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Regions, resources, and economic geography: Sources of U.S. regional comparative advantage, 1880–1987

Sukkoo Kim

Washington University in St. Louis and NBER, Department of Economics, Campus Box 1208, St. Louis, MO 63130-4899, USA

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Abstract

This paper estimates the Rybczynski equation matrix for the twenty two-digit U.S. manufacturing industries for various years between 1880 and 1987. As predicted by the standard general equilibrium theory of interregional trade, the regression estimates show that a consistent set of factor endowments explains a significant amount of the geographic distribution of manufacturing activities over time. Although these results do not rule out the importance of increasing returns, they do suggest certain limits on how increasing returns affect U.S. economic geography.

Keywords: Rybczynski equation matrix; U.S. manufacturing industries; Geographic distribution; U.S. economic geography

JEL classification: F11; F12; R12; N7

1. Introduction

One of the important features of industrialization is the clustering of economic activities. Prior to industrialization, production was geographically dispersed due to the relative intensive use of land in agricultural production. Industrialization and the growth of manufacturing have fundamentally altered the geographic patterns of production as activities became concentrated in cities and in regions. The causes of the geographic concentration of industrial activities was systematically identified by Marshall (1920). According to Marshall, firms may choose to concentrate in a

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given locale because of information spillovers, availability of specialized inputs, and the pooling of the labor market for workers with specialized skills. These forces are now known as the Marshallian externalities or spillovers.[1] However, it is also important to note that Marshall identified natural advantages as one of the chief causes of geographic concentration.[2]

In a recent article, Kim (1995) documents the long-run trends in U.S. regional specialization and industry localization to examine which sources of geographic concentration are most consistent with the data.[3] The data reveal some surprising and interesting trends. Although the process of U.S. industrialization between the late nineteenth and the early twentieth centuries coincided with a dramatic increase in the geographic clustering of economic activities, the trend has significantly reversed since the mid-twentieth century. Indeed, industries in the aggregate are less geographically concentrated than they were during the mid-nineteenth century. The industry patterns of localization are also interesting. In general, the dynamic trends and cross-sectional industry localization patterns seem to be negatively correlated with measures associated with high-tech industries.

While the study of geographic concentration or regional specialization is informative and extremely useful, these studies are subject to certain limits. The most serious problem pertains to the lack of theoretical justification for any particular measure of industry clustering. Consequently, it is difficult to decompose geographic concentration of industries into those caused by spillovers and natural advantages. The recent work by Ellison and Glaeser (1997) attempts to provide a more theoretically motivated measure of geographic concentration. An important feature of the Ellison–Glaeser measure is that it corrects for the

[1]Recently, Krugman (1991a,b) and David and Rosenbloom (1990) have provided formal models of economic geography based on Marshallian externalities. In urban economics, however, these types of models have been in existence for some time. For example, see Muth (1963); Mills (1967, 1980); Henderson (1974, 1988); Fujita (1986, 1988); Berliant and Wang (1993); Berliant and Konishi (1994); Abdel-Rahman (1988); Rivera-Batiz (1988), among others. Also see Fujita and Thisse (1996) for a review of the literature.

[2]Marshall (1920, 268–269) writes: ''Many various causes have led to the localization of industries; but the chief causes have been physical conditions; such as the character of the climate and the soil, the existence of mines and quarries in the neighborhood, or within easy access by land or water. Thus metallic industries have generally been either near mines or in places where fuel was cheap. The iron industries in England first sought those districts in which charcoal was plentiful, and afterwards they went to neighborhood of collieries. Staffordshire makes many kinds of pottery, all the materials of which are imported from a long distance; but she has cheap coal and excellent clay for making the heavy 'saggars' or boxes in which the pottery is placed while being fired. Straw plaiting has its chief home in Bedfordshire, where straw has just the right proportion of silex to give strength without brittleness; and Buckinghamshire beeches have afforded the material for the Wycombe chair making. The Sheffield cutlery trade is due chiefly to the excellent grit of which its grindstones are made.''

[3]Numerous studies have examined the phenomenon of geographic concentration. See Florence (1948); Hoover (1948); Perloff et al. (1960); Fuchs (1962); Krugman (1991b); Ellison and Glaeser (1997), and Dumais et al. (1997), among many others. Most of these studies, however, cover a relatively a short term. Also see Kim (1998a,b).

differences in the size of plants and for differences in the size of the geographic areas. However, since the Ellison–Glaeser measure is observationally equivalent between spillovers and natural advantages, it still cannot effectively distinguish between these two sources of industry concentration.

This paper attempts to differentiate between the importance of natural advantages and spillovers over time by controlling for factor endowments. More specifically, this paper estimates the Rybczynski equation matrix for the twenty two-digit U.S. manufacturing industries for various years between 1880 and 1987. Whereas the Heckscher–Ohlin–Vanek model of interregional trade provides a linear relationship between interregional net exports and factor endowments, the Rybczynski theorem provides a linear relationship between regional production and factor endowments. Thus, in principle, the residual of the Rybczynski estimates provides an upper bound estimate of the importance of spillovers.

The paper finds that a consistent set of factor endowments, as predicted by the standard general equilibrium theory of interregional trade, explains a significant amount of the geographic distribution of manufacturing activities over time. However, the explanatory power of factor endowments declined slightly over time. Although the growth of the unexplained variation may be attributed to the growing importance of Marshallian externalities or spillovers, this conclusion may not be warranted. Since the spillover effects are measured as a residual, it is difficult to ascertain the exact causes of this decline. The growth in the residual may be caused by the growing randomness in the location of manufacturing activities as regional differences in factor endowments diminished over time or by the growth in the importance of foreign trade in goods and factors.

In addition to reporting the Rybczynski regression estimates for each of the twenty 2-digit manufacturing industries, the factor intensities implied by the regression are compared against the independent estimates of factor intensities calculated from the actual amounts of labor, capital, and raw materials used in manufacturing. In general, there is a significant correspondence between the factor intensities implied by the Rybczynski regressions and the actual factor intensities.

The paper is organized as follows. Section 2 presents a formal framework for the analysis and provides a description of the data sources. Section 3 presents the results of the Rybczynski regression estimates. Section 4 examines the changes in the sources of U.S. regional comparative advantage and disadvantage over time. Section 5 concludes with a summary.

2. Methodology and data

This section provides the theoretical framework for the empirical analysis and a description of the data used. The Heckscher–Ohlin model of interregional trade predicts that a region abundant in a particular resource will produce and export products which are relatively intensive in that resource. However, due to the lack of systematic U.S. interregional trade data, the Heckscher–Ohlin model cannot be directly estimated. This paper exploits the Rybczynski theorem which relates regional production with regional factor endowments. The Rybczynski theorem states that, at constant commodity prices, an increase in the supply of a factor will lead to an increase in the production of the commodity that uses that factor intensely and a reduction in the production of other commodities.

The Rybczynski theorem and the other three core theorems of the general equilibrium trade theory, the factor price equalization, the Stolper–Samuelson, and the Heckscher–Ohlin theorems, are based on the following assumptions: the number of goods and number of factors are equal, factors of production move costlessly within region but are completely immobile across regions, commodities are freely mobile across regions, both commodity and factor markets clear competitively, regions have access to identical technologies, factor endowments are relatively similar, and consumers have identical homothetic tastes.[4] Given these assumptions, the following linear relationship between regional output and regional factor supplies can be derived:

$$Y = A^{-1}V \tag{1}$$

where $Y = n \times 1$ vector of outputs, matrix ''A'' is an $n \times m$ factor input intensities or the Rybczynski matrix, and V is an $m \times 1$ vector of endowments.[5]

The analysis of this paper is based on a sample of U.S. states in 1880, 1900, 1967 and 1987. The data on value added for the twenty two-digit manufacturing industries are from the U.S. Census of Manufactures and Niemi (1974). Since the standard industrial codes (SIC) were not developed until the midtwentieth century, the census data for 1880 and 1900 need to be categorized. The 1900 census data come from Niemi (1974) who categorized the data using the 1963 census definitions. The 1880 census data and the 1900 data for the Mountain and Pacific regions were categorized using the 1972 census definitions and Niemi's product list. Table 1 presents the mean and standard deviation of states' manufacturing value added for the twenty two-digit industries.

[4]See Leamer (1984) and Wong (1995) for more detail. Wong (1995) demonstrates the validity of the Rybczynski theorem with factor mobility, and also derives conditions under which the Rybczynski theorem holds with increasing returns.

[5]In the international context, following the classic work by Leamer (1984), scholars estimate the Heckscher–Ohlin–Vanek model which provides a linear relationship between net exports and factor endowments. There are three types of studies that are based on the Heckscher–Ohlin–Vanek equation: $T_i = A^{-1}(V_i - V_W)$ where T_i is a matrix of net exports. Factor content studies regress net exports on factor intensities to infer factor endowments (see Wright, 1990); cross country studies regress net exports on factor endowments to infer factor intensities (see Leamer, 1984); and multifactor studies estimate factor contents of trade and factor abundances and test their correlation (Bowen et al., 1987; Trefler, 1995). Empirical studies based on the Rybczynski equation can be similarly categorized. This paper along with Richardson and Smith (1995) and Harrigan (1995) are cross country or cross-state studies while Grimes and Prime (1993) and Davis et al. (1997) are regional multifactor studies.

