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THE RESOLUTION OF THE LABOR SCARCITY PARADOX

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ABSTRACT

This paper reconciles the apparently contradictory evidence about American and British technology in the first half of the nineteenth century. Past studies have focused on the writings of a number of distinguished British engineers, who toured the United States during the 1850s and commented extensively on the highly mechanized state of the manufacturing sector. Other studies, however, have marshalled evidence that the interest rate was higher, and the aggregate manufacturing capital stock was lower, in the United States relative to Britain. We resolve this paradox by noting that British engineers were most impressed by only a few industries which relied on skilled workers. Using the 1849 Census of Manufactures, we estimate separate production functions for the skilled sector and for the remaining, less skilled manufacturing sector. We find strong relative complementarity between capital and natural resources in the skilled sector, and relative substitutability between skilled labor and capital. Using these parameters in a computable general equilibrium model of the U.S. and British economies indicates greater capital intensity (or labor scarcity) in the skilled manufacturing sector, but overall capital scarcity and higher interest rates, in the U.S. relative to Britain.

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A paradox, a paradox,
A Most ingenious paradox! -- The Pirates of Penzance

The influence of factor endowments on the pattern and rate of economic growth is an important theme in economic history and development. In particular, the rapid expansion of nineteenth-century American manufacturing has often been attributed, both by observers at the time and later economic historians, to the influence of abundant land. Most notably, Rothbarth (1946) and Habakkuk (1962) have argued that the land to labor ratio, which was higher in the U.S. than in Britain, raised real wages in American agriculture, thereby increasing the cost of labor to manufacturers. In turn, the higher wage rate in American manufacturing induced entrepreneurs to substitute capital for the dearer labor, leading to a pattern of growth more capital intensive and more rapid than that in Britain.

Temin (1966) formalized the Rothbarth-Habakkuk hypothesis in a simple neoclassical model of agricultural and manufacturing production. While abundant land in agriculture implied relative labor scarcity in manufacturing, the model also implied that the U.S. interest rate should have been lower than in Britain. Because the U.S. interest rate in the antebellum period was in fact greater than the British rate, he concluded that U.S. had to have been capital scarce rather than labor scarce in manufacturing. That is, although labor may have been dear, capital was even dearer.

This anomalous conclusion provoked a vigorous and enduring controversy. Those supporting the Rothbarth-Habakkuk view sought to restore the labor scarcity result in more general models in which all three factors of production (labor, capital, and land) are used in the production of both outputs (Fogel, 1967; Summers and Clarke, 1980).[1] On the other hand, Field (1983a, b) has marshalled empirical evidence that the U.S. capital-labor ratio was far below that in Britain. None of these studies, however, provides a plausible explanation for all of the empirical regularities in the antebellum economy. The problem with the capital scarcity view of U.S. manufacturing is that one must simply ignore the reports of many distinguished visitors to the antebellum United States who found in a number of industries mechanization more advanced than in Britain, at that time supposedly the most technically developed and capital rich country in the world. The difficulty with the labor scarcity hypothesis is that it cannot explain the strong historical evidence that the aggregate capital-labor ratio in manufacturing was lower, and that the interest rate was higher, in the United States.

This paper reconciles these apparent contradictions and resolves the long debate on labor scarcity by distinguishing between manufacturing industries using primarily skilled workers and those relying on unskilled workers. We show that the technological compatibility between capital and natural resources in the skilled manufacturing sector provided sufficient incentives to substitute capital and inexpensive natural resources for skilled labor. This strong technological complementarity did not extend to the less skilled sector, however; thus while the skilled sector was relatively capital intensive, the less skilled sector (accounting for the great majority of total manufacturing output), and hence the aggregate manufacturing sector, was relatively capital scarce. Furthermore, this argument is not just limited to demonstrating that such a theoretical structure could have generated the labor scarcity result, but is instead firmly based on historical evidence from the antebellum period.

The British engineers who visited the United States picked out only a few industries, primarily those employing skilled workers, for special notice.

Matching those industries with 1850 Census of Manufactures classifications allows the estimation of two separate production functions, one for "skilled" industries, and one for "unskilled" industries. These parameters are then instituted in a three good, four factor computable general equilibrium model based on the agricultural and manufacturing sectors of the U.S. economy in 1849. The model is strictly neoclassical, dealing with aggregated factors of production taken to be the same across countries. Even if the machines, the nature of skilled labor, and capital-labor relations in manufacturing differed between America and Britain (e.g., Lazonick, 1981), such complications are not essential to explaining the labor scarcity result and reconciling the empirical evidence. However, the standard assumption is made that the United States and Britain faced the same technology so that the same range of productive techniques was available to entrepreneurs in both countries (Temin, 1966, pp. 283-284; Habakkuk, p. 215).[2] Therefore the model is also appropriate for Britain as well. By substituting British factor endowments and then simulating the model, we generate factor returns and factor input ratios. This simulation allows us to compare the capital-labor ratios in America and Britain for both skilled and unskilled manufacturing. While direct quantitative evidence on these factor intensities has not been available, our model allows us to generate the relevant capital-labor ratios necessary to resolve the labor scarcity controversy. It is shown that the model produces results consistent both with the labor scarcity result and with the existing body of empirical evidence on factor and product prices in both countries.

Section I surveys the labor scarcity debate, one of the longest lived in economic history. The model is specified and the data are described in

Section II, while the results are presented in Section III. Section IV summarizes the conclusions.

I.

A number of foreign visitors during the first half of the nineteenth century commented on the sophistication of equipment in some sectors of U.S. manufacturing (Habakkuk, 1962, pp. 4-5; David, 1975, pp. 20-21). However, it was the American displays at the Crystal Palace Exhibition of 1851 that produced widespread surprise at the state of mechanization in so primitive a country. Many Britons were forced to admit grudgingly, "Yankees are no longer to be ridiculed, much less despised" (Rodgers, p. 89). Two years later, a group of English commissioners, charged with reporting on exhibits at the New York Exhibition and not finding it open on time, took the opportunity instead to tour about and report on the state of American technology. The Special Reports to parliament of George Wallis and Joseph Whitworth, as well as the report of the Select Committee on Small Arms (1854), together constituted perhaps the most detailed and reliable description available of antebellum U.S. manufacturing. Joseph Whitworth, one of the most prominent engineers of his time and the world's foremost manufacturer of machine tools (Rosenberg, 1969, pp. 1, 20), confirmed earlier reports on the advanced state of mechanization when he characterized U.S. production by "the application of machinery wherever it has been practicable to manufacturers" (Rosenberg, 1969, p. 388) and argued that this was the consequence of the scarcity and high costs of labor (p. 28).

The effects of this higher labor cost, linked by Rothbarth (1946) and Habakkuk (1962) to land abundance, was reformulated by Temin (1966) who attempted to distinguish between the problems of technological practice and technological progress. Land abundance implied first that U.S. manufacturing was capital intensive relative to Britain, the "more machines" argument, and secondly that technical progress was both more rapid and more labor saving in the U.S., the "better machines" argument. The former he formalized in a simple two-sector general equilibrium model which, as we have noted, led him to conclude that U.S. manufacturing must have been capital scarce relative to Britain because of the higher U.S. interest rate.

Fogel (1967) showed that it was possible to restore the labor scarcity result in a more complex model based on Cobb-Douglas production functions with three inputs in each sector rather than the two Temin had specified.[3] Elaborating on this model, Summers and Clarke (1980) dropped the Temin assumption that the U.S. was a small country with prices fixed internationally, instead allowing for less than perfectly elastic product demand. They solved the model analytically, obtaining the result that labor scarcity in manufacturing depends on the elasticity of demand for agricultural products -- if demand were inelastic then land abundance, by lowering agricultural prices and wages, would lead to an increased supply of manufacturing labor, thus contradicting the Rothbarth-Habakkuk hypothesis.[4] However, with perfect international capital mobility so that the interest rate is taken as given, the case which they argue was historically relevant, the traditional labor scarcity result was restored.

Other writers have objected to the restrictions of the Cobb-Douglas production specification, which was imposed _a priori_ without supporting evidence. Most importantly, Rosenberg (1969, 1977) has emphasized the role of natural resource abundance in biasing U.S. manufacturing towards capital-intensive techniques. In an ambitious attempt to reintegrate the "more machines" and "better machines" components of the Rothbarth-Habakkuk thesis, David (1975) developed a theory of induced technical change which linked local technical change and the process of factor substitution. The abundance of land or natural resources, taken to have been a relative complement with capital, encouraged the choice of capital-intensive techniques in manufacturing. In turn, the higher wage-rental ratio induced a pattern of localized technical change such that globally technical progress was more rapid and more labor-saving in the U.S.

Finally, in contrast to the succession of post-Temin models attempting to reestablish the Rothbarth-Habakkuk proposition, Field (1983a, b) argued that American manufacturing was substantially less capital intensive than in Britain. He supported this argument by comparing estimates of aggregate capital stock in the respective countries for the mid-nineteenth century, and by documenting the speed and intensity of capital operation by U.S. entrepreneurs. A two-sector, two-region linear Leontief model was then developed to demonstrate that a higher interest/profit rate would lead a country such as the U.S. to adopt lower manufacturing capital intensity.

The debate on labor scarcity has not been conclusive. The focus has shifted from Habakkuk's documentation of American and British technological development in the nineteenth century to the formulation of general theoretical models assessing the impact of land abundance. There has been too much concentration on comparing alternative models in which labor scarcity may or may not occur and too little concentration on empirical evidence to determine the appropriate model. Indeed, one of the remarkable features of this long controversy is how little attention has been paid to the "facts".[5] At a minimum, a model explaining (or refuting) the labor scarcity result should be consistent with the following three empirical regularities for the antebellum period (which are supported in Appendix A):

1. The United States was relatively capital intensive compared with Britain only in a limited number of manufacturing industries. These industries in general required primarily skilled rather than unskilled labor.

