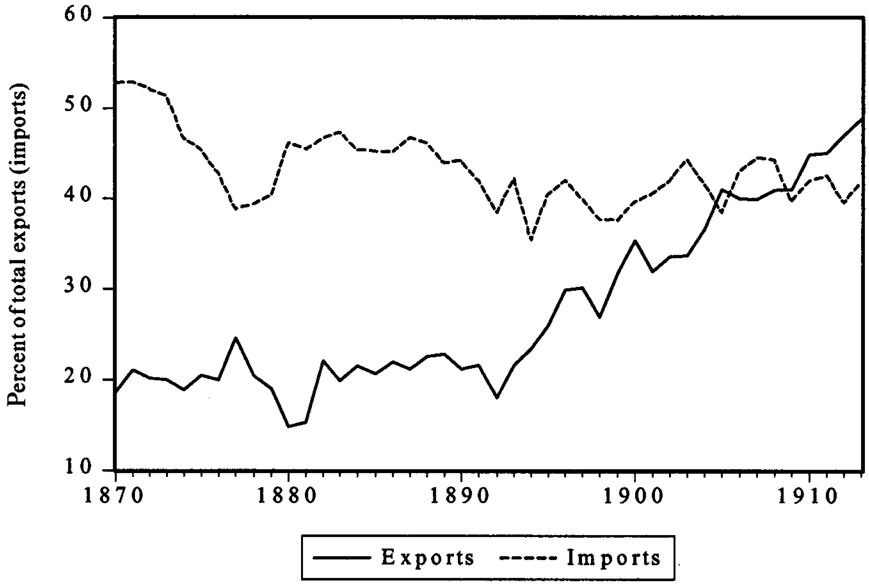
FIGURE 1.—U.S. TRADE IN MANUFACTURED GOODS, 1870–1913



Source: U.S. Bureau of the Census (1975), series U 213-224.

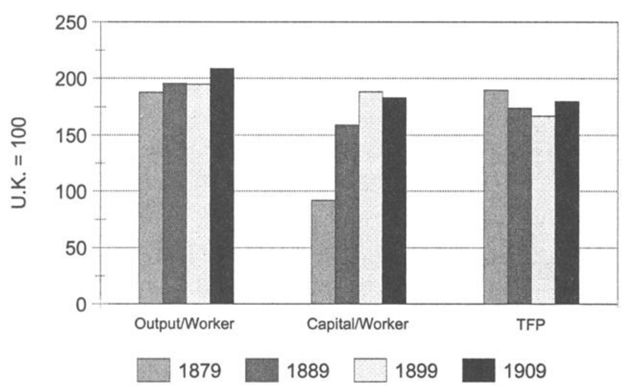
U.S. exports. A system of equations representing the demand for and supply of iron and steel exports from the United States and the United Kingdom is estimated for the period from 1880 to 1913. The parameter estimates allow the calculation of the relative contribution of raw-material prices, productivity improvements, and shifts in world demand to U.S. export growth. Section IV examines some of the implications of the findings, and Section V summarizes the main findings.

II. The U.S. Export Boom after 1895

The explosion of U.S. manufactured exports in the mid-1890s, dubbed by European observers 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% 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 consistent 20% of total exports.

Starting around 1895, however, U.S. manufactured exports suddenly 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% to 35.3% (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% (Lipsey, 1963, p. 144). Export growth then virtually stopped between 1900 and 1908: 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% in those five years and bringing the manufactured share of total exports to nearly 50%. 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.

FIGURE 2.—COMPARATIVE U.S.-U.K. PERFORMANCE IN MANUFACTURING



Source: Broadberry (1997, p. 106).

A. *Factors behind the Export Surge*

Changes in aggregate factor endowments (such as capital accumulation) and productivity improvements in comparison with its 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 to, 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

TABLE 1.—LEADING U.S. EXPORTS, SELECTED YEARS BETWEEN 1890 AND 1913

	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. Figures in millions of dollars; percentages of total exports in parentheses.

period (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 also increased relative to the United Kingdom, 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, and 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% of all exports in 1895 to 9.0% in 1900. In these five years, the volume of iron and steel exports rose by a factor of more than 6, as shown on figure 3 (Lipsey, 1963, p. 257).[1] The ratio of iron and steel exports to production rose from 4.4% in 1889 to 11.7% in 1899 (Statistical Abstract of the United States, 1904, pp. 218, 522).

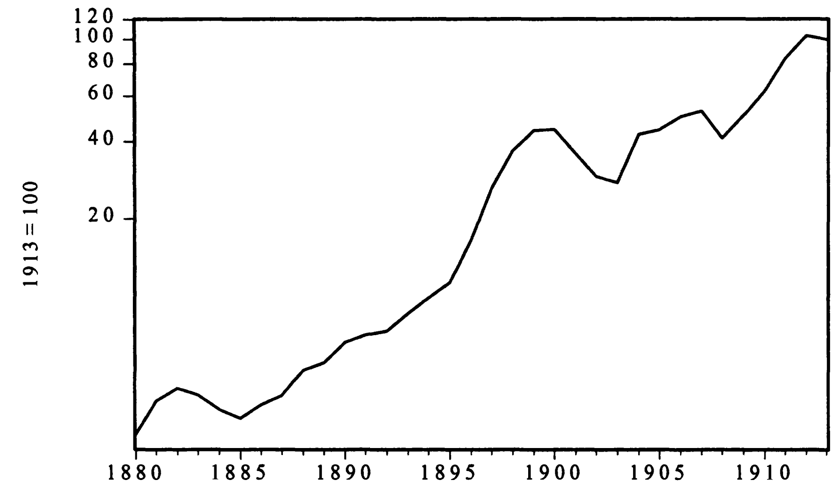
[1] Lipsey presents two series for iron and steel export volume, one for *semi*manufactured exports (069) and another for manufactured exports (070). This paper uses a value-weighted average of these two series to represent overall iron and steel export volume (the weights are from Lipsey, 1963, pp. 168–169).