Table 1
Mean and standard deviation of value added in manufacturing: U.S. states, 1880–1987

Variable	1880 Mean (SD)	1900 Mean (SD)	1967 Mean (SD)	1987 Mean (SD)
20 Food	5.2 (9.6)	15.8 (27.3)	538.6 (639.5)	2465.7 (2484.2)
21 Tobacco	1.1 (2.6)	3.6 (6.7)	40.1 (159.0)	153.3 (1022.9)
22 Textiles	5.9 (14.6)	8.6 (19.7)	165.8 (367.7)	450.8 (1249.7)
23 Apparel	2.9 (8.5)	9.6 (29.5)	204.8 (439.8)	635.5 (1011.1)
24 Lumber and Wood	4.2 (6.1)	8.0 (8.3)	100.5 (139.0)	578.5 (677.1)
25 Furniture and Fixtures	1.1 (2.2)	2.2 (4.3)	83.3 (117.0)	408.8 (603.6)
26 Paper	0.7 (1.8)	2.0 (4.6)	198.8 (212.0)	1016.3 (969.5)
27 Printing and Publishing	1.6 (4.0)	6.1 (14.3)	285.4 (547.5)	1830.7 (2777.1)
28 Chemicals	1.7 (3.5)	3.7 (7.1)	468.8 (611.5)	2462.1 (3182.2)
29 Petroleum and Coal	0.1 (0.3)	1.9 (4.1)	101.7 (275.0)	318.9 (830.1)
30 Rubber and Plastics	0.2 (0.6)	0.8 (2.4)	133.9 (225.0)	892.0 (1044.5)
31 Leather	3.3 (7.8)	4.3 (9.7)	49.2 (87.3)	55.1 (113.1)
32 Stone, Clay and Glass	1.7 (3.1)	6.2 (12.2)	169.6 (210.0)	675.5 (765.1)
33 Primary Metal	2.9 (8.8)	8.3 (25.5)	398.7 (718.9)	913.9 (1369.2)
34 Fabricated Metal	3.1 (5.4)	5.0 (9.3)	368.1 (569.3)	1528.7 (1976.0)
35 Machinery	2.8 (5.5)	9.2 (18.2)	569.9 (867.9)	2411.5 (3050.8)
36 Electrical Machinery	0.04 (0.1)	–	494.8 (764.0)	1952.3 (2709.9)
37 Transportation	1.6 (2.7)	5.3 (7.8)	568.0 (1057.5)	2649.9 (4650.2)
38 Instruments	0.4 (0.8)	0.6 (1.5)	126.9 (335.4)	1429.0 (2696.8)
39 Miscellaneous	1.5 (3.9)	3.9 (9.3)	93.8 (163.8)	347.1 (472.7)
N	47	49	49	49

Notes: Value added is in million dollars.
Sources: U.S. Census of Manufactures, 1880, 1900, 1967, and 1987.

Data on factor endowments are derived from a variety of sources. The data on labor and capital are from Census of Manufactures: labor is the total manufacturing employees and capital is the total amount of gross depreciable assets. While land is often used as a factor endowment in international textbooks, the amount of land is unlikely to serve as a meaningful factor endowment. Consequently, this paper utilizes the production of various extractive industries as a proxy for land. These industries include agriculture, tobacco, timber, petroleum, and minerals.[6] Data on agriculture and tobacco are from the Census of Agriculture. The 1880 data on timber are from the Census of Agriculture, the 1900 data are from special reports on select industries reported in Table 2 in the Census of Manufactures, vol. 3, pt. 3, and the 1967 and 1987 data are from the *Statistical Abstract of the United States*. The 1880 and 1900 data on petroleum and minerals are from the Census of

[6]For example, in 1929, the percentage distribution of raw materials used in manufacturing supplied by agriculture, mining, forestry, fishing, hunting and trapping were 67.4, 27.6, 3.8, and 1.3 percent, respectively (see Thompson, 1933).

Table 2
Mean and standard deviation of factors of production: U.S. states, 1880–1987

Variable	1880 Mean (SD)	1900 Mean (SD)	1967 Mean (SD)	1987 Mean (SD)
Labor	58.1 (106.7)	108.4 (175.5)	393.6 (475.4)	386.1 (416.1)
Capital	63.2 (110.8)	200.6 (345.8)	4453.3 (5188.1)	18 752.0 (19474.0)
Agriculture	47.9 (49.7)	95.7 (91.0)	817.8 (822.8)	1304.8 (1539.8)
Tobacco	10.1 (28.1)	1.1 (3.1)	26.8 (87.3)	36.9 (126.9)
Timber	3.0 (5.2)	4397 (6844)	45 725 (85574)	54 121 (80484)
Petroleum	–	1.5 (4.4)	346.2 (1140.9)	2074.2 (6552.5)
Minerals	3.1 (10.1)	12.7 (32.4)	145.6 (196.5)	892.7 (1222.5)
N	47	49	49	49

Notes: In 1880, labor is employees in thousands; capital, agriculture, timber, and minerals are in million dollars; tobacco is in million pounds. In 1900, 1967, and 1987, labor is employees in thousands; capital, agriculture, tobacco, petroleum, and minerals are in million dollars; and timber is in million board feet.
Sources: Census of Manufactures, 1880, 1900, 1967, 1987. Census of Agriculture, 1880, 1900, 1967, 1987. Census of Mines and Quarries, 1880, 1900. Census of Mineral Industries, 1967, 1987. Statistical Abstract of the United States. See text.

Mines and Quarries while the 1967 and 1987 data are from the Census of Mineral Industries.[7] Table 2 presents the mean and standard deviations of the states' factor endowments.

The Rybczynski equations are estimated using ordinary least squares and the estimates are adjusted for heteroscedasticity using White's (1980) procedure. For each of the twenty 2-digit manufacturing industries, value added is regressed against seven factor endowments for 1880, 1900, 1967 and 1987:

[7]Although data on minerals by different types such as fuel, stone, chemical, and metal minerals are available, the categories were aggregated to reduce the amount of potentially spurious correlations. In 1880, fuel minerals consist of anthracite and bituminous coal, stone minerals consist of slate, silicious, sandstones and marble and lime, and metal minerals consist of iron ore, lead ore, zinc ore, copper ingots, and other minor minerals. The 1900 data on minerals were more detailed. The metal category contains copper ore, iron ore, lead ore, zinc ore, and manganese ore; the fuel category contains anthracite coal, bituminous coal and natural gas; stone category contains cement, clay, limestones and dolomites, marble, sandstones and quartzites, siliceous crystalline rocks, slate, buhrstones and millstones, corundum and emery, crystalline quartz, garnet, grindstones and pulp stones, infusorial earth, tripoli, pumice, oilstones, whetstones, and scythestones; the chemical category contains borax, fluorspar, gypsum, phosphate rock, sulphur and pyrite, talc and soap stones, barytes, and mineral pigments; miscellaneous category contains asbestos, asphaltum and bituminous rock, bauxite, feldspar, flint, fuller's earth, gold and silver, graphite, lithium ore, marl, mica, monazite, precious stones, silica sand, tungsten, uranium and vanadium, and all other minerals. For more detail data description for the 1967 and 1987 data, see the *Census of Mineral Industries*.

$$Y = \alpha + \beta_1 \text{ LABOR} + \beta_2 \text{ CAPITAL} + \beta_3 \text{ AGRICULTURE} + \beta_4 \text{ TOBACCO} + \beta_5 \text{ TIMBER} + \beta_6 \text{ PETROLEUM} + \beta_7 \text{ MINERALS} + \varepsilon. \quad (1')$$[8]

The reader should be aware of a number of potential problems with the data analysis. First, due to data limitations, labor and capital endowments are totals for manufacturing only.[9] Second, the value of products for resource endowments (excluding labor and capital) are subject to problems of double counting.[10] However, since double counting is expected to occur evenly across all states, it should not systematically bias the results. Third, there are omitted variables such as water, water power, and climate. The omission of water supply is likely to be problematic for some industries. For example, in 1975 the chemicals, primary metals and paper industries utilized 19.4, 18.9 and 8.9 billion gallons per day whereas most other industries used approximately 5 billion gallons per day (U.S. Water Resource Council, 1978, p. 45.) Fourth, the assumption of a closed economy distorts the results for industries which import significant amounts of resources or final goods. Despite these complications, however, the regression estimates offer an useful explanation for the geographic distribution of U.S. manufacturing activities over time.[11]

[8] From a technical standpoint, the matrix A must be square and the relative input intensities for goods must be different before the matrix can be inverted. If the matrix is square, then from the estimates of A^{-1}, factor intensities can be recovered by inverting the matrix. In this paper, the number of goods is greater than the number of factors so that the factor intensities cannot be recovered. In principle, it is always possible to choose an equal number of goods and factors since there is an arbitrary element in the aggregation of industries and factors of production. The fact that the number of goods is greater than the number of factors implies a degree of indeterminateness equal to $n - m$, but the indeterminacy can be resolved by hypothesizing a small interregional transportation cost. See Leamer (1984), (16–18).

[9] The total manufacturing capital and labor is chosen for historical comparability. Since most of the variation in capital and labor endowments will be in manufacturing, the problem is not likely to be severe.

[10] As noted by Perloff et al. (1960), ''Perhaps the most serious weakness of 'gross value' concept, over and beyond problems of enumeration, occurs in relation to agriculture where, for example, considerable duplication of values is entailed. The gross value of agricultural products includes the value of crops fed to livestock and also the value of livestock sold to farmers. Thus the duplication of values is greater where crops are raised and fed on farms than in areas where cash crops like wheat and cotton are raised (p. 616).''

[11] On the other hand, there are several advantages to estimating the Rybczynski equation using U.S. regional data rather than estimating the Heckscher–Ohlin–Vanek equation using international data. First, some of the assumptions of the model, that regional factor endowments are in the same cone of diversification, that residents have identical homothetic tastes, and that firms have access to identical technologies, are more likely to be satisfied under U.S. regional setting. Second, political and institutional barriers such as tariffs and trade laws which distort international investigations can be neglected in U.S. regional studies. Finally, the U.S. Census Bureau provides excellent uniform data on U.S. states that is unlikely to be matched by any international data set.

3. The estimates of the Rybczynski equations

The Rybczynski estimates presented in Tables 3–10 and the fit of the regressions presented in Fig. 1 show that factor endowments explain a significant amount of the geographic variability in U.S. manufacturing production for most industries over time. However, the amount of variation explained by the endowments declined over time. The unweighted average of the adjusted-R^2 for the twenty industries are 0.86 in 1880 and 0.83, 0.78 and 0.74 in 1900, 1967 and 1987 respectively. One explanation for the fall in the explanatory power of factor endowments may be the growing importance of spillovers. Or alternatively, the fall in the adjusted-R^2 may be due to the greater randomness in the location of manufacturing activities caused by regional convergence in factor endowments. Factor endowments in U.S. regions have become more similar over time as resources have become increasingly more mobile, and technological innovations have favored the development of substitutes, recycling, and less resource intensive methods of production.

