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14 Specialization and Productivity Performance in Low-, Medium-, and High-Tech Manufacturing Industries

Edward N. Wolff

This paper investigates patterns of industry specialization as measured by a country's share of total industry production for fourteen OECD countries over the period 1970–93. It also employs regression analysis to examine the relation between specialization and relative productivity performance. The study makes use of the 1994 version of the OECD Structural Analysis (STAN) industrial database, which subdivides manufacturing into thirty-three individual industries. Of particular interest are differences in performance between low-, medium-, and high-tech industries, which are classified into groups on the basis of their research and development (R&D) intensity.

There are three principal questions of interest. First, given the continued convergence of overall productivity and capital intensity in these countries, how similar are the industries of specialization among these countries, and have they become more or less similar over this period? Second, do countries have different strengths in terms of labor productivity, and do they maintain their relative productivity positions over time? Third, what factors help explain rising or falling market shares in individual industries?

I find that, despite the continued convergence of aggregate productivity and factor abundance, these countries tended to specialize manufacturing production in different industries and to maintain specialization in the same industries in 1993 as in 1970. They also tended to be strong in different industries in terms of labor productivity performance, but correlations over time in relative industry labor productivity performance within country are considerably weaker than those for market shares.

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Despite the apparent differences in stability of market shares and relative productivity performance over time, the results show that improvement in relative labor productivity is a powerful predictor of a rising market share. This result holds across all industry groups. The rate of capital formation also plays an important role in the determination of market share for low-tech industries but is less significant for medium-tech industries and not significant for high-tech ones. The results also show that relatively higher labor costs generally reduce competitiveness in a particular industry and hence market share but, somewhat surprisingly, that this effect is statistically significant only among low-tech industries and only in the 1970s.

The remainder of the paper is organized as follows. Section 14.1 considers some general guidance from trade theory and reviews some related research on this issue. Section 14.2 presents descriptive statistics on specialization and section 14.3 on the productivity performance of OECD countries over the time period. In section 14.4, I present regression results on the relation between production shares and technology indicators. Concluding remarks are made in section 14.5.

14.1 Theoretical Background

There are two principal approaches found in trade theory that are employed to explain why different countries will specialize production in different industries. The first is the Heckscher-Ohlin (HO) model with factor-price equalization. It makes very sharp predictions about cross-country patterns in labor and total factor productivity at the industry level: namely, that industry productivity levels should be the same in all countries. As a consequence, industries of specialization depend only on relative factor abundance—a country will specialize in those industries that use more intensively the factor that is relatively abundant in that country.

Leamer's (1984) empirical study of trade patterns for over one hundred economies found that general patterns could be explained fairly well by an endowment-based model with ten factors, including capital, several types of natural resources and land, and three skill classes of labor. However, it should be noted that, in that study, manufacturing was disaggregated into only four industry classifications and the model was considerably more successful at explaining trade in primary products than trade in manufactures. Those results are consistent with the argument that the broad pattern of exports—primary versus secondary goods, heavy versus light manufactures—can be explained by general factor endowments but that the specific pattern of exports of manufactures at a more disaggregated level depends on industry-specific factors that do not depend largely on resource endowments.

The second approach emphasizes the role of increasing internal returns to scale (IIRS) and learning by doing in the formation of comparative advantage. The underlying theory was developed by Krugman (1979, 1980), Helpman

(1984), and Helpman and Krugman (1985) and later expanded in Gomory (1992) and Gomory and Baumol (1992). This line of analysis suggests that it is the presence of economies of scale and/or high startup costs that allows different countries to achieve specialization in different products. The country that enters a new product line first may be able to dominate that line by increasing production to the point at which its costs are so low that potential new competitors are unable to enter the field successfully (at least, without dramatic innovations or sufficient subsidies from the government). Even more important is the accumulation of specialized knowledge that is acquired only by being in the industry. This may include knowledge of the details of production steps as well as specialized skills that are mainly acquired on the job, knowledge of marketing channels, and a knowledgeable sales force that is known to customers. This process is also referred to as *learning by doing* since the firm or country that first establishes an industry may be able to descend the cost curve by acquiring the expertise that comes through experience in making the product (see Arrow 1962).