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, cash registers, and printing presses. 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 to $42.4 million. 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 volume of iron and steel exports was even slightly lower in 1908 than in 1900. After 1908, these exports surged again: the iron and steel export volume rose by a factor of more than 2 in the five years to 1913. In this second surge, the iron-and-steel share of total exports rose from 10.0% in 1908 to 12.5% 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% in 1899 to 10.5% in 1909 (Statistical Abstract of the United States, 1915, pp. 436, 452, 192).

Although exports of other manufactured goods grew rapidly during this period, no other industry played such a leading role in propelling the United States toward a net export position in manufactured goods. The key to understanding the changing composition of U.S. exports, therefore, involves an explanation of why American iron and

FIGURE 3.—VOLUME OF U.S. IRON AND STEEL EXPORTS, 1880–1913



Source: Lipsey (1963).

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 such 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 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]

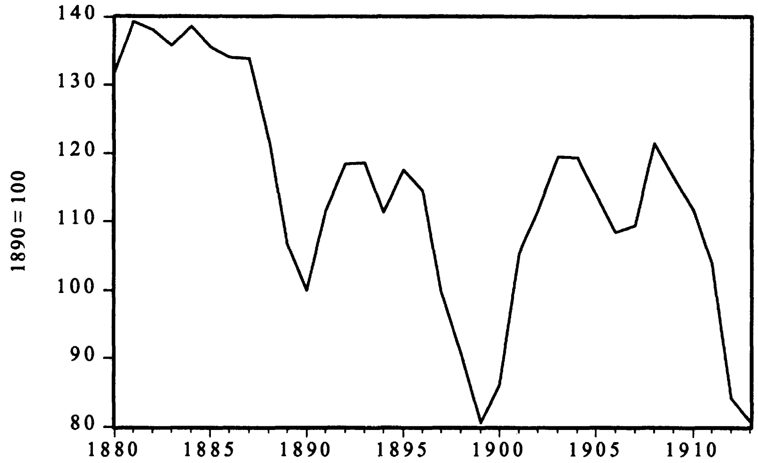
Others have proposed supply-side explanations that focus on the improved competitive position of U.S. producers. Contrary to Nicholas (1980) but consistent with figure 4, Floud (1974) presents evidence that the export surge in machinery in the late 1890s was associated with a pronounced fall in the relative price of U.S. machinery, the cause of which was not identified. Such a shift in supply was less the result of capital accumulation than of productivity growth. 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% for iron and steel products, compared with 5.3% 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% annually in the primary metals industry and 2.3% in the fabricated metals industry, compared with just 0.7% in manufacturing overall (Kendrick, 1961, p. 136). The improved technological efficiency of U.S. iron and steel producers may explain why the export growth was so concentrated in one particular manufacturing sector rather than 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 of greater efficiency that led to lower costs.[3] Between 1889 and 1902, for example, Allen (1981)

[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, partly due to Britain's relative inefficiency, but more importantly to lower input prices in America. . . . "

FIGURE 4.—U.S. EXPORT PRICE RELATIVE TO U.K. EXPORT PRICE, IRON AND STEEL, 1880–1913



Source: Lipsey (1963) and Silverman (1930).

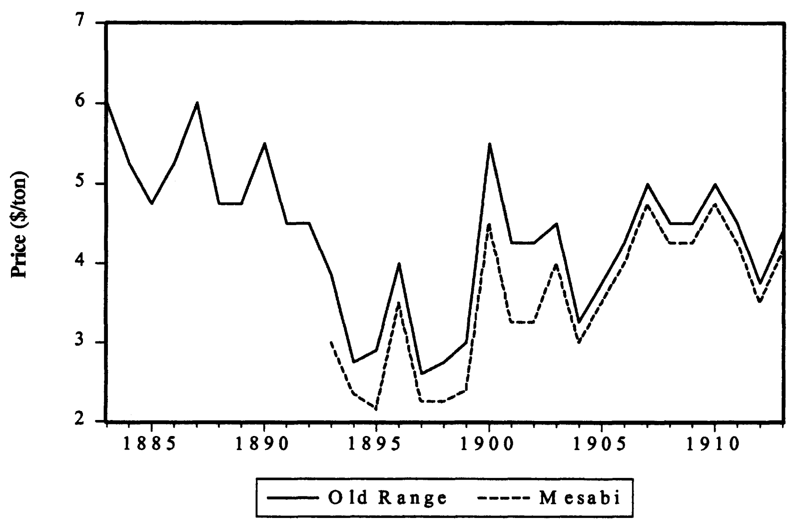
calculates that the unit cost of U.S. steel rails declined 19%, almost entirely due to productivity improvements that reduced costs by 21%, while his calculated input costs rose 2%. Between 1902 and 1910, he finds that input prices rose 5% while productivity increased 7%, thereby reducing unit costs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

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). 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." 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 nonrenewable natural resources.