A closer examination of the Rybczynski regression estimates by industries may provide a better clue as to why some industries are explained by spillovers or factor endowments. If the residual of the Rybczynski estimates are interpreted as the upper bound estimate on the importance of spillovers, the results in Tables 3–10 suggest that the importance spillovers changed over time for different industries. For example, in the late nineteenth century, spillovers may have played a significant role in the location of the rubber and plastics industry, but the importance fell over time. In the textiles, paper, leather and transportation industries, the regressions suggest that spillovers may have become significantly more important over time. However, the low explanatory power of factor endowments for these industries may be explained by factors other than spillovers. For the paper, leather, and transportation industries, the fall in the explanatory power of domestic endowments may be due to the growing importation of timber, hides and automobiles, whereas for the rubber industries, the opposite trend may reflect the substitution of domestic synthetic raw materials for imported natural rubber.

Perhaps, rather than using the adjusted-R^2, which may be affected by some spurious correlations, the reliability of the Rybczynski regression estimates is better examined by matching the implied factor intensities of the regression against the independent calculations of factor intensities. Tables 11 and 12 present manufacturing factor intensities for each of the twenty two-digit industries calculated using data from the Census of Manufactures for years 1880, 1900, 1967, and 1987. Since the Census of Manufactures only provide information on labor, capital and raw materials consumed, factor intensities are reported in capital–labor and material–labor ratios.

In general, there is significant correspondence between the implied factor intensities of the Rybczynski regressions and the independent calculations. For the

Table 3
Rybczynski regression estimates: manufacturing

1880	Food	Tobacco	Textiles	Apparel	Lumber	Furniture	Paper	Printing	Chemical	Petroleum
Constant	−2151[b]	−555.8[a]	4305[b]	−1652[b]	−451.5[b]	−481.8[b]	8.9	−748.8[a]	−123.6	−62.9[b]
	(3.50)	(2.07)	(2.96)	(2.46)	(2.65)	(4.60)	(0.14)	(2.22)	(0.63)	(2.94)
Labor	58.4[b]	21.0[a]	146.9[b]	70.4[b]	31.6[b]	17.0[b]	20.1[b]	30.2[b]	27.2[b]	2.3[b]
	(3.06)	(2.01)	(3.04)	(2.69)	(5.83)	(11.1)	(16.9)	(2.83)	(4.63)	(4.14)
Capital	0.46	−2.1	−3.4	11.6	1.2	0.18	0.45	6.0	0.10	0.44
	(0.04)	(0.35)	(0.14)	(0.74)	(0.31)	(0.13)	(0.46)	(0.81)	(0.03)	(1.22)
Agriculture	105.4[b]	13.2[a]	−135.8[b]	19.1	20.1[b]	13.5[b]	−7.4[b]	15.6[a]	3.4	1.7[b]
	(4.46)	(1.82)	(3.54)	(1.11)	(3.89)	(4.48)	(3.51)	(2.25)	(0.64)	(3.19)
Tobacco	−12.5	15.6	−7.7	−16.4[a]	−1.7	−2.9[a]	−0.67	−8.1[a]	−5.6[a]	−0.62[b]
	(0.92)	(1.46)	(0.50)	(1.90)	(0.46)	(1.76)	(0.66)	(1.72)	(1.83)	(2.46)
Timber	−176.1[b]	14.2	−185.8[b]	−51.4	667.8[b]	26.7[a]	14.9[a]	−40.1[a]	−34.6	−7.4[b]
	(2.10)	(0.79)	(2.44)	(1.35)	(15.0)	(2.34)	(1.78)	(2.01)	(1.55)	(4.77)
Petroleum	–	–	–	–	–	–	–	–	–	–
Minerals	−153.5[a]	−73.9[a]	126.4	−277.3[b]	−75.8[b]	−46.0[b]	−49.8[b]	−101.0[a]	60.0[a]	−2.9
	(2.02)	(1.69)	(0.63)	(2.48)	(3.00)	(6.12)	(13.7)	(2.08)	(2.18)	(1.18)
Adj. R^2	0.879	0.686	0.766	0.854	0.969	0.939	0.965	0.850	0.904	0.894
N	47	47	47	47	47	47	47	47	47	47

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

Table 4
Rybczynski regression estimates: Manufacturing

1880	Rubber	Leather	Stone	Primary Metal	Fab. Metal	Mach.	Elec.	Trans.	Inst.	Misc.
Constant	210.0[a]	861.1	−260.7[a]	−29.1	−637.9[a]	−326.9[a]	−30.3[b]	−311.6[a]	−53.2	−100.5
	(2.06)	(1.13)	(1.70)	(0.16)	(1.98)	(1.86)	(3.86)	(2.12)	(1.07)	(0.42)
Labor	6.1[b]	92.3[b]	23.4[b]	16.3[b]	36.9[b]	47.8[b]	1.0[b]	15.6[b]	7.6[b]	36.7[b]
	(3.26)	(2.54)	(4.92)	(3.17)	(3.94)	(7.07)	(10.9)	(5.00)	(8.92)	(4.20)
Capital	−0.62	−16.0	−1.2	6.5	1.6	1.8	−0.27[a]	0.53	0.18	7.4
	(0.41)	(0.72)	(0.50)	(1.16)	(0.19)	(0.38)	(2.03)	(0.20)	(0.17)	(1.07)
Agriculture	−4.8[b]	−35.2	14.3[b]	−3.7	33.6[b]	9.6[a]	1.1[b]	16.5[b]	1.4	−8.8
	(3.18)	(1.47)	(3.53)	(0.70)	(3.33)	(2.04)	(2.59)	(3.31)	(0.79)	(1.48)
Tobacco	−0.53	1.5	−2.8	7.7[b]	−0.85	−6.8[a]	−0.33[a]	0.18	−0.40	−7.0[a]
	(0.68)	(0.21)	(1.45)	(2.70)	(0.18)	(2.14)	(2.26)	(0.07)	(0.34)	(1.87)
Timber	−6.4	9.1	−62.7[b]	−280.5[b]	−27.2	−46.1[b]	−2.8	64.3[a]	−17.3	−12.6[b]
	(0.61)	(0.25)	(5.23)	(3.09)	(1.13)	(4.67)	(1.46)	(1.94)	(1.63)	(0.39)
Petroleum	–	–	–	–	–	–	–	–	–	–
Minerals	−20.2[a]	−94.1	54.2[b]	774.8[b]	−6.8	−6.6	−3.8[b]	10.0	−8.4[b]	−159.8[b]
	(2.40)	(0.78)	(3.46)	(32.5)	(0.26)	(0.33)	(5.43)	(1.19)	(2.62)	(5.24)
Adj. R^2	0.386	0.738	0.931	0.978	0.886	0.970	0.826	0.890	0.901	0.902
N	47	47	47	47	47	47	47	47	47	47

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

Table 5
Rybczynski regression estimates: Manufacturing

1900	Food	Tobacco	Textiles	Apparel	Lumber	Furniture	Paper	Printing	Chemical	Petroleum
Constant	−3930[a]	−437.4	4371[a]	−3186	220.9	−842.3[b]	93.7	−2076[a]	−265.9	−261.3[a]
	(1.99)	(1.00)	(2.18)	(1.26)	(0.33)	(2.51)	(0.28)	(1.76)	(0.69)	(1.99)
Labor	−129.5[a]	−20.5	350.1[a]	−188.0	58.2	30.1	28.9[a]	−16.3	8.5	−24.6
	(1.86)	(0.46)	(1.91)	(0.92)	(0.91)	(1.39)	(2.28)	(0.27)	(0.20)	(1.60)
Capital	131.9[b]	25.8	−129.2	194.1[a]	−19.1	−3.3	0.98	53.7	16.3	24.7[b]
	(3.66)	(1.11)	(1.42)	(1.74)	(0.56)	(0.28)	(0.13)	(1.51)	(0.75)	(3.14)
Agriculture	115.9[b]	7.7	−82.3[b]	15.1	21.0[b]	8.4[b]	−7.6[a]	18.2[b]	0.54	1.8
	(2.54)	(0.94)	(3.02)	(0.81)	(2.72)	(2.37)	(2.21)	(2.63)	(0.13)	(1.29)
Tobacco	−228.9	674.1[b]	−224.7	−196.9	220.8	−65.8	−62.6	−214.1	−81.9	−9.2
	(0.63)	(4.71)	(0.86)	(0.58)	(1.48)	(1.32)	(1.67)	(1.38)	(1.13)	(0.30)
Timber	−105.0	−12.4	−71.9	−59.0	555.9[b]	27.9	−3.3	10.2	20.6	−26.4[b]
	(0.60)	(0.30)	(0.40)	(0.37)	(3.31)	(0.72)	(0.15)	(0.19)	(0.65)	(2.46)
Petroleum	−101.7	−6.5	−743.5	32.7	−105.3	−49.8	16.0	−54.1	23.3	47.8[b]
	(0.22)	(0.06)	(1.67)	(0.06)	(0.55)	(0.65)	(0.35)	(0.29)	(0.31)	(2.67)
Minerals	−230.1[b]	−27.1	125.3	−523.4[b]	55.4	−30.2	−51.4[b]	−176.9[b]	−27.6	−21.1[a]
	(4.28)	(0.88)	(1.26)	(2.98)	(1.08)	(1.46)	(4.47)	(2.90)	(1.09)	(2.38)
Adj. R^2	0.837	0.697	0.706	0.815	0.667	0.854	0.900	0.889	0.874	0.954
N	49	49	49	49	49	49	49	49	49	49