2. Both the nominal and the real wage rate were higher in the United States than in Britain.

3. Both the nominal and the real cost of capital were higher in the United States than in Britain.

None of the models in the labor scarcity literature can reconcile all three of these empirical regularities. Temin greatly clarified the issue by analyzing it in a general equilibrium framework, but by forcing it into the Procrustean framework of a very simple model, he ignored Habakkuk's fundamental distinction that U.S. manufacturing was relatively more capital intensive in only a few industries.[6] "In many and probably in most fields of technology the English were still far ahead of the Americans at this date [1850's]" (p. 5). Why should U.S. entrepreneurs have adopted sophisticated, capital-intensive technologies relative to Britain in some industries but not in others? Previous models could not answer such a question because they have concentrated on demonstrating that the U.S. manufacturing sector as a whole was labor scarce (or capital scarce), controverting stylized empirical fact number 1.[7] Moreover, previous models have been unable to reconcile general labor scarcity with other empirical evidence. While accepting higher U.S. interest rates, Temin (1966) and Field (1983a, b) were forced to deny the United States was relatively labor scarce in manufacturing at all. Summers and Clarke (1980) supported U.S. relative labor scarcity but only by claiming that real interest rates were lower in the United States.

The model presented in the following section, while limiting itself to the "more machines" and not the "better machines" problem, will be more firmly rooted in Habakkuk's original specification of the labor scarcity phenomenon by distinguishing between two sectors of manufacturing. Because the extensively mechanized industries were also characterized by more highly skilled workers, we characterize those industries as the skilled manufacturing sector; the other industries comprise the unskilled sector.[8] Our resolution of the labor scarcity controversy is based on the relative complementarity of capital and natural resources inputs in the skilled sector.

The complementarity of cheap natural resources provided sufficient incentive for the entrepreneur to invest in the capital-intensive production process, despite the high interest rates. Thus we can potentially reconcile the seemingly contradictory evidence that although some industries displayed ingenuity in the use of labor-saving equipment, the manufacturing sector as a whole was capital scarce.

II.

The economy of the antebellum United States is characterized here by a model with three sectors of production -- skilled manufacturing, unskilled manufacturing, and agricultural goods, and four inputs -- skilled labor, unskilled labor, capital, and land. Other sectors extraneous to the argument, services most importantly, are omitted for simplicity.[9] Aggregate factor endowments are fixed, although some intersectoral factor mobility is allowed.

Industries were classed in the skilled sector if they were noted, primarily by Whitworth and Wallis but also by Habakkuk, as being particularly intensive in the use of machinery relative to Britain. These include agricultural implements, furniture and other woodwork, machinery, hardware, nails, clocks, and guns (Habakkuk, p. 4; Rosenberg, 1969, pp. 170-73, 216, 269, 273, 342, 343). We exclude two manufacturing industries, boots and shoes and cotton textiles, from our group of skilled industries because the mechanized production processes involving skilled workers were only a small proportion of the total industry (see Appendix A for documentation).

We refer to this grouping of industries as the skilled sector, since their distinctive feature appears to have been a much greater reliance on skilled labor.[10] In 1849, these industries constituted only 7 percent of total manufacturing output. The 1849 annual wage in these firms was $329, substantially greater than the $237 average in all other manufacturing and in large part an indication of a greater concentration of skilled workers.[11] Note, however, that the inclusion of an industry in this group depends on whether it was singled out by Habakkuk and others as being particularly capital intensive relative to Britain, and not simply on whether industry wages were above the norm. The skilled sector is taken to hire only skilled workers, and the unskilled sector is assumed to hire only unskilled workers, although both labor classes are assumed equally productive in the agricultural sector.[12]

Although the industries displaying advanced machinery were held to have been more capital intensive than their British counterparts, they were not especially capital intensive compared with U.S. manufacturing as a whole. In 1849, the capital-labor ratio for this group was $539 as compared with $559 for all other manufacturing.

The skilled and unskilled manufacturing sectors are assumed to have Mukerji (1962) multifactor production functions that allow the partial elasticities of substitution to differ between pairs of factors. Skilled labor, capital, and agricultural resources are inputs in the production of skilled manufacturing products, while unskilled labor, capital, and agricultural products enter the unskilled sector. The Mukerji generalization of the CES function holds the ratio of partial elasticities constant over the entire range of production. This can be seen by referring to the skilled and unskilled manufacturing production functions in Table I, which, after some manipulation, indicate that

$$\frac{\sigma_{ij}}{\sigma_{im}} = \frac{1+\rho_m}{1+\rho_j} \quad , \qquad i,j,m = 1,2,3, \; i \neq j \neq m$$

where σ_{ij} is the partial elasticity of substitution between factors i and j, ρ_i is the constant production function parameter. The equation holds for the unskilled sector as well. The function is not necessarily linear homogeneous, though by appropriate scaling of ρ_s or ρ_u, local linear homogeneity can be assured. Note also that the production function will generally not be homothetic; thus at constant factor prices, scale effects will cause differing proportions of inputs to be used. Agricultural production, by which we mean natural resources processed sufficiently for use either in the manufacturing sector or for consumption, is taken to be a constant return to scale Cobb-Douglas function with inputs labor, capital, and farmland. This function is also shown in Table I.

The existence of tariffs and transport costs restricted, within a wide range of prices, U.S. and British trading possibilities. The ratio of duties to the value of dutiable imports was over 25 percent in 1850 and higher than 60 percent during some years in the antebellum period; in addition, Habakkuk found evidence of wholesale markups between 100-150 percent for imported products (p. 41). The existence of tariffs and transportation costs are, moreover, necessary to the labor scarcity argument, since they allowed both higher interest rates and wages in the United States, given the shared technology.[13] There was, however, significant importation of raw materials into Britain, accounting for 40 percent of total domestic agricultural consumption in 1851. To a lesser extent the Americans exported agricultural output as well. We therefore include an exogenous import and export sector, in which consumption expenditures on the agricultural product diverge from output value by the amount of the fixed import or export flow. In order to maintain trade balance, an equal value of manufacturing goods is either imported (in the U.S.) or exported (in Britain), with the composition of skilled and unskilled manufacturing imports and exports determined by the proportional output in each domestic sector. The demand functions, taken to be independent of the income distribution, are derived from a CES utility function and are also presented in Table I.[14,15]

We next consider the estimation of parameters for the equations specified in Table I. The nonlinearity of the Mukerji specification precluded robust estimation of manufacturing production functions, so we adopted the less restrictive translog production function instead to provide estimates of the partial elasticities. The translog function was not chosen for the simulations, however, because of its potential for wandering into non-economic regions given counterfactual endowments, as well as for potential changes in the relative substitution elasticities. Using data from the 1850 Census of Manufactures, the production function with constant returns to scale and symmetry imposed was estimated concurrently with two cost share equations for efficiency (Burgess, 1975, p. 110). The estimating equations may be written as:

$$\begin{aligned}\ln Q - \ln A = {} & \alpha_K \ln(K/A) + \alpha_L \ln(L/A) + \gamma_{KK}(1/2(\ln K)^2 \\ & - \ln K \ln A + 1/2(\ln A)^2] + \gamma_{LL}[1/2(\ln L)^2 \\ & - \ln L \ln A + 1/2(\ln A)^2] + \gamma_{KL}[\ln K \ln L \qquad (1a) \\ & - \ln K \ln A - \ln L \ln A + (\ln A)^2] + \alpha_0 + U_Q\end{aligned}$$

$$\begin{aligned}M_K &= \alpha_K + \gamma_{KK} \ln(K/A) + \gamma_{KL} \ln(L/A) + U_K \\ M_L &= \alpha_L + \gamma_{KL} \ln(K/A) + \gamma_{LL} \ln(L/A) + U_L \qquad (1b)\end{aligned}$$

where K, L, and A denote capital, labor, and agricultural inputs, and M_K and M_L are the cost shares of capital and labor, in the respective manufacturing production functions. The parameters satisfy the restrictions

$$\sum_i \alpha_i = 1 \quad , \quad \sum_i \gamma_{ij} = 0 \quad , \quad i,j = K,L,A \ . \qquad (2)$$

The equations were estimated for skilled manufacturing on a pooled set of state data by industry and for unskilled manufacturing on data by state using the iterative Zellner-efficient estimator which yields asymptotic maximum likelihood estimates independent of the choice of which share equations are included.[16] The regression results are reported in Table II; remaining parameters may be computed using the symmetry and constant returns to scale restrictions in (2).

The Allen partial elasticities of substitution implied by the estimated parameters and evaluated at the sample means are presented in Table III.[17] The substitution elasticity between capital and labor in unskilled manufacturing is less than one, a result consistent with other estimates for nineteenth-century U.S. manufacturing (Abramovitz and David, 1973, p. 434; James, 1981, p. 383). Moreover, the pattern of inequalities in unskilled manufacturing, $\sigma_{KL} < \sigma_{KA} < \sigma_{LA}$, is consistent with that for all U.S. manufacturing in the late nineteenth century (James, 1981, p. 383).

Skilled labor appears to have been a better substitute for capital than unskilled labor was, although this inference involves comparing parameters from different production functions. This result is at variance with some more recent evidence that skilled labor and capital are relative complements (Griliches, 1969; Hamermesh and Grant, 1979, p. 537).[18] Substitution between agricultural goods (or natural resources) and both skilled and unskilled labor is elastic, with unskilled labor being the better substitute.

Most importantly for the issues in this paper, the estimates here support the David-Rosenberg emphasis on the nonseparability of the production function between capital and natural resources. In both skilled and unskilled manufacturing, capital and natural resources are relative complements, $\sigma_{KA} < \sigma_{LA}$, although the relative complementarity is much stronger in the skilled sector. An increase in natural resource inputs implies an increase in the capital-labor ratio in both sectors (holding factor prices constant), with a greater increase in the skilled sector.

The influence of natural resource abundance in influencing the choice of technique in American manufacturing has often been noted. Whitworth himself, for example, observed that in the U.S., "In no branch of manufacture does the application of labour-saving machinery produce by simple means more important results than in the working of wood" (Rosenberg, 1969, p. 343). Ames and Rosenberg (1968) extend the argument in discussing the Springfield Armory.