Probably 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. 378–379) 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.

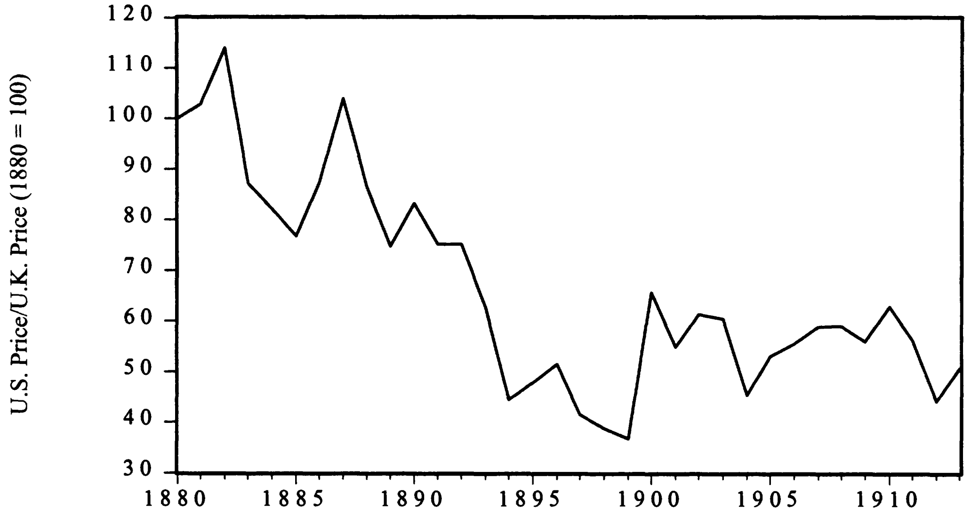
The Mesabi opening in 1892 had dramatic consequences. Minnesota accounted for just 6% of U.S. iron ore production in 1890, but 24% in 1895 and 51% in 1905 (Warren, 1973, p. 116). As figure 5 illustrates, the price of iron ore plunged by about 50% when the Mesabi shipments hit the market, from about \$5 to \$6 per ton in the early 1890s to about \$2 to \$3 per ton by the mid-1890s (Mussey, 1905, p.

FIGURE 5.—PRICES OF LAKE SUPERIOR IRON ORE, 1880–1913



Source: Lake Superior Iron Ore Association (1938, p. 322).

FIGURE 6.—RELATIVE PRICE OF U.S. IRON ORE, 1880–1913



Source: Lake Superior Iron Ore Association (1938) and *Abstract of Statistics for the United Kingdom* (annual, various years).

166; Lake Superior Iron Ore Association, 1938, p. 322). Figure 6 shows that the U.S. price of iron ore, relative to the British import price of iron ore, fell sharply between 1890 and 1895.

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% of the materials costs of producing blast-furnace products (mainly pig iron) in 1890. A 50% decline in the price of iron ore, if fully passed through to the value of products, would imply a 30% reduction in the materials costs of producing pig iron, or a 22% reduction in its price (assuming a constant markup). Pig iron, in turn, comprised 50% of the materials costs (and 32% 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 the lower ore prices through to costs, then the 30% reduction in materials costs would imply a 15% reduction in the materials costs of rolling-mill products. Thus, in an extremely short time, the lower ore price could translate into a substantial cost reduction for a wide range of iron and steel products.

TABLE 2.—COST STRUCTURE OF BLAST FURNACES IN 1890

	Cost (million $)	Percentage of Production Expense	Percentage of Materials Costs
Cost of materials	110.1	83	
Iron ore	63.5	48	58
Coke & coal	33.3	25	30
Other materials	13.3	10	12
Wages & salaries	16.2	12	
Miscellaneous expenses	6.3	5	
Expense of production	132.6	100	
Value of blast-furnace products	145.6		

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.

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%, the export price of iron and steel products fell 24% (Lipsey, 1963, p. 252). This price reduction significantly improved the cost position of domestic producers vis-à-vis British producers, then the leading exporters of iron and steel products, because British iron and steel export prices rose slightly during this period (Silverman, 1930, p. 147). As a result, as figure 4 shows, the price of U.S. iron and steel exports (relative to those from the United Kingdom) fell about 30% from 1895 to 1899 as the lower iron ore prices passed through to export prices.

The sharp fall in the relative price of U.S. iron and steel exports shocked British rivals, who sought to determine if this development was temporary or permanent.[4] 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

[4] "The recent unexpected invasion by American competitors of a 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).

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.[5] 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% in that year (U.S. Commissioner of Corporations, 1912, p. 139). An even more important factor, according to a government report investigating anti-competitive practices in the steel industry, was 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" (U.S. Bureau 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% 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 principle 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% profit margin on Bessemer ores over 1902–1906 (U.S. Bureau 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. This time, U.S. producers were especially aided by a dramatic rise in British export prices in 1912, when a national coal strike, compounded by a railwaymen's strike, stopped production at British mines for nearly two months. British pig-iron prices rose about 30% 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 caused 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 remarkable five-year export surges, between 1895 and 1900 and between 1908 and 1913, in iron and steel products. 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, as figure 4 strikingly illustrates. The next section attempts to determine the contribution of various factors—lower raw-material 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.