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

Table 6
Rybczynski regression estimates: Manufacturing

1900	Rubber	Leather	Stone	Primary Metal	Fab. Metal	Mach.	Elec.	Trans.	Inst.	Misc.
Constant	638.7[a]	−193.6	−442.3	861.5	−1122	−1192[a]	–	−529.9	23.5	383.1
	(1.75)	(0.31)	(1.04)	(0.58)	(1.33)	(1.75)		(1.42)	(0.24)	(0.68)
Labor	47.2[a]	196.8[a]	−25.0	−118.3[a]	7.5	32.6	–	15.7	−9.5	−12.1
	(1.70)	(1.74)	(0.54)	(1.72)	(0.25)	(1.34)		(0.63)	(1.42)	(0.38)
Capital	−18.8	−74.6	46.2[a]	74.4[a]	19.3	33.3[a]	–	4.3	9.9[b]	39.3[a]
	(1.30)	(1.36)	(1.95)	(1.91)	(1.22)	(2.26)		(0.34)	(2.90)	(2.37)
Agriculture	−7.7[a]	−16.9	5.8	−25.0[b]	20.0	3.0	–	21.3[b]	−0.43	−5.1
	(2.40)	(1.66)	(1.15)	(2.44)	(1.42)	(0.37)		(4.08)	(0.52)	(1.28)
Tobacco	−41.2	−176.9	−113.8	387.1	−45.0	−57.7	–	−8.4	−8.9	−87.5
	(0.92)	(0.89)	(1.12)	(1.26)	(0.37)	(0.68)		(0.15)	(0.58)	(1.18)
Timber	−30.9	48.7	−106.4[b]	−285.2[a]	−13.5	−124.0[b]	–	−2.4	−16.2[b]	−95.6[b]
	(1.31)	(0.72)	(2.63)	(1.95)	(0.20)	(2.55)		(0.09)	(3.11)	(2.90)
Petroleum	−14.5	−160.2	320.0[b]	786.4	145.9	499.7	–	4.4	−36.9	−21.7
	(0.41)	(0.98)	(3.28)	(1.11)	(0.80)	(1.40)		(0.85)	(1.14)	(18.9)
Minerals	−16.7	−0.55	−26.3	582.0[b]	−43.4	−20.7	–	84.9[b]	−16.5[b]	−155.9[b]
	(0.88)	(0.01)	(1.04)	(6.64)	(1.63)	(0.59)		(7.16)	(4.07)	(6.84)
Adj. R^2	0.440	0.721	0.947	0.921	0.780	0.964	–	0.937	0.886	0.924
N	49	49	49	49	49	49	–	49	49	49

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.

Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

Table 7
Rybczynski regression estimates: Manufacturing

1967	Food	Tobacco	Textiles	Apparel	Lumber	Furniture	Paper	Printing	Chemical	Petroleum
Constant	−118.1[b]	−14.3	73.5[a]	15.7	2756	−15.1[a]	65.2[b]	−44.3	85.4	−65.9[b]
	(2.70)	(1.55)	(1.99)	(0.28)	(0.44)	(1.85)	(2.79)	(0.78)	(1.01)	(3.18)
Labor	1363[b]	22.7	510.7[b]	2098[b]	29.4	187.4[b]	388.6[b]	2445[b]	282.3	−219.4[a]
	(5.41)	(1.14)	(4.03)	(3.01)	(1.50)	(3.63)	(3.41)	(3.63)	(1.15)	(1.98)
Capital	−38.7[a]	−2.1	−23.5	−132.9[b]	3.8[a]	0.16	1.7	−145.9[b]	66.3[a]	35.8[b]
	(1.75)	(0.92)	(1.67)	(2.44)	(1.93)	(0.03)	(0.15)	(2.72)	(1.97)	(2.95)
Agriculture	277.8[b]	1.1	−71.7	−109.2[a]	5.9[a]	13.0[a]	−24.5	0.35	−57.3	62.8[a]
	(5.79)	(0.23)	(2.64)	(1.76)	(1.68)	(2.10)	(1.27)	(0.01)	(0.71)	(1.79)
Tobacco	−397.6	1676[b]	3055[b]	−189.0	92.3[b]	609.5[b]	−74.0	−955.3[b]	−88.2	−54.0
	(1.43)	(11.1)	(4.85)	(0.74)	(3.59)	(4.15)	(0.78)	(3.46)	(0.26)	(1.16)
Timber	0.48[a]	0.02	−0.05	−0.21	1.5[b]	0.05	0.22	−0.31	−0.76[b]	−0.07
	(2.01)	(1.08)	(0.57)	(0.57)	(13.6)	(1.01)	(1.21)	(0.74)	(2.47)	(0.80)
Petroleum	32.6	1.7	21.6	120.8[a]	0.61	−1.3	−0.10	99.7[a]	107.9[a]	151.9[b]
	(1.11)	(0.80)	(1.31)	(2.21)	(0.27)	(0.26)	(0.01)	(2.12)	(2.26)	(2.71)
Minerals	295.0[a]	50.3	−222.8	117.0	−42.3[b]	−33.7	−101.1[a]	−149.7	160.8	−33.7
	(1.97)	(1.13)	(0.97)	(0.98)	(2.56)	(0.79)	(1.79)	(0.80)	(0.45)	(0.67)
Adj. R^2	0.918	0.835	0.627	0.700	0.932	0.839	0.686	0.815	0.624	0.821
N	49	49	49	49	49	49	49	49	49	49

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

Table 8
Rybczynski regression estimates: Manufacturing

1967	Rubber	Leather	Stone	Primary Metal	Fab. Metal	Mach.	Elec.	Trans.	Inst.	Misc.
Constant	11.2	39.4[a]	−7590	−50.5	−36.2	−20.9	−124.2[b]	−26.2	−7.08	14.0
	(0.61)	(2.38)	(0.87)	(1.06)	(1.09)	(0.31)	(2.05)	(0.17)	(0.19)	(1.02)
Labor	−95.6	377.3[b]	111.5	−1149[b]	59.8	489.1	1867[b]	−384.5	1795[b]	770.3[b]
	(0.36)	(4.97)	(1.64)	(5.98)	(0.14)	(0.95)	(3.63)	(0.36)	(3.96)	(6.25)
Capital	47.9	−23.9[b]	27.6[b]	229.3[b]	102.4[a]	110.1[a]	−44.6	205.4	−120.5[b]	−44.7[b]
	(1.50)	(3.60)	(3.21)	(9.89)	(2.36)	(1.98)	(0.79)	(1.52)	(3.31)	(4.21)
Agriculture	−5.1	−27.4[a]	5.1	−71.2[a]	9.5	106.3	95.4[a]	10.5	−52.0	−22.3[a]
	(0.27)	(2.38)	(0.61)	(1.76)	(0.27)	(1.56)	(1.73)	(0.07)	(1.37)	(1.70)
Tobacco	−212.0[b]	−163.5[b]	−182.4[b]	−1006[b]	−736.2[b]	−1098[b]	−614.9[a]	−1210[a]	−592.8[b]	−308.9[b]
	(2.79)	(4.45)	(5.10)	(3.26)	(4.09)	(2.85)	(1.73)	(2.12)	(3.36)	(3.89)
Timber	−0.23[a]	−0.15[a]	−0.08[a]	−0.71[b]	−0.37[a]	−1.2[a]	−0.07	1.2	−0.21	−0.12
	(1.86)	(1.86)	(1.84)	(3.89)	(1.91)	(2.41)	(0.18)	(0.94)	(0.70)	(1.41)
Petroleum	−52.2[a]	12.7[a]	−15.7[a]	−220.6[b]	−96.1	−158.4[b]	−23.7	−114.3	83.0[b]	27.8[b]
	(1.73)	(1.75)	(1.97)	(6.40)	(2.16)	(2.55)	(0.45)	(1.02)	(2.53)	(2.72)
Minerals	−101.4	−19.2	139.0[b]	513.5	−91.9	−261.8	225.0	−1096	16.3	−10.4
	(0.99)	(0.60)	(4.00)	(1.33)	(0.52)	(0.88)	(0.80)	(1.42)	(0.13)	(0.21)
Adj. R^2	0.657	0.553	0.949	0.884	0.882	0.825	0.867	0.537	0.796	0.880
N	49	49	49	49	49	49	49	49	49	49

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

Table 9
Rybczynski regression estimates: Manufacturing

1987	Food	Tobacco	Textiles	Apparel	Lumber	Furniture	Paper	Printing	Chemical	Petroleum
Constant	−395.8[b]	28.4	277.2[a]	−21.1	14.2	−46.5	368.5[b]	140.8	471.7	−281.8[b]
	(3.26)	(0.38)	(2.60)	(0.26)	(0.44)	(1.08)	(3.25)	(0.47)	(1.21)	(5.63)
Labor	5776[b]	819.5	565.3	5218[b]	−240.0	780.5	−68.8	13163[b]	−1663	681.8
	(4.82)	(1.45)	(0.59)	(4.17)	(0.61)	(1.32)	(0.06)	(2.62)	(0.49)	(1.36)
Capital	−22.0	−13.3	9.6	−68.5[b]	15.6[a]	8.5	45.2	−167.8[a]	174.2[b]	−0.70
	(0.78)	(1.05)	(0.38)	(2.90)	(1.75)	(0.54)	(1.63)	(1.90)	(2.58)	(0.06)
Agriculture	625.4[b]	1.9	−164.8[b]	−184.2[a]	17.4	21.9	−122.7[a]	−177.1	−370.2	49.8[a]
	(8.14)	(0.05)	(2.74)	(2.33)	(0.57)	(0.86)	(2.32)	(0.60)	(1.56)	(1.76)
Tobacco	−1515[b]	7153[b]	7255[b]	632.4	318.4	1814[b]	177.2	−4023[a]	1226	−637.7[b]
	(2.71)	(3.48)	(5.15)	(1.20)	(1.67)	(3.39)	(0.39)	(2.45)	(1.14)	(4.17)
Timber	0.25	−0.21	0.49	0.38	6.8[b]	0.12	2.0[b]	−3.5	−6.1[a]	1.0[a]
	(0.36)	(0.74)	(0.57)	(0.63)	(6.20)	(0.31)	(2.94)	(1.39)	(2.24)	(2.30)
Petroleum	42.4	14.3	−18.6	58.9[b]	−11.5	−14.1	−34.3	101.8	88.3	98.1[b]
	(1.61)	(1.24)	(0.80)	(3.14)	(1.36)	(1.00)	(1.25)	(1.58)	(1.60)	(7.32)
Minerals	205.8[a]	−255.2	−297.8[a]	1.4	−13.6	−87.9[a]	−65.8	124.7	−57.5	55.2[a]
	(2.30)	(1.55)	(1.79)	(0.05)	(0.55)	(1.73)	(1.11)	(0.81)	(0.40)	(2.19)
Adj. R^2	0.945	0.706	0.600	0.765	0.850	0.797	0.509	0.695	0.718	0.911
N	49	49	49	49	49	49	49	49	49	49

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.

Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

Table 10
Rybczynski regression estimates: Manufacturing

1987	Rubber	Leather	Stone	Primary Metal	Fab. Metal	Mach.	Elec.	Trans.	Inst.	Misc.
Constant	4.0	52.0[a]	−52.2	−5.8	−111.8	−240.7	−547.9[b]	−725.6	−188.3	62.8
	(0.06)	(2.29)	(1.46)	(0.07)	(1.20)	(1.05)	(3.12)	(1.30)	(1.04)	(1.14)
Labor	−334.8	358.1[a]	1552[b]	−6059[b]	−832.9	6748[b]	11352[b]	1910	18233[b]	2341[b]
	(0.38)	(2.03)	(3.26)	(3.59)	(0.49)	(4.08)	(4.84)	(0.24)	(5.47)	(4.51)
Capital	62.8[b]	−4.8	2.9	202.0[b]	124.0[b]	−19.1	−149.3[b]	159.0	−304.5[b]	−29.0[b]
	(2.90)	(1.32)	(0.25)	(4.67)	(2.91)	(0.56)	(2.61)	(0.77)	(4.78)	(2.70)
Agriculture	36.3	−26.0[b]	1.9	−77.9	72.1	476.4[b]	345.7[b]	170.7	−125.6	−58.9[a]
	(0.87)	(2.47)	(0.06)	(1.35)	(0.91)	(3.66)	(3.16)	(0.40)	(0.67)	(1.79)
Tobacco	376.4	16.7	−326.6	−2496[b]	−2689[b]	−1947[b]	165.0	−4936	−3694[b]	−689.9[a]
	(1.45)	(0.24)	(1.41)	(3.47)	(5.28)	(2.54)	(0.32)	(1.67)	(2.57)	(2.28)
Timber	−1.5[b]	−0.14	−0.38	−1.7[a]	−3.4[b]	−2.9[a]	0.65	−0.23	1.2	−0.60
	(3.05)	(1.52)	(1.56)	(1.98)	(3.01)	(2.14)	(0.53)	(0.05)	(1.03)	(1.51)
Petroleum	−56.9[b]	1.5	0.92	−186.7[b]	−119.4[b]	−15.9	136.7[b]	−137.1	234.0[b]	15.6[a]
	(2.75)	(0.51)	(0.81)	(4.56)	(2.99)	(0.56)	(2.74)	(0.74)	(4.52)	(1.74)
Minerals	−22.4	−8.7[a]	96.5[b]	164.2[a]	61.5	48.6	158.8[a]	−98.0	44.7	30.1
	(0.82)	(0.94)	(2.92)	(2.19)	(0.98)	(0.45)	(1.82)	(0.25)	(0.30)	(0.93)
Adj. R^2	0.875	0.119	0.906	0.780	0.881	0.863	0.906	0.576	0.799	0.751
N	49	49	49	49	49	49	49	49	49	49

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Notes: See Tables 1 and 2 for descriptive statistics. The *t*-statistics (absolute value in parenthesis) are corrected for heteroscedasticity using White (1980) procedure. Coefficients on factor endowments were multiplied by 10^3.

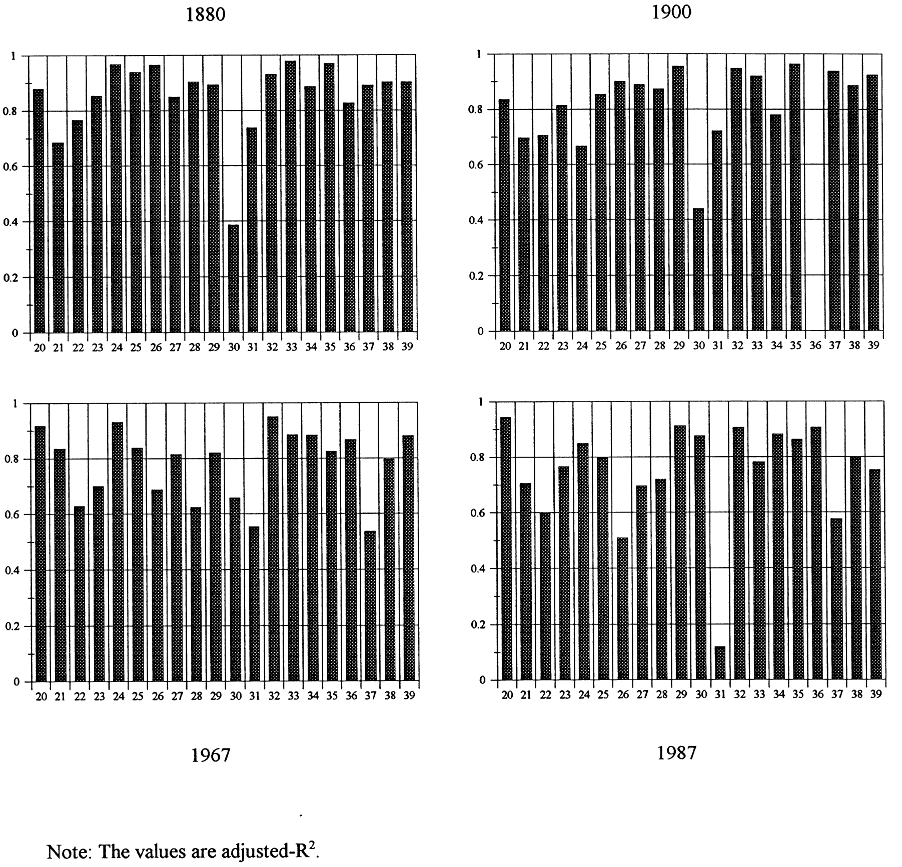

Fig. 1. The fit of the Rybczynski regression estimates, 1880–1987.

labor intensive industries, the matching is somewhat ambiguous for the earlier two periods but is excellent for the latter two periods.[12] In 1967 and 1987, labor coefficients on the instruments, apparel, printing and publishing, miscellaneous, leather, and electrical machinery industries are the most significant. These industries are also significantly labor intensive according to Tables 11 and 12 as they ranked the lowest in capital–labor and materials–labor ratios for those years. There is also a reasonable correlation between the implied capital intensities from the regressions and the independent estimates of capital intensities from the census

[12]The poor matching of the implied factor intensities of the Rybczynski regressions and the actual figures may be caused by the low variation in factor intensities in 1880 and 1900. For example, the coefficient of variation across industries for capital–labor and material–labor ratios for 1900 was 0.40 and 0.76 respectively whereas, for 1987, they were 1.23 and 1.75 respectively.

Table 11
Manufacturing factor intensities

1880				1900			
Capital/Labor ($1000 per Employee)		Materials/Labor ($1000 per Employee)		Capital/Labor ($1000 per Employee)		Materials/Labor ($1000 per Employee)	
20 Food	2.121	20 Food	5.092	20 Food	3.449	20 Food	4.447
28 Chemicals	1.653	29 Petroleum	3.296	33 Primary Metal	2.671	33 Primary Metal	2.986
33 Primary Metal	1.540	28 Chemicals	1.529	28 Chemicals	2.482	29 Petroleum	2.229
29 Petroleum	1.400	31 Leather	1.486	29 Petroleum	2.391	30 Rubber	1.525
26 Paper	1.351	33 Primary Metal	1.423	26 Paper	2.101	31 Leather	1.516
36 Electrical	1.290	30 Rubber	1.351	30 Rubber	2.003	28 Chemicals	1.354
35 Machinery	1.095	26 Paper	1.158	35 Machinery	1.738	24 Lumber and Wood	1.071
22 Textiles	1.059	24 Lumber and Wood	0.951	38 Instruments	1.579	26 Paper	1.033
27 Printing	1.003	36 Electrical	0.845	22 Textiles	1.544	34 Fabricated Metal	0.964
34 Fabricated Metal	0.994	39 Miscellaneous	0.840	34 Fabricated Metal	1.540	39 Miscellaneous	0.895
38 Instruments	0.960	22 Textiles	0.829	24 Lumber and Wood	1.498	23 Apparel	0.833
24 Lumber and Wood	0.914	37 Transportation	0.779	27 Printing	1.390	37 Transportation	0.793
39 Miscellaneous	0.886	21 Tobacco	0.747	31 Leather	1.337	22 Textiles	0.786
37 Transportation	0.822	34 Fabricated Metal	0.734	39 Miscellaneous	1.329	35 Machinery	0.783
30 Rubber	0.813	23 Apparel	0.730	37 Transportation	1.247	25 Furniture	0.730
25 Furniture	0.756	35 Machinery	0.708	32 Stone, Clay and Glass	1.128	21 Tobacco	0.712
31 Leather	0.740	25 Furniture	0.682	25 Furniture	1.128	38 Instruments	0.585
32 Stone, Clay and Glass	0.587	38 Instruments	0.553	21 Tobacco	0.824	32 Stone, Clay and Glass	0.514
21 Tobacco	0.457	27 Printing	0.533	23 Apparel	0.676	27 Printing	0.435
23 Apparel	0.429	32 Stone, Clay and Glass	0.338	36 Electrical	–	36 Electrical	–

Sources: U.S. Census of Manufactures, 1880, 1900, 1967, 1987.