> There is evidence which suggests that the woodworking machines which were popular in America and neglected in England were not only labour-saving but also wasteful of wood. Their adoption in America and neglect in England

> may be attributable not only -- or perhaps not even primarily -- to differences in the capital-labor ratios in the two countries but rather to the cheapness of wood in the United States and its high price in England. (p. 831)

Numerous examples of resource-using tendencies, particularly with lumber, in American manufacturing are cited in Rosenberg (1972) and Hindle (1975).

Probably more significant than the use of greater physical amounts of raw materials in production was the fact that American resource abundance made for cheaper energy. Christensen (1981) shows that the cost of both water and steam power per horsepower was lower in the United States than in Britain in the late antebellum period. The combination of inexpensive energy (i.e., natural resources) and the strong relative complementarity between natural resources and capital must have provided a strong impetus for the U.S. skilled manufacturing sector to substitute away from labor and into capital.[19]

Finally, the factor shares in the Cobb-Douglas agricultural production function are taken from Fogel and Engerman (1974, pp. 131-133) for antebellum agriculture, and are also presented in Table III.[20]

Habakkuk emphasized that industrial labor was not only dearer in the United States, but also that its supply was less elastic (pp. 15-16). We therefore specify an intersectoral labor supply function of the following form.

$$L_S = \gamma_0 \left[\frac{W_S}{W_A}\right]^{\gamma_1} L_A \qquad (3)$$

$$L_U = \gamma_2 \left[\frac{W_U}{W_A}\right]^{\gamma_3} L_A$$

where L_S, L_U, and L_A are labor supplied in skilled manufacturing, unskilled manufacturing, and agriculture, respectively, W_i, $i = S,U,A$ is the sector-specific wage, and γ_i, $i = 0,\ldots,3$ are parameters of the labor supply function. Noting that the total supply of labor is assumed fixed, so that $L_A + L_U + L_S = \bar{L}$, we can write the partial elasticity of manufacturing and agricultural labor supply as

$$\varepsilon_S = \gamma_1\left(1 - \frac{L_S}{\bar{L}}\right)$$

$$\varepsilon_U = \gamma_3\left(1 - \frac{L_U}{\bar{L}}\right) \tag{4}$$

$$\varepsilon_A = \frac{\gamma_1 L_S + \gamma_3 L_U}{\bar{L}}$$

where ε_S, ε_U, and ε_A represent the skilled, unskilled, and agricultural elasticities, respectively.

The labor supply elasticity in each manufacturing sector is thus roughly proportional to γ_1 or γ_3; by varying these parameters, we can impose either greater or less labor mobility in the U.S. economy. Initially we assume a labor supply elasticity in the United States equal to .30, a value consistent with recent estimates for less developed countries (Mundlak, 1978). Capital, on the other hand, is assumed fixed within the agricultural and aggregate manufacturing sectors; because we know from historical evidence their actual levels, we need not simulate them. However, capital is assumed perfectly mobile between the skilled and unskilled manufacturing sectors.

This model is more Habakkukian in spirit even if not in all exact details than previous contributions to the labor scarcity debate. However it is still too simple to reflect the richness of detail and multitudes of conjectures in Habakkuk's analysis. For example, we neglect the effects of differences in the price of capital goods across countries,[21] as well as those resulting from greater imperfections in the U.S. labor and product markets, on the choice of capital and labor inputs. Habakkuk argued that average profit rates in U.S. manufacturing may have been high relative to Britain due to local monopoly power, but that these profit rates would have fallen rapidly as the firm expanded past local product and labor markets, thereby providing American entrepreneurs with incentives for capital-intensive production methods (pp. 68-69, 74, 75). While these possible discontinuities in the rate of return are not captured in our model, it is nevertheless complex enough to reconcile the stylized facts of labor scarcity.

Table IV presents the historical evidence on outputs of and factor inputs employed in the agricultural and manufacturing sectors of the United States and Great Britain in the mid-nineteenth century. This date is an appropriate one to compare the choice of technique in the U.S. and Britain because the U.S. labor scarcity question has generally been regarded as an issue only for the antebellum period and it began to be widely discussed in the 1850's. Quite conveniently, our stylized American and British economies are very similar in size at this time, both in terms of total output and output per capita. As would be expected, however, factor endowments differed dramatically. While the labor forces in each country were quite similar, there was more than twice as much capital in Britain (Field, 1983a), but only one-seventh the land.[22]

Finally, consider the foreign sector. The British economy imported substantial quantities of natural resource products. The total value of agricultural products (or natural resources) imported into the U.K. minus re-exports was £72.5 million for 1851 (Mitchell, 1962, pp. 291-292, 297).[23] While there are no data for imports into Great Britain alone in 1851, we note that in 1829, the destination of 98 percent of total U.K. imports was Britain (Mitchell, 1962, pp. 289-292). Assuming a similar ratio held in 1851 and converting the figures into dollars at the par exchange rate, we find that imports into Britain amounted to $354.2 million. Similarly, total exports of crude materials plus crude foodstuffs from the U.S. in 1849 was $94 million.

The computable general equilibrium model is solved in two steps. In the first stage, the more detailed U.S. data on output, factor supply, and prices are used to normalize the production and demand functions. For example, using observed output, capital stock, labor, and agricultural inputs in skilled manufacturing, along with estimates of the three elasticities of substitution from Table III, we can solve for ρ_1, ρ_2, ρ_3, δ_1, δ_2, and δ_3. The final parameter ρ_S is then set to ensure local linear homogeneity. Prices of all final outputs are normalized to $1.00 in the initial U.S. equilibrium.

The second stage is to calculate the new equilibrium in Great Britain. We substitute factor endowments in Britain for those of the U.S., and allow the model to iterate from the production side to the consumption side and back again until a fixed point set of equilibrium factor and product prices are realized. Solving the model in this way ensures local stability, although the model may fail to converge for extreme parameters or odd starting values. The model determines sectoral output in Great Britain. Together with the relative prices determined within the structure of the simulation, and actual British GNP in 1851, $1297.7 million, we can express British price levels relative to the U.S. numeraire prices.

III

The simulation results comparing prices and the capital-labor ratio in the U.S. and Britain are presented in Table V. The factor returns for the

United States based on 1849 historical statistics are presented in the first column. Recall that these returns are not the outcome of the simulation, but rather are parameters implied by empirical evidence on factor income, aggregate employment, and capital stock. The skilled wage exceeds the unskilled wage by 39 percent ($329/$237), while the agricultural wage is substantially less than the unskilled wage. Although the annual unskilled wage rate of $237 compares favorably with the $253 wage constructed from evidence on daily wages by Abbott (1905) and Goldin and Sokoloff (1982),[24] the agricultural wage is well below estimates of average yearly earnings of farm laborers. However, the problem here is not so much with the model as a more fundamental difficulty in reconciling agricultural wages implied by national product account factor shares with those observed directly; even if all the proceeds of farm output were paid only to workers, they would have still received a wage of only $183.[25] The gross return to fixed capital in the skilled and unskilled manufacturing sector, as specified in the 1850 Census, was 0.45 and 0.43, respectively, figures consistent with higher real interest and depreciation rates in the U.S. (see Appendix A). The divergence between the return to manufacturing capital and the lower return to agricultural capital suggests substantial capital immobility. Although our model does not allow for capital mobility between agricultural and manufacturing sectors, expanding the definition of manufacturing capital to include working capital virtually eliminates the divergence in returns.[26]

The results in brackets in Table V for the return to capital and for the capital-labor ratio reflect the adjustment of manufacturing capital to equalize factor returns, because in the initial equilibrium the return to capital in U.S. skilled manufacturing was slightly higher than in unskilled manufacturing. The parameter values in the brackets therefore correspond to a redistribution of capital within the U.S. manufacturing sector to ensure equal return to capital.

Results for the simulated British economy are described in the second column of Table V. First note that relative prices and wages between Britain and the U.S. appear quite reasonable. The prices of skilled and unskilled manufacturing goods are, respectively, 0.45 and 0.70, while the price of agricultural products is one-third higher than in the United States. The British prices of manufactured products are substantially lower than U.S. prices, but not so low as to preclude the existence of an American manufacturing industry once tariffs and transport costs are taken into account. As noted earlier, the U.S. tariff in 1850 averaged about 25 percent. Transport costs for raw cotton over the 1840-1860 period, computed by comparing New York and Liverpool prices, averaged about 15 percent of the final price (Mitchell, 1962, p. 491; U.S. Historical Statistics, 1975, p. 209), and such a figure for shipping a bulk, easily transportable commodity is most probably a lower bound for transport costs in general. The protection of distance would have sufficiently insulated the U.S. skilled manufacturing sector.[27]

The British wages in skilled and unskilled manufacturing, $207 and $149, respectively, are 63 percent of the corresponding American wages, a ratio slightly less than the 76 percent calculated in the Appendix from historical sources but nevertheless quite close. The British agricultural wage is calculated to be 26 percent below the unskilled wage rate, which agrees closely with the reported difference of 32 percent by Lindert and Williamson (1983). The essential equality of British and U.S. agricultural wages, while in accord with Adams (1970), understates the true difference in earnings between U.S. and British agriculture, because the self-employed American farmer also received a return to land in contrast with British tenant farmers and laborers.[28]

The return to capital in Britain is shown to be 0.16 in both manufacturing sectors, and 0.07 in the agricultural sector. The return to capital in British manufacturing in the model is very similar to the independently calculated return on capital of 0.18 (see Appendix A). There is less information on the return to capital in British agriculture, but again it seems reasonable that the simulation indicates a lower relative return to the agricultural capital.

Note that the model shows the United States to have been more capital intensive in the skilled manufacturing sector. The British capital-labor ratio in skilled manufacturing, $413 per worker, is lower than the $539 figure in the United States, while in the unskilled sector there was far less capital per worker in the U.S., $559 versus $848 in Britain. The U.S. was more capital intensive than Britain in the skilled sector, even though overall in manufacturing it was less capital intensive. Thus the labor scarcity hypothesis is confirmed by the simulation model.