Which industries a country may specialize in may depend on history and a variety of influences, some of them perhaps fortuitous (for an illuminating discussion of the process, see Krugman [1991]). Moreover, an important role can be played by the availability or unavailability of ancillary industries that can substantially facilitate a country's success in the production of some particular product or type of products. Geographic externalities may also play an important role since, once an industry is established in a country or place, there is greater likelihood of suppliers and customers also specializing there. This approach suggests that leadership positions may persist for long periods of time, thus ensuring relatively stable industry specialization over time.

Earlier work (Dollar and Wolff 1993) found strong evidence of convergence on the economywide level in GDP per worker, the capital/labor ratio, aggregate labor productivity, total factor productivity (TFP), and average real wages for a sample of nine OECD countries covering the period 1970–86. Dollar and Wolff also examined the same variables for nine manufacturing sectors and found that, except for real wages, convergence at the industry level was generally not as strong as that for the economy as a whole. In fact, aggregate convergence in labor productivity could to some extent be attributed to the modest labor productivity leads that different countries enjoyed in different industries. The results are similar for TFP and capital intensity.

A further result of this development is that the export patterns of the industrial countries were not converging or becoming more similar. This result is consistent with Dollar and Wolff's conclusion that specialization has continued at the industry level in the advanced industrial countries. Moreover, in a bilateral comparison of Japan and the United States, a clear relation is evident between TFP growth at the industry level and changing comparative advantage. The industries in Japan with growing comparative advantage over this period tended to be those in which its TFP relative to the United States increased rapidly. Dollar and Wolff argued that TFP captures some influence that contributes to comparative advantage and that this factor is likely to be technology as disembodied knowledge, as embodied in machinery, or as reflected in skilled labor.

These earlier results seem less in accord with an HO type of model than with one based on the IIRS approach. HO theory suggests that convergence in aggregate performance, particularly aggregate capital/labor ratios, should be accompanied by a convergence in the trade patterns of these countries. The IIRS approach, in contrast, emphasizes technology differences between countries as the basis of specialization and suggests that trade patterns may shift in accordance with movements in productivity levels.

In this paper, I examine whether these results hold up for a larger sample of countries, a more detailed industry classification, and a longer time period. Moreover, using econometric techniques, I analyze more formally the relation between comparative advantage as reflected in a country's market shares in individual industries and relative productivity performance.

It should also be noted that the convergence of real wages at the industry level, found in Dollar and Wolff (1993), greatly strengthens the notion that productivity growth should be an important determinant of changing comparative advantage. Those results imply that, among OECD countries, differences in the cost of labor (and, to some extent, capital) were not important determinants of differences in unit costs by the 1980s.[1] Given the similarity in factor prices, trends in relative productivity then may become more crucial determinants of cost competitiveness and production share.

14.2 Convergence of Production Patterns?

In this section, I investigate whether industrial production patterns of developed countries have tended toward convergence over the last two decades. I use the 1994 OECD STAN database, available on diskettes. The time period covered is 1970–93. This source provides statistics on value added, which is measured in both current and 1985 local prices;[2] gross capital formation in current prices (although this version unfortunately lacks capital stock data); total employment; employee compensation;[3] and purchasing power parity (PPP) conversion factors for each country and year (although not available on the industry level). Data on each of these variables are provided on the industry level—a total of thirty-three manufacturing industries—although they are not

1. Nakamura's (1989) study of Japan, Germany, and the United States also found that, by the late 1970s, input prices were quite similar among these three countries, with the result that the "relative TFP level has become the principal determinant of sectoral cost advantage and disadvantage among the three countries" (p. 713).