Table 12
Manufacturing factor intensities

1967				1987			
Capital/Labor ($1000 per Employee)		Materials/Labor ($1000 per Employee)		Capital/Labor ($1000 per Employee)		Materials/Labor ($1000 per Employee)	
29 Petroleum	90.0	29 Petroleum	118.3	29 Petroleum	426.5	29 Petroleum	973.1
28 Chemicals	33.6	21 Tobacco	38.2	28 Chemicals	154.2	21 Tobacco	145.2
33 Primary Metal	27.1	20 Food	34.9	21 Tobacco	137.3	20 Food	144.1
26 Paper	24.7	28 Chemicals	22.4	26 Paper	119.6	28 Chemicals	134.2
32 Stone, Clay and Glass	18.7	37 Transportation	22.0	33 Primary Metal	103.9	37 Transportation	109.4
20 Food	12.5	33 Primary Metal	21.2	32 Stone, Clay and Glass	67.9	33 Primary Metal	106.5
21 Tobacco	11.2	26 Paper	17.7	20 Food	55.8	26 Paper	96.1
30 Rubber	11.0	22 Textiles	12.6	37 Transportation	49.0	24 Lumber and Wood	59.1
34 Fabricated Metal	9.1	34 Fabricated Metal	12.4	30 Rubber	43.4	22 Textiles	55.9
22 Textiles	8.7	30 Rubber	11.6	35 Machinery	43.3	35 Machinery	54.0
37 Transportation	8.6	35 Machinery	11.4	36 Electrical	42.5	32 Stone, Clay and Glass	53.7
24 Lumber and Wood	8.6	24 Lumber and Wood	11.2	38 Instruments	36.4	30 Rubber	51.1
35 Machinery	8.3	32 Stone, Clay and Glass	10.4	34 Fabricated Metal	36.2	34 Fabricated Metal	49.8
27 Printing	7.6	36 Electrical	10.4	22 Textiles	35.0	36 Electrical	48.7
38 Instruments	7.4	38 Instruments	9.1	24 Lumber and Wood	33.1	39 Miscellaneous	39.2
36 Electrical	6.3	39 Miscellaneous	8.9	27 Printing	30.6	38 Instruments	37.9
39 Miscellaneous	5.0	25 Furniture	8.5	39 Miscellaneous	20.1	31 Leather	36.9
25 Furniture	4.5	23 Apparel	8.3	25 Furniture	17.5	25 Furniture	33.9
23 Apparel	2.3	31 Leather	7.7	31 Leather	10.6	27 Printing	31.0
31 Leather	2.2	27 Printing	7.3	23 Apparel	7.3	23 Apparel	29.6

Sources: U.S. Census of Manufactures, 1880, 1900, 1967, 1987.

of manufactures. In 1900 the correlation is highest for the food, primary metal, chemicals, petroleum, machinery and instruments industries, which all rank in the top of the capital–labor ratios, but is rather low for the apparel and stone, clay and glass industries. In 1967 and 1987 the correlation is the highest for the petroleum, chemicals, primary metal and stone, clay and glass industries which consistently rank among the highest capital–labor ratios; the correlation is most disappointing for lumber and wood which ranks in the bottom half of the capital–labor ratios.

Since independent estimates of the factor intensities for the extractive resources—agriculture, tobacco, timber, petroleum and minerals—are unavailable, the results of the regressions are compared to raw material intensities calculated from the Census of Manufactures. In 1880 and 1900 the most material intensive industries were food, petroleum, primary metal, leather and rubber; in 1967 and 1987, they were petroleum, tobacco, food, chemicals, transportation and chemicals. According to the Rybczynski regressions, the respective extractive resources were highly statistically and economically significant for most of these cases.

4. Sources of U.S. regional comparative advantage

Tables 13–16 show that the sources of U.S. regional comparative advantage

Table 13
Sources of U.S. regional comparative advantage (elasticities at the means in parenthesis)

1880	
20 Food	Agriculture[b] (0.97), labor[b] (0.65)
21 Tobacco	Labor[a] (1.08), agriculture[a] (0.56)
22 Textiles	Labor[b] (1.45)
23 Apparel	Labor[b] (1.51)
24 Lumber and Wood	Timber[b] (0.48), labor[b] (0.44), agriculture[b] (0.23)
25 Furniture and Fixtures	Labor[b] (0.93), agriculture[b] (0.61), timber[a] (0.07)
26 Paper	Labor[b] (1.61), timber[a] (0.06)
27 Printing and Publishing	Labor[b] (1.09), agriculture[a] (0.46)
28 Chemicals	Labor[b] (0.95), minerals[a] (0.12)
29 Petroleum and Coal	Labor[b] (0.93), agriculture[b] (0.57)
30 Rubber and Plastics	Labor[b] (1.71)
31 Leather	Labor[b] (1.64)
32 Stone, Clay and Glass	Labor[b] (0.81), agriculture[b] (0.41), minerals[b] (0.10)
33 Primary Metal	Minerals[b] (0.86), labor[b] (0.33), tobacco[b] (0.03)
34 Fabricated Metal	Agriculture[b] (0.97), labor[b] (0.50)
35 Machinery	Labor[b] (0.69), agriculture[a] (0.52)
36 Electrical Machinery	Labor[b] (0.99), agriculture[b] (0.17)
37 Transportation	Labor[b] (0.55), agriculture[a] (0.48), timber[a] (0.12)
38 Instruments	Labor[b] (1.14)
39 Miscellaneous	Labor[b] (1.46)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

Table 14
Sources of U.S. regional comparative advantage (elasticities at the means in parenthesis)

1900	
20 Food	Capital[b] (1.68), agriculture[b] (0.70)
21 Tobacco	Tobacco[b] (0.21)
22 Textiles	Labor[b] (4.44)
23 Apparel	Capital[a] (4.06)
24 Lumber and Wood	Timber[b] (0.31), agriculture[b] (0.25)
25 Furniture and Fixtures	Agriculture[a] (0.37)
26 Paper	Labor[a] (1.58)
27 Printing and Publishing	Agriculture[b] (0.28)
28 Chemicals	None
29 Petroleum and Coal	Capital[b] (2.63), petroleum[b] (0.04)
30 Rubber and Plastics	Labor[a] (6.19)
31 Leather	Labor[a] (4.91)
32 Stone, Clay and Glass	Capital[a] (1.49), petroleum[b] (0.07)
33 Primary Metal	Capital[a] (1.80), mineral[b] (0.89)
34 Fabricated Metal	None
35 Machinery	Capital[a] (0.73)
36 Electrical Machinery	(not available)
37 Transportation	Agriculture[b] (0.39), mineral[b] (0.21)
38 Instruments	Capital[b] (3.35)
39 Miscellaneous	Capital[a] (2.11)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

changed over time as technological advances in production and transportation altered factor intensities and factor mobility.[13] In the late nineteenth century, given the prevalence of small scale manufacturing and the low mobility of labor and resources, the sources of comparative advantage in manufacturing were labor and resources. As manufacturing became increasingly capital intensive through the turn of the twentieth century, capital also became an important source of comparative advantage. In 1900, the dominant sources of comparative advantage were capital and resources. In the second half of the twentieth century, the differing combinations of labor, capital and resources contributed to explaining the economic geography of manufacturing industries. However, as capital became

[13]Since technological innovations affect factor intensities in production as well as the nature and mobility of factor endowments, these innovations constantly change the optimal location of manufacturing activities from the perspectives of resources and the Heckscher–Ohlin model. Thus, to the extent the neoclassical interregional trade model explains the location of manufacturing activities, the dynamic patterns of geographic concentration and deconcentrating are then accompanied by significant closing and opening of plants in different locations (see Dumais et al., 1997). Moreover, the static Rybczynski regression estimates presented in this paper are in some sense lower bound estimates of the importance of resources since at any given point in time plants are in the process of relocating to new optimal regions.

Table 15
Sources of U.S. regional comparative advantage (elasticities at the means in parenthesis)

1967	
20 Food	Labor[b] (1.00), agriculture[b] (0.42), mineral[b] (0.07), timber[a] (0.04)
21 Tobacco	Tobacco[b] (1.12)
22 Textiles	Labor[b] (1.21), tobacco[b] (0.49)
23 Apparel	Labor[b] (4.03), petroleum[a] (0.20)
24 Lumber and Wood	Timber[b] (0.68), capital[a] (0.17), agriculture[a] (0.05), tobacco[b] (0.02)
25 Furniture and Fixtures	Labor[b] (0.89), tobacco[b] (0.20), agriculture[a] (0.13)
26 Paper	Labor[b] (0.77)
27 Printing and Publishing	Labor[b] (3.37), petroleum[b] (0.12)
28 Chemicals	Capital (0.63), petroleum[a] (0.08)
29 Petroleum and Coal	Capital[b] (1.57), petroleum[b] (0.51)
30 Rubber and Plastics	None
31 Leather	Labor[b] (3.02), petroleum[a] (0.09)
32 Stone, Clay and Glass	Capital[b] (0.72), mineral[b] (0.12)
33 Primary Metal	Capital[b] (2.56)
34 Fabricated Metal	Capital[a] (1.24)
35 Machinery	Capital[a] (0.86)
36 Electrical Machinery	Labor[b] (1.49), agriculture[a] (0.16)
37 Transportation	None
38 Instruments	Labor[b] (5.61), petroleum[b] (0.22)
39 Miscellaneous	Labor[b] (3.23), petroleum[b] (0.10)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

increasingly mobile over the twentieth century, its importance as a source of regional comparative advantage declined.