One might ask next: What are the effects of a change in the stock of land on the capital-labor ratio in manufacturing? Not surprisingly, the outcome of the simulation model parallels the results from the simpler Temin two-sector model. Setting the elasticity of labor supply in the agricultural sector equal to 0.3 (and $\gamma_1 = \gamma_3$) allows workers limited mobility between agricultural and manufacturing sectors. The U.S. case (with equal factor returns, so that the capital-labor ratios are in brackets) in the first column of Table V can be compared with the third column, which calculates equilibrium prices and quantities for the counterfactual U.S., differing from the actual U.S. only by having a land endowment equal to that of Britain. Reading from column 3 to 1, we can see that increasing the land endowment increases both the wage of the agricultural worker and the capital-labor ratio in both manufacturing sectors. Such a result is not surprising; the introduction of an increased endowment of land leads to rising farm wages and migration from manufacturing into farming. Because the capital stock in all of manufacturing is fixed, the new manufacturing capital-labor ratio is higher, so the return to capital falls. In agriculture, on the other hand, the migration of labor along with increased land causes a rise in the return to capital (allowing for capital mobility would reduce the magnitude of these effects). While the direction of change is not surprising, the minimal response of factor prices to the seven-fold increase in land is noteworthy. The physical marginal product of agricultural capital and labor rises significantly in response to the abundant land. However, the lower price of agricultural output, caused by the increased agricultural production, reduces the wage and the return to capital (i.e., the value of the marginal product) sufficiently that the magnitude of changes in the factor returns are quite small (Summers and Clarke, 1980). Varying only the land endowment in this model therefore provides results which are consistent with previous studies, but cannot explain the historical pattern of lower overall capital intensity, a higher real interest rate, and a higher skilled manufacturing capital-labor ratio in the United States relative to Britain.

A central focus of Habakkuk was the role of labor supply in explaining American labor scarcity. Not only was industrial labor dearer in the United States but its supply was also less elastic, owing to the barriers of high information and transportation costs (p. 15-16). In addition, he felt that the relative abundance of skilled workers in the U.S. led to a lower skilled wage differential. The combination of a lower elasticity of unskilled labor supply, a lower perceived skilled wage differential, and complementarity between skilled labor and capital led Habakkuk to believe that manufacturers would substitute out of labor and into more capital-intensive production techniques (p. 25). We can separate the argument into two parts.

Consider first the role of the industrial labor supply elasticity. The U.S. manufacturing sector, having to attract workers from farming, would have been more likely to substitute capital for labor when the sector expanded, since the labor intensive methods would have led to yet higher wages. We can evaluate the influence of the labor supply elasticity in our simulation model by posing the question: How would increasing the manufacturing labor supply elasticities from our assumed value of 0.3 to the counterfactual case of 0.6 have affected the capital-labor ratio in American manufacturing?[29] The detailed results are presented in the first two columns of Table VIII in Appendix B. As might be expected, increasing the labor supply elasticity reduces the capital-labor ratio in both sectors of manufacturing; the higher manufacturing wages attract more workers into manufacturing, thereby driving down the capital-labor ratios. That is, if United States labor had been more mobile (as Habakkuk suggested the British were), the manufacturing capital-labor ratio would have been much lower. Conversely, if the labor supply elasticity were significantly lower in the U.S. than in Britain, the labor scarcity result would have been more likely to occur, strengthening the simulation results in Table V. Note however that varying the labor supply elasticity affects the capital-labor ratio levels in both manufacturing sectors and thus cannot account for U.S. labor scarcity in only the skilled sector. Differences across countries in labor supply elasticity alone are neither necessary nor sufficient for a complete resolution to the labor scarcity debate.

The second part of Habakkuk's argument distinguishes between skilled and unskilled workers. He suggests that a lower skilled wage differential in the United States created an incentive for manufacturers to substitute skilled workers and capital (taken to have been relative complements) for the inelastically supplied unskilled workers. This argument clearly relies on the specification of the manufacturing production function, which in his implicit model has three inputs -- skilled workers, unskilled workers, and capital. Our simulation model cannot address this issue directly, because we separate manufacturing into two sectors and include natural resources in both production functions. There are at least a couple of reasons however to suggest that such an explanation for labor scarcity is not correct. First, our regression results (Table II) suggest it was the skilled artisans who were the relative substitutes for capital, while unskilled workers were relative complements in U.S. manufacturing. Andrew Ure, for example, observed that early mechanization involved the substitution of unskilled for skilled labor (Habakkuk, 1962, pp. 153-154). As a result, imposing a higher British skill differential reduces, rather than augments, the labor scarcity result in the simulation model. A 20 percentage point greater skill differential in Britain (following Habakkuk), presented in the third column of Table VIII, increased the capital-labor ratio in the skilled sector so much as to eliminate the labor scarcity result. Second, evidence cited in Appendix A suggests the skill differential in the United States was no different from that in Britain. Williamson and Lindert (1980, p. 67) argue that while the skill premium was lower in the U.S. early in the nineteenth century, it increased rapidly relative to Britain over the antebellum period. This trend in the skill differential is consistent with a trend toward labor scarcity in U.S. skilled manufacturing before the Civil War.

Neither factor emphasized by Habakkuk, neither the more inelastic industrial labor supply in the U.S. nor the lower skilled wage differential, is necessary for the greater capital intensity in U.S. skilled manufacturing as compared with Britain. Indeed, a lower U.S. skill premium weakens rather than strengthens the labor scarcity result.

Summers and Clarke (1980) placed considerable importance on the elasticity of demand for agricultural products. Therefore let us consider the sensitivity of the labor scarcity result to changes in the elasticity of substitution parameter in the utility function. Reducing the substitution elasticity parameter (β) to 0.75 (corresponding to a price elasticity of the demand for food equal to 0.32 in the U.S.) indicates a capital-labor ratio of $474 in skilled British manufacturing, still below the U.S. ratio of $539. Increasing β to 3.0 (corresponding to a price elasticity of food equal to 1.26 in the U.S.) weakens the labor scarcity result only slightly, to an implied value for the British skilled sector of $449. The choice of the proper elasticity of substitution in demand is more important for the implied prices and wages in the simulation model. Either extremely high or extremely low values of β lead to unreasonably low values for British skilled manufacturing product and agricultural wages.

If it was neither land abundance alone, or differences in labor supply elasticities, then what does generate the labor scarcity result? Consider next simulations which compare the U.S. with Britain, rather than the U.S. with a counterfactual U.S. economy. The simulations indicate that the production function parameters are essential to obtaining the labor scarcity result. If the manufacturing sectors are characterized by a CES production function that imposes an equal elasticity of substitution among the three factors, then the hypothesis of labor scarcity is rejected. When the common elasticity of substitution is set to either 0.8 or 1.2, the capital-labor ratios in British skilled manufacturing was \$773 and \$791, respectively, as compared with the U.S. figure of \$539. The David-Rosenberg hypothesis emphasized that capital and natural resources were relative complements in production. Even though they were in fact relative complements in both the skilled and unskilled manufacturing sectors, it was the much lower partial elasticity in the skilled sector (.81 as compared with 1.71 in the unskilled sector) that dictated the pattern of factor intensity reversal between the U.S. and Britain. Increasing this parameter to the unskilled value, 1.71, for example, would imply capital scarcity in both U.S. manufacturing sectors. (The detailed simulation results appear in Table IX of Appendix B). The results are somewhat sensitive to the partial elasticity of substitution between labor and capital in skilled industry as well. Reducing its value from 1.34 to the equivalent value in unskilled industy, .85, makes Britain slightly more capital intensive in skilled manufacturing (Table IX).

The necessary conditions for the labor scarcity result therefore depend on the production parameters in the two manufacturing sectors as well as the pattern of factor endowments. In particular, the relative complementarity between capital and natural resources, and the relative substitutability between capital and labor in the skilled sector, combined with abundant land and scarce capital, led to the curious phenomenon of labor scarcity.

IV.

This paper reconciles the apparently contradictory evidence about American and British technology in the first half of the nineteenth century and in doing so resolves the labor scarcity paradox. A computable general equilibrium model for the U.S. and Britain at mid-century is developed which follows Habakkuk's emphasis on distinguishing between skilled and unskilled labor. Using empirically estimated production function parameters and actual factor endowments, the simulation model supports the existence of limited labor scarcity in the United States. The sector of manufacturing employing primarily skilled workers is shown to have been more capital intensive than in Britain, even though British manufacturing as a whole was much more capital intensive than in the U.S. Finally, both the real and nominal wage rates and the return to capital are shown to have been higher in America, a result also consistent with the empirical evidence.

While the model does indicate that an increase in land promotes labor scarcity in manufacturing, Temin (1971, p. 177) proves to be ultimately correct when he observed, "If labor was scarce in American manufacturing this was not due simply to an abundance of land." In addition to land abundance, the labor scarcity result appears also to depend on differences in production technology between skilled and unskilled manufacturing. The arguments by David and by Rosenberg emphasizing the relative complementarity of capital and natural resources in production are confirmed here. Land or natural resource abundance in the U.S. promoted greater capital intensity in manufacturing not so much through its impact on the labor market but rather through its relative complementarity with capital.[30] Moreover, relative complementarity alone is not sufficient for the labor scarcity result; as we have seen from the skilled manufacturing sector, capital and natural resources must be <u>strong</u> relative complements. If the manufacturing production functions are simplified to CES, the labor scarcity result is lost.

In similar fashion, the capital-labor substitution relationship is also important for the labor scarcity result. If skilled labor is no closer substitution for capital in production than unskilled labor, the greater capital intensity in U.S. skilled manufacturing disappears. On the other hand, industrial labor supply differences between the U.S. and Britain, emphasized by Habakkuk, are not crucial to resolving the labor scarcity problem. A more inelastic supply of labor to manufacturing in the U.S., ceteris paribus, does lead to greater capital intensity in both the skilled and unskilled sectors in the model. However, such differences in labor supply elasticities are unlikely to explain labor scarcity by themselves, because they cannot account for the lower overall capital intensity in the United States. The other aspect of Habakkuk's argument, that lower skilled wage differentials in the United States induced the substitution of skilled labor and capital for the dearer and less elastically supplied unskilled labor, contradicts the empirical evidence. First, from the Appendix, the skill differential in the U.S. was no lower than in Britain, at least by the 1850's; second, from the estimated production functions, skilled, rather than unskilled, labor was more substitutable with capital. Thus, if the supply of industrial labor had been more inelastic in the U.S. than in Britain, this would reinforce the labor scarcity result, but in itself is neither a necessary nor sufficient condition.