[5] The average quoted prices at lower Lake ports for Mesabi Bessemer ore rose 56% from its 1898–1899 average to its 1902–1906 average (U.S. Bureau of Corporations, 1912, p. 139).

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

This section develops an econometric model of aggregate iron and steel exports from the United States that incorporates the key determinants of export supply and demand. The model is then used to evaluate the contribution of changes in raw-material prices, productivity, and world demand on U.S. export growth. A similar model of exports from the United Kingdom, which was then the world's leading exporter of iron and steel products, is also estimated for purposes of comparison.

A. Model Specification and Estimation

The demand for U.S. iron and steel exports is specified as

$$X_{\mathrm{US}} = \beta_0 p_{\mathrm{US}}^{\beta_1} p_{\mathrm{UK}}^{\beta_2} y^{*\beta_3} \mu,$$

where X_{US} is the quantity of U.S. iron and steel exports, p_{US} is the price of U.S. iron and steel exports, p_{UK} is the price of competing U.K. iron and steel exports, y^* is a foreign demand shift variable, and μ is a random demand shock. (Time subscripts have been suppressed.)

The inverse supply of U.S. iron and steel exports is specified as

$$p_{\mathrm{US}} = \alpha_0 X_{\mathrm{US}}^{\alpha_1} p_{\mathrm{ORE}}^{\alpha_2} p_{\mathrm{COAL}}^{\alpha_3} w_{\mathrm{US}}^{\alpha_4} t^{\alpha_5} USS^{\alpha_6} \epsilon,$$

where p_{US} is the price of U.S. iron and steel exports, X_{US} is the quantity of U.S. iron and steel exports, p_{ORE} is the domestic price of iron ore, p_{COAL} is the domestic price of coal, w_{US} is the domestic wage for iron and steel workers, t is a time trend representing technological progress, *USS* is a dummy variable indicating the formation of the U.S. Steel Corporation, and ϵ is a random supply shock. The U.S. Steel variable, which takes the value of 1 from the year 1901, allows us to test the hypothesis that the U.S. Steel consolidation resulted in a higher markup of prices above materials costs; the current specification implicitly assumes a fixed markup of iron and steel prices above costs (table 2 implies the markup is 9.8%) with a shift after 1901 due to the creation of U.S. Steel. The time trend captures the changes in export prices that cannot be attributed to the other independent variables and is taken to indicate technological progress.

After taking logs, the demand and supply equations are, respectively,

TABLE 3.—IRON AND STEEL EXPORTS: ESTIMATES OF SUPPLY AND DEMAND, 1880–1913

Dependent Variable	U.S. Export Demand (log U.S. Export Volume)	U.S. Export Supply (log U.S. Export Price)	U.K. Export Demand (log U.K. Export Volume)	U.K. Export Supply (log U.K. Export Price)
Constant	−9.34* (2.59)	4.03* (0.10)	0.56 (0.88)	−0.41 (1.77)
Log U.S. export price	−2.74* (0.58)	—	0.57* (0.19)	—
Log U.K. export price	1.88* (0.68)	—	−0.35 (0.25)	—
Log foreign income	2.56* (0.25)	—	0.44* (0.09)	—
Log export volume	—	0.06 (0.04)	—	0.14 (0.13)
Log domestic iron ore price	—	0.37* (0.07)	—	0.61* (0.15)
Log domestic coal price	—	0.08 (0.11)	—	0.41* (0.13)
Log domestic wage	—	−0.04 (0.11)	—	0.41 (0.42)
Time trend	—	−0.014* (0.006)	—	−0.009* (0.003)
U.S. Steel dummy (1901–1913)	—	0.24* (0.05)	—	—
U.K. producer collusion (1912–1913)	—	—	—	0.21* (0.05)
Adjusted R^2	0.88	0.88	0.41	0.87
S.E.	0.41	0.06	0.14	0.05

Note: * indicates significance at the 5% percent level. Standard errors appear in parentheses. Demand and supply of iron and steel exports from the United States and United Kingdom estimated as separate systems using three-stage least squares (3SLS).

$$\log X_{US} = \beta_0 + \beta_1 \log p_{US} + \beta_2 \log p_{UK} + \beta_3 \log y^* + \mu, \quad (1)$$

$$\log p_{US} = \alpha_0 + \alpha_1 \log X_{US} + \alpha_2 \log p_{ORE} + \alpha_3 \log p_{COAL} + \alpha_4 \log w_{US} + \alpha_5 t + \alpha_6\, USS + \epsilon. \quad (2)$$

The price and quantity of U.S. exports are both endogenous variables. As a result, these equations can be estimated by three-stage least squares, which allows for contemporaneous correlation between the error terms. The specification of the demand for and supply of U.K. iron and steel exports is exactly the same as in the U.S. case. In the supply equation, however, the U.S. Steel dummy variable is replaced by another dummy variable representing the period of producer collusion in 1912–1913, as discussed above. The data used in the estimation are described in an appendix.

The first two columns of table 3 report the estimates for the U.S. demand and supply equations. The price elasticity of demand for U.S. exports is estimated to be −2.7, indicating that demand is fairly price-elastic. The cross-price elasticity of demand with respect to British export prices is 1.9. The income elasticity of demand is 2.56, suggesting that demand for U.S. exports is highly responsive to changes in foreign income.