4.1. Labor and capital

Labor was a significant source of comparative advantage for all manufacturing industries in 1880. For sixteen of these industries, labor was economically the most significant; for the remainder, it ranked second. Output elasticities with respect to labor were highest for rubber and plastics, leather, paper, textiles, apparel and miscellaneous industries and ranged from 1.71 to 1.45; they were the lowest for lumber and wood and primary metal industries at 0.44 and 0.33, respectively. In 1900 the number of products for which labor was a source of advantage fell sharply to four, but the output elasticities were higher in general. Labor was a source of comparative advantage for rubber and plastics, leather, textiles, and paper. In 1967 and 1987 the importance of labor rose again as it was a source of comparative advantage for ten industries in 1967 and for nine industries

Table 16
Sources of U.S. regional comparative advantage (elasticities at the means in parenthesis)

1987	
20 Food	Labor[b] (0.90), agriculture[b] (0.33), mineral[a] (0.07)
21 Tobacco	Tobacco[b] (1.72)
22 Textiles	Tobacco[b] (0.59)
23 Apparel	Labor[b] (3.17), petroleum[b] (0.19)
24 Lumber and Wood	Timber[b] (0.63), capital[b] (0.51)
25 Furniture and Fixtures	Tobacco[b] (0.16)
26 Paper	Timber[b] (0.11)
27 Printing and Publishing	Labor[b] (2.78)
28 Chemicals	Capital[a] (1.33)
29 Petroleum and Coal	Petroleum[b] (0.64), agriculture[a] (0.20), timber[a] (0.18), minerals[a] (0.15)
30 Rubber and Plastics	Capital[b] (1.32)
31 Leather	Labor[b] (2.51)
32 Stone, Clay and Glass	Labor[b] (0.89), minerals[b] (0.13)
33 Primary Metal	Capital[b] (4.14), minerals[b] (0.16)
34 Fabricated Metal	Capital[b] (1.52)
35 Machinery	Labor[b] (1.08), agriculture[b] (0.26)
36 Electrical Machinery	Labor[b] (2.24), agriculture[b] (0.23), petroleum[b] (0.15), minerals[a] (0.07)
37 Transportation	None
38 Instruments	labor[b] (4.93), petroleum[b] (0.34)
39 Miscellaneous	Labor[b] (2.60), petroleum[b] (0.09)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

in 1987.[14] Industries for which output elasticity was consistently greater than one for both years are instruments, apparel, printing and publishing, miscellaneous, leather, and electrical machinery.

Capital was not a source of comparative advantage for any manufacturing industry in 1880. However, the importance of capital rose in 1900 as it was significant for eight industries. By 1967 and 1987, the number settled down to seven and five industries respectively. Industries for which capital was a source of comparative advantage for two or more years are primary metal, petroleum, chemicals, stone, clay and glass, fabricated metal, machinery, and lumber and wood.

4.2. Extractive resources: Agriculture, forestry and minerals

Agricultural products were sources of comparative advantage for food manufacturing for all years. Food manufacturing was resource oriented because it was

[14]Given the growing importance of education, differentiation of labor types by education and skill levels has grown over time. See Richardson and Smith (1995) for the estimates of the Rybczynski regression matrix using six different labor types for 1987.

intensive in raw materials and experienced significant weight reduction in the manufacturing process. For example, over eighty percent of inputs to meat packing came from the agricultural sector and as much as fifty percent of weight was lost when livestock was transformed into wholesale meat. Other products such as flour milling, dairy processing, and canning, preserving, and freezing of fruits and vegetables were also resource oriented for similar reasons. There were some exceptions to this rule, but their contribution to the food sector was relatively minor. Certain beverage, bakery and confectionery products, especially those whose quality deteriorated rapidly with transportation, tended to locate near their markets rather than resources.

Agricultural products were also sources of comparative advantage for many industries other than food manufacturing, but their importance diminished significantly over time. In 1880, agriculture was significant for tobacco, lumber and wood, furniture and fixtures, printing and publishing, petroleum and coal, stone, clay and glass, fabricated metals, electrical machinery, and transportation industries. Given the low levels of scale economies in tobacco manufacturing, tobacco leaf was grown widely in agricultural areas in 1880. The geographic correlation of agricultural products and industries such as lumber and wood, furniture, fabricated metal, machinery, electric machinery and transportation was likely to be caused by the significant use of wood in the manufacturing of these products and the relative abundance of timber and seasonal labor in the agricultural regions. By 1900, however, the agricultural products became a less significant source of comparative advantage in manufacturing.

Tobacco leaf production was a source of comparative advantage for tobacco manufacturing for all years after 1900 and its significance rose over time. As the demand for tobacco products shifted from cigars and chewing tobacco to cigarettes, tobacco leaf became a significant source of comparative advantage for tobacco manufacturing.[15] Since tobacco leaf production is concentrated in a few

[15]There were three important types of cigarette leaf that were grown in the United States. Flue-cured tobacco was grown largely in North Carolina, South Carolina, Virginia and Georgia. Burley tobacco was grown primarily in Kentucky and Tennessee. Maryland tobacco was grown in that state. The American manufacturers blended these leafs in different proportions to produce cigarettes. The lower grades of Burley and flue-cured leaf were used to produce chewing tobacco. The cigar leaf, which is considerably different from the cigarette leaf, was grown primarily in Pennsylvania, Wisconsin, Connecticut, and Massachusetts. Prior to 1880, when scale economies in the tobacco industry were low, when cigars and chewing tobacco were relatively more important than cigarettes, and when the Turkish leaf held premium status, most regions produced tobacco leaf of some sort and manufactured tobacco products. Thus, it is not surprising that agricultural production rather than raw tobacco production was correlated with tobacco manufacturing in 1880. However, as the demand for cigarettes grew, tobacco manufacturing mechanized, scale economies rose, and the industry became intensive in raw materials. The supply of cigarette leafs became an important source of comparative advantage for tobacco manufacturing and tobacco production became increasingly clustered in the few cigarette leaf growing states (see Nicholls, 1951).

southern states, the supply of raw tobacco also serve nicely as a proxy for unskilled workers. The correlation between tobacco leaf production with textiles, lumber and wood, and furniture and fixtures in 1967, and with textiles, furniture and fixtures, and rubber and plastics in 1987 indicate the importance of unskilled workers in these industries.

Timber was a source of comparative advantage for lumber and wood in all years. Since the cost of transporting timber was relatively high, and because there was considerable weight loss in the manufacturing process, the lumber and wood industry was located near timber supplies.

Although timber (spruce, pine, hemlock, and fir) was also a significant input in paper production, it was significant for paper only for 1880 and 1987. This inconsistent result may be due to fact that the paper market contained two major segments with different orientations and that significant amounts of timber was imported from Canada. While the pulp and paper segments were resource oriented, converted paper products (paper coating and glazing, paper bags and envelopes, paperboard containers and boxes), which add bulk and value in processing, were oriented toward markets. In 1880, timber was also a source of advantage for the transportation and furniture industries.[16] Many transportation products such as ships, carriages, wooden freight trains, and furniture were highly intensive in timber. However, as metal replaced wood in transportation products, the supply of timber became a relatively less important source of comparative advantage. In furniture manufacturing, the considerable bulk gain in the manufacturing process probably reduced the importance of timber supplies as a source of comparative advantage.

Petroleum crude oil was a source of comparative advantage for manufactured petroleum for all years beginning in 1900.[17] Given that petroleum refining was intensive in crude oil and was subject to significant scale economies, it was resource oriented. Although petroleum crude oil is also a significant input to petrochemicals, it was only statistically significant for 1967.

Minerals were a source of comparative advantage for primary metal in 1880,

[16]In 1880 and 1900, certain types of timber was a significant source of comparative advantage in leather production. Despite the considerable weight reduction in the processing of hides, leather production did not always locate near hide supplies. Since tanning barks (hemlock, oak, chestnut, and sumac) weighed two and a half times more than hides, production was located near tan bark supplies. Only ten percent of the weight of bark consisted of active tannin agents and the bark was bulky, fragile and subject to deterioration if exposed (see Hoover, 1937). As techniques for extracting tannin from barks were developed, and as synthetic tannin was discovered, the supply of tan bark lost its source of comparative advantage in leather production.

[17]The petroleum category could not be constructed for 1880.

1900 and 1987. These estimates confirm the general notion that ‘‘iron moves to coal,’’ but coal’s influence has declined over time.[18] Minerals were a source of comparative advantage for chemicals in 1880.[19] Some chemicals such as alumina and fertilizer production were resource oriented. The production of alumina from bauxite and fertilizer from phosphate rocks both involved a substantial weight reduction in the manufacturing process. Minerals were a source of comparative advantage for the production of stone, clay and glass in 1900, 1967 and 1987. However, the output elasticity with respect to minerals was extremely low. The low economic significance of minerals may be caused by the wide geographic

[18] In the early nineteenth century, five tons of coal and two tons of ore were needed in order to produce a ton of steel. Over time, technological innovations reduced the coal content and increased the locational pull of iron ore. The advantage of the Pittsburgh region’s Connellsville coke gave way to the Great Lake region’s close proximity to Mesabi ore. As the location of metal ore relative to coal became more important, metal minerals became sources of comparative advantage for manufacturing primary metals. However, the Rybczynski regressions showed little signs of geographic correlation between ore production and iron and steel industries. Metal minerals were a source of comparative advantage for primary and fabricated metals in 1967 and for machinery in 1880 and 1987. The locational pull of coal is likely to have been greater than ore in 1880, but not thereafter. In 1880, Pennsylvania had enormous locational advantages in producing iron and steel. In that year, Pennsylvania made 84.2 percent of U.S. coke and almost half of the all the fuel used for pig iron production was accounted for by Pennsylvania anthracite coal and Connellsville coke. Moreover, at that time, more than half of the ore production came from New York, New Jersey and Pennsylvania and only about 24 percent came from Michigan and Wisconsin. By 1900, however, the use of bituminous coal and coke accounted for approximately 85 percent of pig iron production. Ore from Minnesota, Michigan and Wisconsin accounted for approximately 75 percent of ore production (Warren, 1973). The disappointing result may be caused the arbitrary nature of defining states as regional boundaries. The use of states as regional boundaries does not capture the fact that the Minnesota Mesabi ore is really ‘‘near’’ the other states in the Great Lakes region due to cheap water transportation. The cost of transporting the Mesabi ore to inland points in Minnesota may be much greater than shipping ore to other states along the Great Lakes. In 1898, the cost of shipping ore by rail was around $0.004 per ton mile by rail whereas the Lake rate was $0.00079 (Warren, 1973). The mills also needed to locate near an abundant source of water supply. An annual capacity of two million tons of steel needs about three hundred fifty million tons of water. The correlation between domestic ore supply and primary metal production was also lessened by the use of imported ore by mills located in the East coast and the substitution of ore by scrap metal. In 1890, all blast furnaces west of Pittsburgh used Lake Superior ore. The East coast furnaces located in Baltimore, Sparrows Point, Steelton, Pottstown, Norristown, Chester, Bethlehem, Riegelsville, Catasaqua, and Oxford used foreign ore. Furnaces in Millerton, Cannan, Wassai and Kent used Salisbury ore (see Warren, 1973, p. 118).