A final unanswered question is, why did labor scarcity go away during the second half of the nineteenth century? Habakkuk (pp. 126-127) suggested that increased immigration after the 1840's, by increasing the elasticity of the labor supply, reduced the incentive for capital-intensive investments. If the labor supply factors were not central to the labor scarcity result during the first half of the nineteenth century, it seems implausible that they could account for its demise during the latter half. Similarly, Habakkuk's argument that technical progress in the second half of the century became more dependent on the autonomous advance of scientific knowledge is neither well documented nor particularly convincing (pp. 194-195).

The ultimate reason why labor scarcity in U.S. manufacturing ceased to be noteworthy was that the United States as a whole had, by the end of the nineteenth century, became more capital intensive than Britain. The American capital-labor ratio in manufacturing, which in 1880 had been slightly below that in Britain, was by 1890 well above the British ratio ($1535 versus $1176) (Feinstein, 1972, p. T99; U.S. Census Office, 1902).[31,32] The same pattern held for specific industries; the capital labor ratio in U.S. textiles was $1963 in 1899, while in U.K. textiles the ratio was, in 1907, $811 at par exchange rates. Similarly, the 1899 U.S. ratio in iron and steel was about four times the corresponding 1907 U.K. figure (Great Britain Board of Trade, 1913, pp. 13, 35; U.S. Bureau of the Census, 1913).

The disappearance of the labor scarcity question may well have been a consequence of localized technical change. David (1975), as we have noted, suggested that the relative complementarity of natural resources (or land) and capital led to a pattern of local technical change in the United States that was globally both more rapid and more labor-saving. James (1981) lent support to this hypothesis by showing that natural resources and capital were indeed relative complements in U.S. manufacturing for every Census year between 1850 and 1900. Thus the more rapid U.S. rate of labor-saving technical change lowered the relative price of capital goods during the middle part of the nineteenth century, thereby accelerating the rate of capital formation in the manufacturing sector (David, 1977). Just as the combination of land abundance and the complementarity between natural resources and capital induced the antebellum skilled manufacturing sector to choose more capital-intensive techniques, the "more machines" story, it also promoted rapid and labor-saving technical change in the manufacturing sector, or the "better machines" story. It was the second half of the Rothbarth-Habakkuk argument, that localized innovation in both the skilled and unskilled manufacturing sector led to greater use of capital, that ultimately can explain the disappearance of the labor scarcity question by the end of the nineteenth century.

APPENDIX A

Extent of Labor Scarcity

The group of manufacturing industries which we identify in Section II as having been more highly mechanized in the United States by the 1850's are essentially those identified by Habakkuk (p. 4) as areas of American superiority. Since Habakkuk's classification in turn was based primarily on the Special Reports of Wallis and Whitworth (Rosenberg, 1969), we consider in this section some of their observations on the state of American technology. It should be reemphasized that they were much more than casual observers; Whitworth in particular was impressively, perhaps uniquely, qualified to compare American with British productive techniques. Even though the evidence here is impressionistic without quantified data to support it, it still clearly must be reckoned with.

The commissioners most probably focused on best practice or state of the art technology in the various American industries. That these best practice firms were not atypical representations is suggested by the fact that higher depreciation rates (see later in the Appendix) insured that a greater proportion of U.S. factories were of recent vintage.

American woodworking superiority in the antebellum period was well recognized (Rosenberg, 1969, pp. 32-49). Whitworth commented extensively on this industry ("In no branch of manufacture does the application of labor-saving machinery produce by simple means more important results than in the working of wood" p. 343), and singled out agricultural equipment in particular ("Labour-saving machines are most successfully employed in the manufacture of agricultural implements" p. 343). In addition, Wallis was impressed by the manufacture of decorative furniture (". . .extensive establishments exist for the production of decorative furniture, the constructive portions being for the most part prepared by machinery by which labour is greatly economised. . ." p. 294).

The industries distinguished by their mechanization were not limited to woodworking. In metal working and hardware, Wallis declared that "In the finish of the joints great accuracy is obtained, whilst the labour of filing is saved by grinding the joints of the hinges on stones adapted to the purpose, and driven by steam-power" (p. 269). Whitworth was similarly impressed with clock manufacturing:

> the superiority obtained in this particular manufacture is not owing to any local advantage; on the contrary, labour and materials are more expensive than in the countries to which the exportations are made; it is to be ascribed solely to the enterprise and energy of the manufacturer, and his judicious employment of machinery (p. 342; see also Church, 1975).

Finally, the speed in which skilled gun workers could assemble a rifle stock, as carefully timed and documented by Whitworth (pp. 364-65), so impressed the British government that they sent a committee on machinery back to the United States, ultimately to purchase more than 12000 in muzzle and stock producing machines.

Not all industries awed the visiting British. Wallis, for example, did not find particularly advanced technology in industries such as silk (". . .in the growth and preparation of the raw material, the United States have receded, and not advanced, since 1844" p. 232). Similarly, production techniques in leather and furs differed "in no important point with the methods used, or the purposes to which it is applied in Europe." (p. 235) Aside from these clearly negative comments, many descriptions of the individual industries simply lacked any specific comparison of production methods in the two countries; these industries included woolens and worsted, flax and hemp, carpets, wearing apparel and standard clothes, and glass and porcelain.

We have excluded a few minor industries from our skilled sector, despite mention by the British observers, primarily because there was no straightforward match between the 1850 Census classification and the observers' category. These include fishing net manufacture (p. 353), printing and dyeing (p. 246) and type foundries in printing and publishing (p. 240).

Two major industries, boots and shoes and cotton textiles, are sometimes identified as having been more mechanized in the United States. While it was likely that they were more capital intensive than other U.S. manufacturing industries (Sokoloff, 1984a), we omit them from our specified group of industries because American superiority was limited to only particular production processes and was not characteristic of the industry as a whole. In boots and shoes, lasts were cut using advanced techniques (p. 171), but the rest of the industry was unmechanized. Of the 11,639 workers employed during the late 1840's by the Lynn, Massachusetts shoe companies, only 321 cut the shoes from the stock. The remainder were either female binders (7,170), male cordwainers (4,132) or management. Owing to the aggregated nature of the data, we therefore include the machine operators with the sewers and cordwainers in the unskilled sector.

Cotton textiles was another industry meriting notice by the British visitors. Wallis noted that ". . .it is often found that a weaver will attend to four looms in the United States, who, in the same quality of work, would attend to only two in England." (p. 216) His observations are supported by a comparison of looms per total factory workers in Lowell and the United Kingdom. In 1850, the ratio of looms to workers in Lowell was 1.07, while the ratio in the U.K. was only 0.76 (Rosenberg, 1969, pp. 308-309; Mitchell, 1962, pp. 185, 187). However, the ratio of spindles to total factory workers was far lower in Lowell, 34.5, than the ratio in the U.K. as a whole, 63.4 although this difference may be an overstatement if British factories were less integrated than those in Lowell. Aside from differences in machine speed and quality of fabric, it seems clear that Lowell mills were relatively labor saving in looms, but labor abundant in spinning. Because weaving cannot be separated from spinning operations in the data, however, we are also forced to consider the aggregated industry, cotton textiles, as an unskilled industry. It is interesting to note that wages for weavers (who were predominately women) were between 18 and 48 percent higher than spinners in 1839-41 (Ware, 1931, p. 239), suggesting that the factories most readily substituted capital for the skilled, rather than unskilled workers.

Wage Differences

Extensive impressionistic and quantitative evidence indicates that unskilled wages were substantially higher in the United States than in Great Britain during the first half of the nineteenth century. Habakkuk (p. 11) cites estimates that wages were a third to a half higher, while Adams found that American skilled workers earned 37 percent more, and unskilled workers 25 percent more than equivalent British workers in 1830. A comparison of 1850 nonagricultural unskilled wage in Britain and the United States (Williamson and Lindert, 1983, p. 4; Abbott, 1905) indicates that the British wage, valued at the par exchange rate, was only .76 of the American rate.

Moreover, real wages, nominal wages adjusted by a cost of living index, were even higher in the United States. The cost of living was lower in the United States because of the lower prices for agricultural goods, which at that time constituted the bulk of expenditures in a workingman's budget.

Using U.S. weights from Hoover's consumer price index (1960, pp. 177-178) and U.S. and British price data from the Aldrich Report (the British Sauerbeck price series is reprinted there), we calculate that the real wage for a non-agricultural worker in 1850 was 32 percent higher in the United States.[33] With the much more aggregated budget shares for British laborers reported in Lindert and Williamson (1983) the U.S. real wage advantage rises to 52 percent.[34] Thus even though nominal wage rates in agriculture were similar in the U.S. and England (Adams, 1970), the real wage in the U.S. would have been higher because of the lower cost-of-living index.

There is a substantial amount of evidence on the wage differential for male skilled workers in Britain and America. Rosenberg (1967), citing Zachariah Allen's 1829 manual The Science of Mechanics, found that carpenters in the United States were paid 45 percent, and masons 65 percent above unskilled workers. The differential for most machine workers was not as significant; between 25 and 42 percent for ordinary machine makers, and 50 to 75 percent for best machine makers.

Zabler (1974) used evidence from iron firms in eastern Pennsylvania to suggest that the skill differential in the U.S. was not particulary high. He found a wage premium for skilled workers of only .15 during the period 1821-1830. The problem common to all of these comparisons, that a large number of occupations must be divided into only two categories, is most evident in this study since the "skilled" miller earned less than the "unskilled" filler in 26 of the 31 years recorded. Adams (1970), on the other hand, reported higher wage differentials of .73 in Philadelphia during the year 1830.