Turning to the export supply equation, the reciprocal of the coefficient on export volume indicates the elasticity of export supply. The elasticity of export supply is very elastic at 16.7. This may seem high, but overall domestic supply appears to have been highly elastic, and the export supply elasticity would be even greater, because only about 10% of domestic output was sold abroad during this period. The elasticity of iron and steel prices with respect to ore prices and coal prices was 0.37 and 0.08, respectively. This implies that a 50% decline in the price of ore, as experienced in the mid-1890s, should reduce the price of final iron and steel products by nearly 20%, consistent with the earlier calculations. Wages were a small part of production costs (only about 10%, according to table 2), and the coefficient on wages is slightly negative and insignificant.

The coefficient on time is taken to reflect the productivity growth of domestic producers. The coefficient indicates that export prices experienced an annual reduction of 1.4%, on average, after controlling for other factors affecting prices. The coefficient on the U.S. Steel dummy variable suggests that, after controlling for input prices, export prices for iron and steel were 24% higher, on average, after the industry consolidation in 1901. This magnitude is similar to Allen's (1981, pp. 522–523) finding that markups in the steel rail industry rose 18% between 1889 and 1902.

The supply estimates make clear that the Masabi opening had a substantial effect on the price of exports. If the Mesabi opening is assumed to be a once-and-for-all 50% drop in the price of iron ore, then, using the coefficient 0.37 from the table 3 regression, this translates into an immediate 19% fall in U.S. iron and steel export prices. The coefficient on time indicates that there is a 1.4% average annual decline in export prices attributed to productivity improvements. Over a 12 year horizon, these ongoing productivity improvements translate into a comparable 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 a dozen years of productivity improvements in the iron and steel industry.

The last two columns in table 3 present the estimates of export supply and demand for the United Kingdom, which make an interesting comparison with the U.S. results. Export demand is much less elastic for U.K. iron and steel exports than for U.S. exports. A possible explanation for this result is Britain's colonial ties with such countries as Canada, Australia, and India, which were important sources of foreign demand. These colonial ties include low-cost information and shipping networks, long-established producer-consumer relationships, easier access to credit and insurance, and other factors that might have led these foreign purchasers to be more apt to stick with British suppliers and be less price-sensitive than might otherwise be the case.[6] The demand for U.K. exports, however, is much less income-elastic than demand for U.S. exports. As foreign markets grew, consumers apparently had a greater preference for American over British products. This could be due to dissimilar product mixes in the characteristics, quality, or delivery aspects of the products, or to other factors.

The export supply equation of the United Kingdom indicates that export prices were more sensitive to changes in the prices of raw-material inputs than the export prices of the United States. The reciprocal of the coefficient on export volume indicates that the elasticity of export supply was about 6.9, much less than that of the United States. The coefficient on time also indicates that productivity growth was slower in U.K. industry than in U.S. industry, consistent with Allen's (1977) work. The implications of these differences will be drawn out below.

[6] Allen (1979, p. 914) notes that "in Empire and home markets, purchasers were apparently willing to pay a premium for British steel which prevented a similar collapse in those areas and cushioned the deterioration of British trade. Empire preference, the necessity to design engineering projects in metric units, the need for the Germans to develop an English-language sales system, and unfamiliarity with the quality of German steel would all slow the response of sales to the price change."

TABLE 4.—DECOMPOSING THE SOURCES OF U.S. IRON AND STEEL EXPORT GROWTH

Percentage	1892–1899	1908–1913	1892–1913
Total increase in export volume	498	142	1,261
Average annual increase in export volume	71	28	60
Contribution of:			
Change in iron ore price	48	5	13
Change in coal price	5	−2	−2
Productivity growth	34	49	83
Foreign demand	5	24	25
British export prices	8	24	11
U.S. steel formation	—	—	−30

Note: Figures may not sum to 100 due to rounding.

B. Relative Contributions to Export Growth

The estimated parameters of the demand and supply equations can be used to calculate the relative contributions of the various factors behind the U.S. export surge. A reduced-form equation for export volume in terms of the underlying supply and demand factors can be solved out by substituting equation (2) into equation (1). The effect of the domestic price of iron ore on the volume of U.S. exports is then captured by $\beta_1\alpha_2/(1 - \alpha_1\beta_1)$, that of technological progress on export volume is captured by $\beta_1\alpha_5/(1 - \alpha_1\beta_1)$, and so on.

Table 4 calculates the percentage contribution of the exogenous factors to the growth in U.S. iron and steel exports for three periods, 1892 to 1899, 1908 to 1913, and 1892 to 1913. In the first period, which saw the most rapid growth in exports, about half of the growth is attributable to the lower price of iron ore. This suggests that the Mesabi effect alone helped increase exports by almost 250% in a short interval. Productivity accounts for about a third of total export growth during this period, and various other factors make up the rest. Clearly, during this phase of the export expansion, the sharp decline in iron ore prices improved the price competitiveness of U.S. exports and helped stimulate the tremendous growth in iron and steel exports.

Raw materials prices, however, played almost no role in the second phase of export growth from 1908 to 1913. About half of the growth in exports can be attributed to productivity improvements; the other half can be attributed to rapidly growing foreign demand and to the inability of British exporters to meet that demand due to domestic strikes and producer collusion.