[19] In a previous version of this paper, minerals were further subdivided into chemical minerals. The supply of chemical minerals were significant source of comparative for chemical manufacturing for 1900 and 1967.

distribution of stone minerals and the relatively high cost of transporting the stone, clay and glass products.[20]

5. Sources of U.S. regional comparative disadvantage

The sources of regional comparative disadvantage in U.S. manufacturing are presented in Tables 17–20. In general, extractive resources acted as a source of comparative disadvantage for a variety of industries. In 1880, the supply of

Table 17
Sources of U.S. regional comparative disadvantage (elasticities at the means in parenthesis)

1880	
20 Food	Timber[a] (−0.10), mineral[a] (−0.09)
21 Tobacco	Mineral[a] (−0.21)
22 Textiles	Agriculture[b] (−1.10), timber[b] (−0.09)
23 Apparel	Mineral[b] (−0.31), tobacco[a] (−0.06)
24 Lumber and Wood	Mineral[b] (−0.06)
25 Furniture and Fixtures	Mineral[b] (−0.14), tobacco[a] (−0.03)
26 Paper	Agriculture[b] (−0.49), mineral[b] (−0.22)
27 Printing and Publishing	Mineral[a] (−0.20), timber[a] (−0.07), tobacco[a] (−0.05)
28 Chemicals	Tobacco[a] (−0.03)
29 Petroleum and Coal	Timber[b] (−0.15), tobacco[b] (−0.04)
30 Rubber and Plastics	Agriculture (−1.11), minerals[a] (−0.31)
31 Leather	None
32 Stone, Clay and Glass	Timber[b] (−0.11)
33 Primary Metal	Timber[b] (−0.29)
34 Fabricated Metal	None
35 Machinery	Timber[b] (−0.05), tobacco[a] (−0.02)
36 Electrical Machinery	Capital[b] (−0.44), mineral[b] (−0.31), tobacco[a] (−0.09)
37 Transportation	None
38 Instruments	Mineral[b] (−0.07)
39 Miscellaneous	Mineral[b] (−0.35), tobacco[a] (−0.05)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

[20]The cost of transporting stone, clay and glass products was relatively high since products such as cement and clay bricks were relatively low value per weight items while glass products were fragile items to transport. In the nineteenth century, the Lehigh Valley had significant advantages for producing cement due to its abundant supply of limestone and coal. Over time, cement production became relatively widespread. This dispersion was due to the widespread availability of energy sources and limestone, and the relatively high cost of transporting the final product. The clay brick industry was much like the cement industry except that Georgia was the home of some of the best clay. Although the importance of natural gas and electricity for glass production was well known, major glass producing states such as Pennsylvania, New Jersey, West Virginia, and Ohio also had abundant supplies of sand that was low in iron oxide and alumina and high in silica.

Table 18
Sources of U.S. regional comparative disadvantage (elasticities at the means in parenthesis)

1900	
20 Food	Labor[a] (−0.89), mineral[b] (−0.19)
21 Tobacco	None
22 Textiles	Agriculture[b] (−0.92)
23 Apparel	Mineral[b] (−0.69)
24 Lumber and Wood	None
25 Furniture and Fixtures	None
26 Paper	Agriculture[a] (−0.37), mineral[b] (−0.33)
27 Printing and Publishing	Mineral[b] (−0.37)
28 Chemicals	None
29 Petroleum and Coal	Mineral[a] (−0.14), timber[b] (−0.06)
30 Rubber and Plastics	Agriculture[a] (−0.90)
31 Leather	None
32 Stone, Clay and Glass	Timber[b] (−0.08)
33 Primary Metal	Agriculture[b] (−0.29), timber[a] (−0.15)
34 Fabricated Metal	None
35 Machinery	Timber[b] (−0.06)
36 Electrical Machinery	(not available)
37 Transportation	None
38 Instruments	Mineral[b] (−0.35), timber[b] (−0.12)
39 Miscellaneous	Mineral[b] (−0.51), timber[b] (−0.11)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

minerals was a significant source of comparative disadvantage for eleven industries whereas the supply of tobacco and timber hindered the production of manufacturing in seven industries. Over time, minerals became a minor source of comparative disadvantage whereas the supply of tobacco, timber and agriculture continued to play a significant role in hindering the growth of several industries. Labor played a minor role throughout but the comparative disadvantage of capital increased over time.

6. Conclusion

This paper has attempted to differentiate between geographic concentration caused by natural advantages and spillovers by controlling for factor endowments. The Rybczynski regression estimates suggest that, despite a slight fall in their explanatory power, factor endowments explain a large amount of the geographic variation in U.S. manufacturing over time as predicted by the standard general equilibrium model of interregional trade. The geographic distribution of manufacturing activities between 1880 and 1987 is explained by a relatively short list of factor endowments constructed from labor, capital, and extractive industries.

Table 19
Sources of U.S. regional comparative disadvantage (elasticities at the means in parenthesis)

1967	
20 Food	Capital[a] (−0.32)
21 Tobacco	None
22 Textiles	Agriculture[b] (−0.35)
23 Apparel	Capital[b] (−2.89), agriculture[a] (−0.44)
24 Lumber and Wood	Mineral[b] (−0.06)
25 Furniture and Fixtures	None
26 Paper	Mineral[a] (−0.07)
27 Printing and Publishing	Capital[b] (−2.28), tobacco[b] (−0.09)
28 Chemicals	Timber[b] (−0.07)
29 Petroleum and Coal	Labor[a] (−0.85)
30 Rubber and Plastics	Petroleum[a] (−0.14), timber[a] (−0.08), tobacco[b] (−0.04)
31 Leather	Capital[b] (−2.16), agriculture[a] (−0.46), timber[a] (−0.14), tobacco[b] (−0.09)
32 Stone, Clay and Glass	Petroleum[a] (−0.03), tobacco[b] (−0.03), timber[a] (−0.02)
33 Primary Metal	Labor[b] (−1.13), petroleum[b] (−0.19), timber[b] (−0.08), agriculture[a] (−0.14), tobacco[b] (−0.07)
34 Fabricated Metal	Petroleum[a] (−0.09), tobacco[b] (−0.05), timber[a] (−0.04)
35 Machinery	Timber[a] (−0.99), petroleum[b] (−0.96), tobacco[b] (−0.52)
36 Electrical Machinery	Tobacco[a] (−0.03)
37 Transportation	Tobacco[a] (−0.06)
38 Instruments	Capital[b] (−4.26), tobacco[b] (−0.13)
39 Miscellaneous	Capital[b] (−2.12), agriculture[a] (−0.19), tobacco[b] (−0.09)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

Moreover, the factor intensities inferred from the Rybczynski regression estimates match well with independent estimates of factor intensities from the Census of Manufactures.[21]

Although the decline in the explanatory power of the Rybczynski regressions might signal the growing importance of spillovers in determining the location of U.S. manufacturing, several other explanations are also possible. Since the spillover effects are measured as a residual, it is difficult to ascertain the exact

[21] In general, the sum of the elasticities from the Rybczynski regressions is approximately one for most industries, confirming the assumption of constant returns to scale. Some outliers are petroleum whose elasticity is 1.75 for 1967 and 1987, rubber with 0.25 for 1880 and 1967, leather with less than 0.25 in 1967 and 1987, and textiles whose elasticity is about 0.5 throughout. While it is beyond the scope of this paper to decompose U.S. manufacturing output changes in terms of growth and interregional trade effects, the results of the Rybczynski estimates shed some light on this issue. For each of the twenty 2-digit manufacturing industries, the output elasticity with respect to resources can be calculated from the Rybczynski coefficients by summing the output elasticities across all factors (including labor and capital). Contrary to the hypothesis put forth by Wright (1990), the Rybczynski regressions suggest that natural resources did not contribute much to economic growth. The sum of elasticities for natural resources is close to zero or negative for most industries over time.

Table 20
Sources of U.S. regional comparative disadvantage (elasticities at the means in parenthesis)

1987	
20 Food	Tobacco[b] (−0.02)
21 Tobacco	None
22 Textiles	Mineral[a] (−0.59), agriculture[b] (−0.48)
23 Apparel	Capital[b] (−2.02), agriculture[a] (−0.38)
24 Lumber and Wood	None
25 Furniture and Fixtures	Mineral[a] (−0.19)
26 Paper	Agriculture[a] (−0.16)
27 Printing and Publishing	Capital[a] (−1.72), tobacco[b] (−0.08)
28 Chemicals	Timber[a] (−0.13)
29 Petroleum and Coal	Tobacco[b] (−0.07)
30 Rubber and Plastics	Petroleum[b] (−0.13), timber[b] (−0.09)
31 Leather	Agriculture[b] (−0.62)
32 Stone, Clay and Glass	None
33 Primary Metal	Labor[b] (−2.56), petroleum[b] (−0.42), timber[a] (−0.10), tobacco[b] (−0.10)
34 Fabricated Metal	Petroleum[b] (−0.16), timber[b] (−0.11), tobacco[b] (−0.06)
35 Machinery	Timber[a] (−0.06), tobacco[b] (−0.03)
36 Electrical Machinery	Capital[b] (−1.43)
37 Transportation	None
38 Instruments	Capital[b] (−4.00), tobacco[b] (−0.10)
39 Miscellaneous	Capital[b] (−1.57), agriculture[a] (−0.22), tobacco[a] (−0.07)

[a] = Significant at the 5 percent level. [b] = Significant at the 1 percent level.
Note: Factor endowments are reported in this table if they are statistically significant the 5 percent level.

causes of the decline. The decline may be due simply to the growth in the randomness in the location of manufacturing activities caused by the growing similarities in regional factor endowments. In addition, a more detailed examination of the Rybczynski regression estimates by industries also suggests that the growth in imports in raw materials and final goods may have also reduced the effectiveness of domestic resources in explaining the location of some industries. Clearly, additional effort is needed to set limits on the importance of Marshallian externalities or spillovers in U.S. economic geography.

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