Williamson and Lindert (1980) found a substantial surge in the relative price of skilled workers from 1816 to 1856. While machinists received a 50 percent differential in 1825, it grew to 90 percent during the 1840's and rose to 120 percent in the 1850's (p. 68). The wage differential reached its maximum during the period 1850-60; "(T)he wage structure in urban Massachusetts in the 1850's was almost exactly like that in England in 1825. It never again reached that height in the three decades that followed." (p. 71)

Using a detailed compilation of army reports listing wages paid to civilians at military forts, Margo and Villaflor (1983) examined the skill differential paid to carpenters in the United States. The premium was highest in the southern New England states, where, for example, carpenters in Boston and New London were paid 73 percent more than laborers during the late 1830s and 1840s, but the difference declined substantially in the frontier areas. According to their regression results, carpenters in the west north central region in 1840 were paid only 20 percent more than the unskilled workers.

Finally, we present evidence on skilled daily wages, by detailed occupational group, from the Aldrich Report. The averages were weighted by the number of employees reported as receiving the wage, and we calculate the skill differential by comparing these wages with the average wage for male unskilled workers (also using the Aldrich Report) computed by Abbott (1905). Table VI presents the results; building trades were paid a premium of 65 percent during 1850-51, printing trades a premium of 75 percent, and engineers a difference of 66 percent.

The evidence suggests then that the skill differential in the United States during the early 1850's was approximately 60 to 70 percent in the eastern states, and somewhat lower in frontier regions. Furthermore, the decade of the 1850's probably represented a peak in the wage differential relative to preceding and later years (although see Margo and Villaflor, 1983). We next turn to studies of British skill differentials.

Zachariah Allen observed British wage rates during the 1820's as well. The wages of carpenters were 31 percent above wages of common laborers, while both masons and ordinary machine makers were paid a 49 percent differential. The greatest wage premium was paid to best machine makers, who earned 2.62 times the unskilled wage rate (Adams, 1970).

The most detailed source of British relative wage data from around 1850 comes from the series of papers by Bowley and Wood, and compiled by Lindert and Williamson (1983). Table VI also includes these estimates of British wages. Shipbuilders were paid a premium of 43 percent over nonagricultural unskilled workers, while building trades and printing trades received a differential of 48 and 67 percent, respectively. Although these two skill premiums are less than the corresponding American values from Table VI, engineers in Great Britain enjoyed a substantially larger differential than engineers in the U.S. On average, however, the skill differential is about 60 percent, a value quite similar to the premium in the U.S.

There is little evidence from the late 1840's and 1850's therefore to support Habakkuk's proposition that the skill differential was less in the United States than in Britain (pp. 21-22). For both countries, the differential was approximately 60 or 70 percent in the more industrialized regions. Since the skill differential was widening in the antebellum United States, the 1850's then may have been the first decade during which the United States had caught up to Britain in terms of the skill differential.

On the basis of this evidence, we constrain the skill differential in British manufacturing to be equal to that in U.S. manufacturing in the model. The premium actually used, 39 percent, represents the difference between average annual wages in U.S. skilled and unskilled manufacturing. On the one hand this figure may overstate the "true" skill differential between male workers because of the greater proportion of lower-paid women and children in the unskilled manufacturing labor force;[35] on the other hand, however, the differential may be understated because many of the "skilled" industries employed less skilled workers and assistants as well, while the "unskilled" industries similarly employed some skilled workers and foremen. Although we adopt 39 percent as our aggregate skill differential, the pattern of results is not particularly sensitive to the level of the skill differential.

Capital Cost Differences

The real return to capital in manufacturing was significantly higher in the United States than in Great Britain during the first half of the nineteenth century -- both gross and net, on average, and at the margin. The average gross return to fixed capital in U.S. manufacturing in 1849 calculated from Census data was 42.6 percent as compared with 18.0 percent in Great Britain in 1851 (constructed from Table IV; Deane and Cole, 1969, pp. 143, 152; Lindert and Williamson, 1983, p. 4).[36] The relevant consideration in choice of technique, the marginal user cost of capital, was higher in U.S. manufacturing as well.

Summers and Clarke (1980, p. 134) argue that even though nominal rates were higher in the antebellum U.S. than in Britain the more rapid deflation rate in Britain implied approximately equal real interest rates over the period. This assertion is contraverted by Table VII which presents nominal and expected real interest rates for the two countries averaged by decade for the 1801-1860 period and is based on the same data used by Summers and Clarke. Nominal interest rates in the U.S. are represented by yields on New England municipal bonds and in Britain by yields on 3 percent consols.

Expected real rates are constructed by adjusting the nominal interest rate by the anticipated inflation rate -- the predicted value from a regression of the present inflation (or deflation) rate on those for the preceding two years (the Warren-Pearson price index is used for the U.S. and the Rousseaux index for Britain).[37] With the exception of the first two decades, influenced by the Napoleonic Wars, real interest rates were consistently and significantly higher in the U.S. than in Britain. Over the whole antebellum period U.S. real rates averaged 1.13 percentage points higher, and in the "peacetime" decades of 1821-1860 they averaged 1.61 percentage points (or 46 percent) greater. Indeed, taking the anticipated rate of price change into account has virtually no effect on the magnitude of the differential. For the 1821-1860 period the US-GB differential in terms of nominal rates was 1.59 percentage points and in terms of real rates, 1.61 percentage points.

Furthermore, it seems quite unlikely that the observed differential could be accounted for entirely by a risk premium.[38] Precise measurement of the premium resulting from a higher possible default risk of American bonds would be very difficult or impossible. However, we may observe the response to the defaults in the U.S. in the early 1840's. These defaults were not widely anticipated, but they caused the differential to increase by only .42 percentage points -- from 1.43 percentage points in the 1830's to 1.88 percentage points in the 1840's. By the 1850's the differential fell to only .18 percentage points above the level in the pre-default decade. This relatively small response suggests that risk considerations alone cannot explain higher U.S. interest rates. Real interest rates therefore appear to have been higher in the United States than in Britain in the period before the Civil War. Such higher interest rates in the U.S. moreover are consistent with a wide range of American social and economic phenomena -- from eating more quickly to holding smaller inventories than Europeans (Field, 1983a, pp. 414-415). They are also consistent with the evidence on international net capital flows which shows the United States to have been a continual net importer of British capital (Williamson, 1964, pp. 89-124).

The marginal gross return to manufacturing capital was higher in the United States, owing to both the higher interest rates and higher depreciation rates.[39] In response to the higher real rate Americans attempted to reduce capital costs by running their machines and factories longer and faster. In cotton textiles, for example, spindle speed was significantly more rapid in the U.S. and increased substantially as well after 1828 (Habakkuk, 1962, pp. 54-55; Brito and Williamson, 1973, p. 243; Field, 1983a, pp. 412-413). Such higher utilization rates were in turn reflected in more rapid rates of depreciation in the U.S.[40] Further evidence may be seen in the well-known "flimsiness" of American capital goods, such as machine tools and woodworking machinery, relative to British products. Similarly, in railroad and canal construction Americans produced less durable results than did the British (Habakkuk, 1962, pp. 86-89). Again, here the construction of less durable, more rapidly depreciating structures and equipment may be viewed as consistent with a higher U.S. real interest rate.

Direct calculation of the gross return to manufacturing capital from national income figures and of a real interest rate series from nominal interest and inflation rates both confirm that the cost of capital services or return to capital was higher in the antebellum U.S. than in Britain. The widely noted higher rates of utilization and depreciation of U.S. capital are consistent with this, and Habakkuk's argument that product and factor markets were more imperfect in America than in Britain in the early nineteenth century reinforce this conclusion as well (pp. 63-79).

APPENDIX B

Table VIII

Prices, Factor Returns, and Capital-Labor Ratios in the United States and Great Britain: Tests of the Habakkuk Hypothesis

	United States, 1849 Labor Supply Elasticity = .3	United States, 1849 Labor Supply Elasticity = .6	Great Britain, 1851 Skilled Wage Differential = 59%
P_S	1.00	.93	.58
P_U	1.00	.97	.69
P_A	1.00	1.01	1.34
W_S	329.	291.	236.
W_U	237.	211.	142.
W_A	103.	105.	120.
r_S	.46	.43	.16
r_U	.43	.43	.16
r_A	.19	.19	.07
$(K/L)_S$	539.	466.	559.
$(K/L)_U$	559.	475.	785.

Table IX

Prices, Factor Returns, and Capital-Labor Ratios
in the United States and Great Britain:
Varying Skilled Manufacturing Production Parameters

	United States 1849	Great Britain 1851	Great Britain 1851	Great Britain 1851
	Base Case	Base Case	$\sigma^S_{KA} = 1.71$	$\sigma^S_{LK} = .85$
P_S	1.00	.45	.65	.87
P_U	1.00	.70	.68	.68
P_A	1.00	1.33	1.34	1.35
W_S	329.	207.	191.	193.
W_U	237.	149.	138.	139.
W_A	103.	118.	119.	120.
r_S	.46	.16	.17	.16
r_U	.43	.16	.17	.16
r_A	.19	.07	.07	.07
$(K/L)_S$	539.	413.	1476.	559.
$(K/L)_U$	559.	848.	712.	776.

Notes

1. In Temin's model (1966) only land and labor are used in the production of agricultural goods, and labor and capital in the production of manufactured goods.

2. By specifying a smooth factor price frontier (as a result of assuming common well-defined production functions) we rule out the possibility of a factor intensity reversal due to a shift in technology. In such a case a higher interest rate (in the U.S., say) might be associated with a more capital-intensive technology. See Yeager (1976), pp. 323-324 and the discussion in Field (1983a), pp. 429-431.

3. This point is also argued by Ames and Rosenberg (1968). Such a result however is not inconsistent with Temin's more general argument (1971) that in more complicated models the labor scarcity result may be possible but not necessarily follow. Only in the simple two sector, two input model is the general labor scarcity proposition a necessary consequence.

4. Two other conditions must be met as well: 1) the share of land in agriculture must be greater than in manufacturing; 2) manufacturing must use a higher proportion of the economy's capital than the labor (Summers and Clarke, p. 132).