Taking the entire period from 1892 to 1913 into consideration, the growth of U.S. exports appears to be explained largely by productivity growth, to some degree by higher foreign demand, and to a lesser degree by lower iron ore prices and higher British export prices. The price effects of the U.S. Steel consolidation exerted a sharp downward jolt to exports. Figure 3 shows the impact of U.S. Steel on export growth around 1901, and one can imagine the path exports might have taken had they continued on trend.

Over the entire period, however, the contribution of iron ore prices to export growth appears to be small and swamped by the cumulative effects of productivity improvements. But there are several reasons to believe that the contribution of the Mesabi range to overall export growth was not necessarily so small.

First, Allen's (1977) research indicates that productivity changes and natural-resource endowments may have been complementary for the industry. The initially lower productivity in the U.S. pig-iron industry than 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." If we take this to imply that half of the industry's productivity growth was itself due to the opening of the Mesabi range, then Mesabi's contribution (directly due to lower costs and indirectly via the productivity inducements) increases to about 50% over the period from 1892 to 1913.

Second, America's resource abundance as a result of Mesabi probably contributed to the United States having a more elastic supply of exports than competing countries. 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 and at low cost, implies that U.S. iron and steel producers faced a highly elastic domestic supply of iron ore. The more elastic is the supply of intermediate goods, the more elastic is the supply of final goods.[7] Because there was a secular increase in demand for iron and steel goods during this period, the country with a more elastic export supply would achieve a greater share of world exports, as the United States did.

Between 1895 and 1913, U.S. production of iron ore increased from 15,958 tons to 61,980 tons, and 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 only from 12,615 tons to 15,997 tons (Burnham and Hoskins, 1943, p. 107). To expand output and exports, British producers were forced to search abroad for cheaper ore: in 1869, just 1.2% of U.K. iron and steel production relied on imported iron ore, but by 1913 about 43% of domestic production used imported (mainly Spanish) ore (Flinn, 1955, p. 86). This relative scarcity of important inputs constituted a constraint on production that could be the cause of Britain's lower elasticity of export supply.

Thus, resource abundance appears to have contributed to U.S. export growth directly, by lowering the prices of key material inputs, and indirectly, by improving productivity and by reducing the scarcity constraints on domestic production that helped increase the elasticity of export supply.

IV. Implications and Assessment

These results indicated that a combination of factors was behind the tremendous growth in U.S. manufactured exports after 1895. The results support Wright's (1990) finding that U.S. exports were intensive in their use of natural resources, but go beyond his work in making explicit the link between the price of key raw materials, the price of manufactured exports, and the subsequent timing of the growth in export volume. The results also support Allen's (1979) finding that productivity growth in the U.S. industry played an important role in promoting exports.[8] The results of the previous section have implications for several related issues of current research.

A. *Tradability of Inputs*

If the world market for iron ore had been perfectly integrated, the abundance of natural resources and raw materials in the United States would not have differentially affected U.S. producers, because it would also have affected conditions of supply in the United Kingdom and elsewhere. There was a flourishing trade in iron ore in Europe, where Britain received supplies from Spain and Germany from Sweden. But the Lake Superior iron ores did not become an internationally traded good, and the impact of Mesabi was not transmitted to the world market except through the price of final iron and steel goods. The iron ores were kept within

[7] The relationship between the elasticity of output supply and the elasticities of input supplies can be written as $\epsilon = 1/(\Sigma\theta_i/s_i)$, where ϵ is the elasticity of supply, θ_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, so that any increase in the elasticity of input supply will translate into an increase in the output supply elasticity.

[8] 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 of the greater efficiency of U.S. producers. Although this conclusion is consistent with the table 4 results for the period 1892 to 1913 as a whole, Allen's data were not entirely suitable for illustrating the importance of input prices. For example, Allen (1981) uses cost data from 1889, 1902, and 1910 to disentangle the components of price reductions of U.S. steel rails. These benchmark years unfortunately miss the dramatic reduction in ore costs between 1892 and 1899 and its impact on the competitive position of U.S. producers. These three 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.

the United States for two reasons: high transportation costs and the industry's high degree of vertical integration (within the U.S. Steel Corporation). The St. Lawrence seaway, which linked the Great Lakes to the Atlantic Ocean through Canada, was not opened until the late 1950s. (The Erie canal was too small to be an efficient supply route.) In the absence of this shipping route, iron ore would have had to be loaded and unloaded from railroad to ship to railroad multiple times in order to reach the ocean, making its transport prohibitively expensive.

In addition, 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.

Not only were the Lake Superior iron ores fully utilized by the domestic steel industry 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). Findlay and Jones (2001) stress the importance of input tradability on the pattern of trade and contrast the case of iron ore with that of raw cotton. Cotton was easily traded and was exported in great quantities from the United States. The domestic cotton textile industry had no international cost advantage despite the presence of local cotton production.[10] By contrast, the Lake Superior iron ores could not be easily exported, and America's resource abundance manifest itself in exports of the intermediate and final goods embodying those resources.

B. *Natural Resources as a Blessing or Curse for Economic Development?*

Recent research has suggested that natural-resource abundance may prove detrimental to economic development. An older literature on the Dutch disease examines situations in which an increase in the demand for nontradables, due to a positive resource discovery or terms-of-trade shock, squeezes resources out of the manufacturing sector. Sachs and Warner (2001) summarize more recent evidence that natural-resource abundance can be harmful for economic growth—in part, they hypothesize, because the production of resources crowds out production of manufactured goods. (See Anderson, 1998, for a dissenting view.) Similarly, Lane and Tornell (1999) argue that rent seeking is intensified in resource-rich countries, particularly those with weak institutions, and that this is a further detriment to growth.