5. Some valiant exceptions to this are Uselding (1972), Brito and Williamson (1973), James (1981), and Field (1983a, b).

6. Temin (1966, pp. 281-283) is aware of this distinction but does not incorporate it into his model.

7. For example, Earle and Hoffman (1980, p. 1057) flatly and erroneously assert, "Most American industries used demonstrably more machinery than

equivalent British industries." Their analysis of the labor scarcity question is particularly confused, but they do find that "the characteristic feature of American capitalism" is "the use of cheap, instead of expensive inputs, provided any differences in productivity are overcome." (p. 1090)

8. The importance of the distinction between skilled and unskilled labor to the labor scarcity result, developed by Habakkuk, has been noted by Uselding (1975; 1977, pp. 164-165), Brito and Williamson (1973), and Goldin and Sokoloff (1982, pp. 755-756). Goldin and Sokoloff emphasize in particular the use of women and children in manufacturing as another response to the problem of expensive male labor (1982, pp. 742, 755-756; 1983).

9. Moreover, little is known empirically about production in the service sector, so specification would have had to have been rather arbitrary. See James (1978).

10. For example, Field (1980, pp. 162-163) classes the workers in these industries in the two highest skill categories -- balanced and high skills.

11. Part of the difference however reflects the greater presence of females in the unskilled sector. Counting the female wage as .5 of the male wage (Sokoloff, 1984b), we calculate the annual male wage in the skilled sector as $325 as compared with $276 in other manufacturing, still a significant difference.

12. Restricting the use of skilled labor to skilled manufacturing and unskilled labor to unskilled manufacturing ignores the possibility of substituting among skilled labor, unskilled labor, and capital in a generalized four factor production function. The specification of such a function however would present a very complex problem. Habakkuk, for example, quotes Andrew Ure to the effect that early manufacturing growth involved the substitution of unskilled labor and capital for skilled labor (pp. 153-154), but he himself

argued that more capital-intensive production methods required more skilled labor per unit output than relatively labor-intensive ones (p. 24). Later writers have focused on one thread or the other of this argument. For example, Williamson and Lindert (1980) assume skilled labor and capital to have been relative complements, but Harley (1974) in his study of the choice of technique in Edwardian industry emphasizes the substitution of unskilled labor and capital for skilled labor.

Nevertheless, in our specification here the unskilled labor market is still able to influence skilled labor conditions and the choice of technique through labor supply channels. In any case, this characterization is roughly consistent with empirical evidence and available data do not permit satisfactory estimation of a four factor production function (unskilled labor, skilled labor, capital, natural resources).

13. Habakkuk (p. 43) also raises the possibility that if the tariff was levied primarily on relatively labor-intensive imports, it would have raised real wages relative to capital and thereby shifted U.S. demand toward products made by capital-intensive techniques. The antebellum tariff did in fact increase real wages the most, but its principal effect was to increase the returns to both labor and capital at the expense of land and slaveholders, a possibility which Habakkuk recognizes in a footnote. (James (1978), p. 248.)

14. Prices are not taken to be fixed at world levels in spite of the presence of an international sector. The protection of tariffs and distance makes it quite reasonable that U.S. producers faced downward sloping demand curves, and it is not implausible that British producers faced them as well. British manufacturers may well still have been price makers rather than price takers in world markets, while in agriculture complete adjustment to the repeal of the Corn Laws may not yet have occurred. To be sure, demand elasticities may

have been greater than those facing American producers and if this were the case the differences between U.S. and British output and factor prices which the model predicts will be overstatements.

15. Lack of data on consumption patterns precludes a more detailed specification. A similar one for the demand side has been used by Williamson and Lindert (1980, p. 225). Rosenberg (1972, pp. 39-51) has argued that Americans were more disposed to accepting standardized goods produced by mechanization. If this had been the case, then the model, which assumes no differences in the nature of demand between America and Britain, is biased against finding labor scarcity in U.S. manufacturing.

16. Value of output is deflated by a regional price index (Coelho and Shepherd, 1974). Labor input is measured by total employment with one additional worker per firm added to correct for entrepreneurial labor input (Sokoloff, 1984b). Atack (1976, p. 279) has shown that different measures of labor input, such as taking interstate variation in the sex composition of the labor force into account, for example, has only very small effects on parameter estimates in nineteenth-century U.S. production functions. Capital figures used are those reported in the Census of Manufactures, which are argued by Davis and Gallman (1978, p. 9) to have represented market values. The measure of agricultural goods input, A, is taken as the value of raw material inputs deflated by a regional index of natural resource prices (see James (1981), pp. 385-386). The observations are weighted by the ratio of the number of firms in a given state to the total.

17. The Allen partial elasticity of substitution between inputs i and j is defined as

$$\sigma_{ij} = (\sum_i f_i X_i / X_i X_j)(|F_{ij}|/|F|) \quad i,j = K, L, A$$

where F is the bordered Hessian of the production function f and $|F_{ij}|$ is the cofactor of the ijth element of F.

18. Williamson and Lindert (1980, p. 223) take this twentieth-century result to have been the case in the nineteenth century as well.

19. Habakkuk (pp. 33-34) considered but rejected the influence of American resource abundance in accounting for labor scarcity. He suggested that away from the Fall Line supplies of power would have been both dearer and less elastic in fact than in England, contrary to Christensen's later calculations (1981, p. 322).

20. The production function itself was based on data for Southern agriculture, although Fogel and Engerman take the estimated factor shares to have prevailed in Northern agriculture as well in their relative efficiency calculations. We use these estimates rather than Gallman's (1972) which are based on assumed rates of return to agricultural capital much lower than the ones in our model (Table V).

21. Note that if the price of capital goods had been higher in the U.S., the capital-labor ratio in U.S. skilled manufacturing would have been overstated. However, somewhat tenuous evidence from 1865 on British machine tools suggests that the capital prices may have been roughly comparable between the two countries by around mid-century. The mean price of machines produced that year by the British firm of Greenwood and Batley was £89 as compared to £92, the average price of machine tools sold in England by the American firm of Brown and Sharpe (Floud, 1976, pp. 113-114). See also note 39.

22. In general, there has been little effort made to refine these measures of factor endowments. For example, because of insufficient data labor force

totals have not been adjusted for differences in composition, such as by converting them into a measure of male equivalent workers (Sokoloff, 1984b). Differences between slave and free workers in terms of hours worked are neglected as well (Fogel and Engerman, 1977, pp. 285-288). Land input is simply measured in acres, not taking fertility differences between the U.S. and Britain into account.

23. The natural resource imports were corn, coffee, sugar, tea, wine, timber, raw cotton, raw wool, silk, tobacco, flax, hemp, oils, seeds, hides and skins, dyewoods and dyestuffs.

24. Abbott (1905) reported daily unskilled wages of $.91. Noting that women comprised 26 percent of unskilled workers and that their relative wage was approximately 60 percent of men's (although this differential varied by region; Goldin and Sokoloff, 1982), average annual wages for 310 days of work would have been $253.

25. Budd (1960, pp. 384-385) working up from wage data and including implicit earnings of slaves finds the labor share more than exhausts agricultural sector income in 1850, a rather improbable result. Part of this discrepancy might be the result of assuming that slave workers, like free workers, receive the going wage.

26. In our basic simulation capital is measured as fixed capital, as reported by the Census, and working capital is not counted. Bateman and Weiss (1981, pp. 116, 193-195), allowing for depreciation and adding a correction for working capital to the denominator of the rate of return calculation, compute the 1849 net return to U.S. manufacturing as 22 percent, a figure very close to the 19 percent rate of return on agricultural capital in the model. Equality of returns to capital across sectors therefore could be achieved by simply appropriately inflating the figures for manufacturing capital to

reflect working capital as well as fixed. The problem with using this latter measure of capital, which would eliminate possibly theoretically objectionable divergencies in rate of return across sectors, is that there is not a good measure of working capital in the U.K. American entrepreneurs, responding to higher interest rates, were generally viewed as conserving on working capital and holding smaller inventories than their British counterparts (Field, 1983a, pp. 414-415), but we do not know exactly how much lower. Imposing some undocumented differential in the ratio of working to fixed capital across countries adds an element of arbitrariness to the comparison, while not influencing the results. In any case, it should be noted that the higher return to capital in manufacturing than in agriculture is consistent with the results of Bateman and Weiss (1981, p. 130).

27. Moreover, the export of machinery from Britain was prohibited until 1843 (Habakkuk, 1962, p. 96).

28. This point is also made by Habakkuk (1962, p. 13).

29. We do this computationally by fixing γ_0 and γ_2 assuming that the true elasticity is 0.3. Then we double γ_1 and γ_3 and solve the simulation model.

30. Note that the focus has shifted from land abundance increasing the agricultural wage (Habakkuk) to the influence of abundant natural resources, primarily through decreasing the cost of power, and thereby spurring mechanization. By land abundance here therefore we really mean natural resource abundance.

31. This calculation of the British capital-labor ratio in manufacturing assumes the share of manufacturing capital in the gross reproducible capital stock to have been the same in 1880 and 1890 as in 1920.

32. Note that a more elastic supply of unskilled workers after mid-century, as argued by Habakkuk, would seem to imply a lower manufacturing capital-labor ratio in the U.S. rather than a higher one.

33. This figure probably understates the U.S. advantage, because firewood and rents were excluded from the cost of living adjustments. In both of these categories U.S. prices should have been lower.

34. This result, of course, ostensibly violates well known properties of index numbers. However, the U.S. and British weights do not cover the same range of commodities, the U.S. weights being much more detailed. The results are consistent, however, in indicating substantially higher real wages in the U.S.

35. See note 12.

36. These figures are overestimates of the true rate of return because they omit working capital from the denominator of the true rate of return calculation. See note 28.

37. Summers and Clarke compute realized or ex post real rates (p. 134), rather than expected rates which should be the relevant ones in the choice of technique.

38. Summers and Clarke suggest that taking risk factors into account it may well have been the case that the real return on capital in the United Kingdom may have been actually higher than in the United States (p. 135).