The case of the United States suggests that different outcomes are possible. The adverse effects of the Dutch disease, however, hinge again on the tradability of the resources. Unlike many developing countries that currently export unprocessed raw materials, the turn-of-the-century United States did not export many of its mineral resources but did export goods whose production required those resources. Furthermore, David and Wright (1997) argue that complementarities between resources and manufacturing actually enabled those resources to accelerate development in manufacturing, just as Allen (1977) noted with the Lake Superior ores and productivity. And in the U.S. case, domestic institutions and private property rights were strong, and there was little apparent redistributive activity associated with the revenues generated by the resource extraction.

C. *The Politics of U.S. Trade Policy*

The dramatic shift in the trade position in U.S. manufacturers also stimulated changes in underlying economic interests that were a precondition for shifting U.S. trade policy from protectionism toward reciprocity. As the Republican chairman of the House Ways and Means Committee, William McKinley gave his name to the high protective tariff in 1890. But just eleven years later, as president, McKinley announced 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). McKinley's change of heart reflected the fact that many domestic industries that had faced import competition in 1890 were showing a much greater interest in foreign export markets in 1901.[11]

To sum up, the situation in the turn-of-the-century United States was special. America's natural resources were generally not exported in a raw state, but formed the basis for its comparative advantage in final goods that used those resources intensively. A combination of high transportation costs and the large domestic market acted to prevent the large-scale export of those resources. The presence of strong political institutions also prevented a battle over the redistribution of profits associated with the resources.

The expansion in manufactured exports in the 1890s was so impressive that the U.S. government published a special

[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 was true earlier; in 1899, ore exports were worth \$66,400 and ore imports were \$401,595.) Data from the *Statistical Abstract of the United States*.

[10] In fact, the United States never became a net exporter of cotton textiles, perhaps because high U.S. wages hampered the much more labor-intensive cotton textile industry than the material-intensive iron and copper manufacturing industries. Wages accounted for 25% to 30% of the value of cotton textile products, for example, but only about 10% in iron and steel, according to the Census of Manufactures of 1890.

[11] The Republican party took another half a century, however, to endorse the policy of reciprocal tariff reductions (Irwin and Kroszner, 1999).

statistical report in 1907 examining the situation. The report supports Wright's (1990) findings about the resource-based nature of U.S. manufactured exports. Iron and steel manufactures constituted the largest category of manufactured exports, and its growth "has been coincidental with the development of the great iron mines of the United States" (U.S. Department of Commerce and Labor, 1907, p. 10). The second largest category of manufactured exports was copper. Exports of copper manufactures rose from 0.3% of exports in 1890 to nearly 6% of exports in 1913, as shown on table 1, because electrification prompted much greater demand for a host of copper-related manufactured products, particularly copper wire. This growth was facilitated by massive copper extraction in the West, but—as in the case of iron ore—the United States remained a small net *importer* of raw copper through this period despite its domestic abundance.[12] The third largest category of manufactured export was refined mineral oil, "which became an article of export only after the great oil discoveries in the decade 1860–1870."

V. Conclusions

This paper has sought to determine the underlying factors behind the remarkable 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, fundamentally altered industry conditions in the mid-1890s and laid the groundwork for a striking change in the composition of U.S. exports. Resource abundance formed the basis for the U.S. export success around the turn of the century directly, by lowering the prices 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. Productivity improvements also played a key role in promoting the expansion of exports.

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 satisfying (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).

[12] 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). Hyde (1998) examines the history of the copper industry during this period.

REFERENCES

Abramovitz, Moses, and Paul A. David, "Convergence and Deferred Catch-up: Productivity Leadership and the Waning of American Exceptionalism." (pp. 21–62), in Ralph Landau, Timothy Taylor, and Gavin Wright (Eds.), *The Mosaic of Economic Growth* (Stanford, CA: Stanford University Press, 1996).

Allen, Robert C., "The Peculiar Productivity History of American Blast Furnaces, 1840–1913," *Journal of Economic History* 37 (1977), 605–633.

——— "International Competition in Iron and Steel, 1850–1913," *Journal of Economic History* 39 (1979), 911–937.

——— "Accounting for Price Changes: American Steel Rails, 1879–1910," *Journal of Political Economy* 89 (1981), 512–528.

American Iron and Steel Association. *Annual Statistical Report.* (Philadelphia: American Iron and Steel Association, 1901).

Anderson, Kym, "Are Resource-Abundant Economies Disadvantaged?" *Australian Journal of Agricultural and Resource Economics* 42 (1998), 1–23.

Bowley, A. L. *Wages and Income in the United Kingdom since 1860* (Cambridge, U.K.: Cambridge University Press, (1937).

Broadberry, Stephen N. *The Productivity Race: British Manufacturing in International Perspective, 1850–1990* (New York: Cambridge University Press, 1997).

Burnham, T. H., and G. O. Hoskins, *Iron and Steel in Britain, 1870–1930* (London: Allen & Unwin, 1943).

Carr, J. C., and W. Taplin, *History of the British Steel Industry* (Cambridge, MA: Harvard University Press, 1962).

Creamer, Daniel, Sergei P. Dobrovolsky, and Israel Borenstein, *Capital in Manufacturing and Mining: Its Formation and Financing* (Princeton: Princeton University Press, 1960).

David, Paul A., and Gavin Wright, "Increasing Returns and the Genesis of American Resource Abundance," *Industrial and Corporate Change* 6 (1997), 203–245.

Findlay, Ronald, and Ronald Jones, "Input Trade and the Location of Production," *American Economic Review* 91 (2001), 29–33.

Floud, R. C., "The Adolescence of American Engineering Competition, 1860–1900," *Economic History Review* 27 (1974), 57–71.

Flinn, M. W., "British Steel and Spanish Ore, 1871–1913," *Economic History Review* 8 (1955), 84–90.

Head, Jeremiah, and Archibald Head, "The Lake Superior Iron Ore Mines: Their Influence upon the Production of Iron and Steel," *Cassier's Magazine* 16 (1899), 623–646.

Hogan, William T. *Economic History of the Iron and Steel Industry in the United States,* 5 vols. (Lexington, MA: Lexington Books, 1971).

Hyde, Charles K., *Copper for America: The United States Copper Industry from Colonial Times to the 1990s* (Tucson: University of Arizona Press, 1998).

Irwin, Douglas A., and Randall S. Kroszner, "Interests, Institutions, and Ideology in Securing Policy Change: The Republican Conversion to Trade Liberalization after Smoot-Hawley," *Journal of Law and Economics* 42 (1999), 643–673.

Jeans, J. Stephen (Ed.), *American Industrial Conditions and Competition (Report of a Committee of the British Iron Trade Association)* (London: British Iron Trade Association, 1902).

Kendrick, John W., *Productivity Trends in the United States* (Princeton: Princeton University Press, 1961).

Lake Superior Iron Ore Association, *Lake Superior Iron Ore, 1938* (Cleveland: Lake Superior Iron Ore Association, 1938).

Lane, Philip, and Aaron Tornell, "The Voracity Effect," *American Economic Review* 89 (1999), 22–46.

Lipsey, Robert E., *Price and Quantity Trends in the Foreign Trade of the United States* (Princeton: Princeton University Press for the National Bureau of Economic Research, 1963).

Maddison, Angus, *Monitoring the World Economy, 1820–1992* (Paris, OECD, 1995).

McLean, I. W., "Anglo-American Engineering Competition, 1870–1914: Some Third Market Evidence," *Economic History Review* 29 (1976), 452–464.

Mitchell, Brian R., *Economic Development of the British Coal Industry, 1880–1914* (Cambridge, U.K.: Cambridge University Press, 1984).

——— (Ed.), *British Historical Statistics* (New York: Cambridge University Press, 1988).

Mussey, Henry Raymond, *Combination in the Mining Industry: A Study of Concentration in Lake Superior Iron Ore Production* (New York: Columbia University Press, 1905).

Nelson, Richard R., and Gavin Wright, "The Rise and Fall of American Technological Leadership: The Postwar Era in Historical Perspective," *Journal of Economic Literature* 30 (1992), 1931–1964.

Nicholas, S. J., "The American Export Invasion of Britain: The Case of the Engineering Industry, 1870–1914," *Technology and Culture* 21 (1980), 570–588.

Parsons, Donald O., and Edward John Ray, "The United States Steel Consolidation: The Creation of Market Control," *Journal of Law and Economics* 18 (1975), 181–219.

Sachs, Jeffrey D., and Andrew M. Warner, "The Big Push, Natural Resource Booms, and Growth," *Journal of Development Economics* 59 (1999), 43–76.

——— "The Curse of Natural Resources," *European Economic Review* 45 (2001), 827–838.

Silverman, A. G., "Monthly Index Numbers of British Export and Import Prices, 1880–1913," *Review of Economic Statistics* 12 (1930), 139–148.

U.S. Bureau of the Census, *Historical Statistics of the United States* (Washington, Government Printing Office, 1975).

U.S. Bureau of Corporations, *Report of the Commissioner of Corporations on the Steel Industry, Part I: Organization, Investment, Profits, and Position of the United States Steel Corporation* (Washington: Government Printing Office, 1911).

U.S. Bureau of Corporations, *Report of the Commissioner of Corporations on the Steel Industry,* Part II: Cost of Production, Preliminary Report (Washington: Government Printing Office, 1912).

U.S. Bureau of Labor Statistics, *History of Wages in the United States from Colonial Times to 1928,* BLS bulletin no. 604 (Washington: Government Printing Office, 1934).

U.S. Department of Commerce and Labor, *Exports of Manufactures from the United States and Their Distribution by Articles and Countries, 1800 to 1906* (Washington: Government Printing Office, 1907).

Vanek, Jaroslav, *The Natural Resource Content of United States Foreign Trade, 1870–1955* (Cambridge, MA: The MIT Press, 1963).

Warren, Kenneth, *The American Steel Industry, 1850–1970: A Geographical Interpretation* (Oxford: Clarendon, 1973).

Wright, Gavin, "The Origins of American Industrial Success, 1879–1940," *American Economic Review* 80 (1990), 651–668.

DATA APPENDIX

The price of U.S. iron and steel exports is taken from 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). 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). Foreign income is a weighted average of GDP in Canada and Australia, taken from Maddison (1995). Most American and British exports were sold to third markets (that is, outside each others's market to Canada, Australia, Mexico, and elsewhere) in which they were competing against one another.