39. Brito and Williamson (1973) emphasize another factor influencing the cost of capital services, differences in the relative price of investment goods in the two countries. They suggest that due to the tariff the ratio of the price of capital goods to that of manufactured consumption goods was lower in the U.S. and that the real costs of capital services were in fact lower in the U.S. as well. To be sure, the relative price of capital goods in the U.S. did

decline over the middle part of the nineteenth century, but this was not characteristic of the entire antebellum period (David, 1977). Direct evidence on Brito and Williamson's asserted inequality relationship is rather inconclusive. Sketchy data on American and British antebellum machinery prices preclude detailed comparisons, but the price difference between U.S. and British machinery in cottons and woolens did not appear to be systematically less than the tariff on manufactured goods over the 1810-1830 period (Jeremy, 1981, pp. 188, 229). For example, for woolen spinning in the 1820s the British price per spindle was $.40, while in the U.S. it was $1.25. Habakkuk (1962, p. 106) cites for a later period, the 1840s, the best English opinion as believing that the same types of machines were generally cheaper in Britain than in America (also see note 21).

40. It may be noted that this characterization of more intense capital use and hence more rapid depreciation in the antebellum U.S. than in Britain is reflected in the assumptions underlying the construction of capital stock figures in the two countries. For the U.S. Gallman assumes a lifetime for equipment of 15 years and for structures of 50 years, while for Britain Feinstein takes lifetimes of 40 and 100 years respectively (Davis and Gallman, 1978, p. 457; Feinstein, 1978, pp. 52, 56).

Table I

Production, Consumption, and Import-Export Equations

Production

$$Q_S = \delta_0[\delta_1 L_S^{-\rho_1} + \delta_2 K_S^{-\rho_2} + \delta_3 A_S^{-\rho_3}]^{-1/\rho_S}$$

$$Q_U = \delta_0^*[\delta_1^* L_U^{-\rho_1^*} + \delta_2^* K_U^{-\rho_2^*} + \delta_3^* A_U^{-\rho_3^*}]^{-1/\rho_U}$$

$$A = \theta_0 L_A^{\theta_1} K_A^{\theta_2} T^{\theta_3}$$

where:

$$\bar{L} = L_S + L_U + L_A$$

$$\bar{K} = K_S + K_U + K_A$$

$$A = A_S + A_U + Z_A$$

$$Y = P_S Q_S + P_U Q_U + P_A A$$

and Q_S is skilled manufacturing output,

Q_U is unskilled manufacturing output,

A is agricultural output,

L_i is labor in sector i,

K_i is capital in sector i,

T is the acres of land, and

Z_A is the portion of domestic agricultural (or natural resource) output not used in domestic manufacture,

P_i is the price in sector i,

Y is the total GNP, and

δ_i, ρ_i, δ_i^*, θ_i are production parameters, $i = 0,1,2,3$

Consumption

Utility: $$U = (\mu_S X_S^{-\beta} + \mu_U X_U^{-\beta} + \mu_A X_A^{-\beta})^{-1/\beta}$$

Budget Constraint: $Y = P_S X_S + P_U X_U + P_A X_A$

Demand: $$X_i = \frac{\phi_i Y}{P_S + \phi_U P_U + \phi_A P_A}$$

where $$\phi_i = \left(\frac{\mu_i P_S}{\mu_S P_i} \right)^{\beta}$$

and

β is the constant elasticity of substitution between any two consumption goods, and

X_i is domestic consumption in sector i.

Import-Export

$$X_A = Z_A + \frac{E}{P_A}$$

$$X_S = Q_S - \frac{\eta E}{P_S}$$

$$X_U = Q_U - \frac{(1-\eta)E}{P_U}$$

$$\eta = \frac{Q_S}{Q_S+Q_U}$$

where E is the total dollar value of natural resource imports ($E > 0$) or exports ($E < 0$), and η is the proportion of total manufacturing output produced by the skilled sector.

Note: British and American subscripts are suppressed for simplicity.

Table II

Production Function Parameter Estimatees, 1849 United States
(t statistics in parentheses)

	α_K	α_L	γ_{KK}	γ_{LL}	γ_{KL}
Unskilled Manufacturing	.2748 (13.01)	.2051 (22.20)	.0521 (1.89)	.0723 (5.42)	-.0040 (-2.81)
Skilled Manufacturing	.3036 (14.04)	.2952 (19.76)	.0554 (2.74)	.0614 (3.51)	-.0266 (-1.88)

Table III

Parameter Specifications

	σ_{KL}	σ_{KA}	σ_{LA}
Skilled Manufacturing	1.26	.81	1.34
Unskilled Manufacturing	.85	1.71	2.07
	θ_1	θ_2	θ_3
Agriculture	.58	.17	.25
		β	
Demand Functions		1.5	

Note: Symbols and subscripts are defined in Table I.

Table IV

Output and Factor Endowments of the United States and Great Britain

	United States, 1849	Great Britain, 1851
Outputs:		
Gross Agricultural Output	$ 828. mill	$ 518.2 mill
Value Added in Skilled Manufacturing	43. mill	} 779.5 mill
Value Added in Unskilled Manufacturing	421. mill	
Total Product	$1292. mill	$1297.7 mill
Endowments:		
Labor in Agriculture	4.52 mill	2.10 mill
Labor in Skilled Manufacturing	0.07 mill	} 3.20 mill
Labor in Unskilled Manufacturing	.88 mill	
Total Labor Force	5.47 mill	5.30 mill
Capital in Agriculture	$1324.8 mill	$1946.4 mill
Capital in Skilled Manufacturing	40.3 mill	} 2441.3 mill
Capital in Unskilled Manufacturing	424.9 mill	
Total Capital	$1858.0 mill	$4387.7 mill
Land in Agriculture	293.6 mill acres	38.8 mill acres

Note: British figures are converted into dollars at the par exchange rate $4.8655/£.

Sources: United States

Gross Agricultural Output - Gallman (1960), p. 43.

Value Added in Manufacturing - U.S. Census of Manufactures, (1850), p. 143.

Labor in Agriculture - Lebergott (1964), p. 511.

Labor in Manufacturing - U.S. Census of Manufactures, (1850), p. 143.

Capital in Agriculture - Calculated from Davis and Gallman, (1978), pp. 18-21.

Capital in Manufacturing - U.S. Census of Manufactures, (1850) p. 143.

Land - U.S. Historical Statistics, (1975), p. 457.

Table IV (Cont.)

Great Britain

Gross Agricultural Output - Deane and Cole, (1969), pp. 166-167.

Value Added in Manufacturing - Deane and Cole, (1969), pp. 143, 166-167; Gallman (1960), p. 43; U.S. Historical Statistics (1975), p. 139. Constructed from Value Added in Mining Manufacturing, and Building by assuming average labor productivity in mining and building between the U.S. and Great Britain to have been the same. Working with Lewis's figures (1978, pp. 246-266) produces an estimate for 1852 of £159.5 million (or $776 million), very close to the figure reported here.

Labor in Agriculture and
Labor in Manufacturing - Deane and Cole, (1969), p. 143.

Capital in Agriculture and
Capital in Manufacturing - Interpolated from Feinstein, (1978), p. 42.

Land - O'Brien and Keyder, (1978), p. 105.

Table V

Prices, Wages, the Return to Capital, and Capital-Labor Ratios in the United States and Great Britain: Simulation Results

	United States, 1849	Great Britain, 1851	United States, 1849 (with 38.8 million acres)
P_S	1.00	0.45	1.17
P_U	1.00	0.70	1.28
P_A	1.00	1.33	1.50
W_S	329.	207.	325.
W_U	237.	149.	232.
W_A	103.	118.	91.
r_S	0.46 [.43]	0.16	.46
r_U	0.43 [.43]	0.16	.46
r_A	0.19	0.07	.17
$(K/L)_S$	539. [571.]	413.	499.
$(K/L)_U$	559. [558.]	848.	490.

Note: Figures in brackets represent the simulation that initially adjusts the base case U.S. manufacturing capital stock so that the marginal return to capital is equalized. S, U, and A stand for skilled manufacturing, unskilled manufacturing, and agriculture, respectively.

Table VI

Daily Wages in the United States and Britain, 1850-51

Occupation	U.S. Nominal Wage	U.S. Skill Differential	British Nominal Wage	British Skill Differential
Nonagricultural, Unskilled	$0.91	---	$0.70	---
Building Trades, Skilled	1.50 (471)	0.65	1.04	0.48
Printing Trades, Skilled	1.59 (34)	0.75	1.17	0.67
Engineering, Skilled	1.51 (1093)	0.66	1.32	0.87
[Iron Foundry Workers]	[2.23]	[1.45]		
Shipbuilders, Skilled	---	---	1.00	0.43

Note: Sample size of U.S. workers are in parentheses.

Note: British annual wages are converted to daily ones by assuming (as Williamson and Lindert do) that employers worked 52 weeks per year, 6 days per week.

Sources: U.S. unskilled wage - Abbott (1905).
U.S. skilled wages - Compiled from the Aldrich Report (U.S. Senate Committee on Finance, 1893).
British wages - Williamson and Lindert (1983), p. 4.

Table VII

U.S. and British Real and Nominal Interest Rates, 1801-1860
(in percent)

	Nominal Interest Rates			Real Interest Rates		
	U.S.	G.B.	Differential	U.S.	G.B.	Differential
1801-1810	5.23	4.78	.45	5.26	5.64	-.38
1811-1820	5.20	4.56	.64	5.65	4.94	.71
1821-1830	4.76	3.63	1.13	4.99	3.48	1.51
1831-1840	4.97	3.39	1.58	5.03	3.60	1.43
1841-1850	5.03	3.24	1.79	5.42	3.54	1.88
1851-1860	3.17	1.86	1.86	5.09	3.48	1.61
1801-1860	5.03	3.79	1.24	5.24	4.11	1.13
1821-1860	4.95	3.36	1.59	5.13	3.52	1.61

Sources: Interest rates - Homer (1963), pp. 195-196, 286-287.
Price indices - Historical Statistics (1975), p. 201; Mitchell (1962), p. 471.

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