2. The value added is exclusive of value-added taxes and other indirect business taxes.

3. This is defined as the sum of wages and salaries, social insurance taxes, and other employee fringe benefits paid by the employer.

available for nonmanufacturing sectors. The STAN database has relatively complete data on fourteen OECD countries—Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom, and the United States.[4]

Comparisons of output among the countries is made on the basis of value added by industry in 1985 local currency converted to 1985 U.S. dollars on the basis of the 1985 PPP rate for that country. This is problematic for two reasons. First, gross output (sales) is the preferable measure to use when computing market share. Second, ideally, conversion to a common currency should be made on the basis of industry-specific PPPs for each country, as is the practice in the International Comparison of Output and Productivity (ICOP) project (see, e.g., Maddison and van Ark 1989).

Despite these limitations, calculations of production shares based on value added are very highly correlated with those calculated from gross output among the industries and countries for which the data exist (correlation coefficients are on the order of 0.95–0.98). Second, since manufactures are generally tradables, there is some presumption that local prices will tend toward equilibrium international prices of individual industries. Third, in most of the analysis—particularly the econometric applications—I am interested in changes over time in production shares and related variables. Thus, insofar as biases tend to remain stable over time (e.g., percentage differences between industry-specific and overall PPPs for a given country), the biases will "wash out" in equations that use first differences.

I begin (in table 14.1) with measures of production shares (PRODSHR) for thirty-three manufacturing industries in the three largest economies, Germany, Japan, and the United States. The production share for country h in industry i is defined as

$$\text{PRODSHR}_i^h = Y_i^h / \Sigma_h Y_i^h, \tag{1}$$

where Y_i^h is country h's production of good i valued in 1985 U.S. dollars, and output is based on value added by industry. The aggregation over h covers the fourteen countries in the STAN database with the requisite data, and the index therefore shows country h's share of the total production of product i among the fourteen countries.

The thirty-three industries selected are the most detailed ones available with the requisite data. They are all three-digit ISIC industries, with the exception of transport equipment, which is available on the four-digit level. These industries are divided into three technology groups on the basis of the average R&D intensity of production of these industries in OECD countries in 1985, as follows: *low tech,* less than 0.5 times the mean R&D intensity; *medium tech,* from

4. Data are also provided for Austria, Korea, Mexico, New Zealand, Portugal, and Spain, which are unfortunately incomplete for many series. As a result, these countries will not be included in the data analysis reported here.

Table 14.1 **Production Shares (PRODSHR) of Germany, Japan, and the United States and the OECD Leader, 1970 and 1993[a]**

	1970				1993			
ISIC Code[b] and Industry	GER	JPN	USA	Leader	GER	JPN	USA	Leader
3000 Total manufacturing	.14	.13	.40	USA	.11	.23	.37	USA
Low-tech industries[c]								
311.2 Food	.09	.20	.30	USA	.07	.21	.33	USA
313 Beverages	.20	.19	.20	GER	.14	.15	.26	USA
314 Tobacco	.24	.02	.50	USA	.35	.04	.29	GER
321 Textiles	.11	.16	.28	USA	.08	.12	.36	USA
322 Wearing apparel	.12	.14	.36	USA	.05	.19	.41	USA
323 Leather & products	.14	.15	.21	USA	.08	.20	.20	ITA
324 Footwear	.12	.03	.33	USA	.06	.05	.16	ITA
331 Wood products	.09	.10	.48	USA	.08	.11	.51	USA
332 Furniture & fixtures	.17	.16	.32	USA	.12	.15	.34	USA
341 Paper & products	.09	.10	.48	USA	.09	.16	.45	USA
342 Printing & publishing	.06	.19	.45	USA	.05	.20	.41	USA
353 Petroleum refineries	.28	.06	.30	USA	.21	.12	.25	USA
354 Petroleum & coal products	.22	.05	.49	USA	.15	.09	.53	USA
355 Rubber products	.16	.09	.42	USA	.08	.20	.40	USA
356 Plastic products nec	.12	.22	.33	USA	.12	.23	.38	USA
361 Pottery, china, etc.	.11	.15	.12	ITA	.08	.18	.12	ITA
362 Glass & products	.10	.21	.41	USA	.14	.18	.31	USA
369 Nonmetal products nec	.15	.16	.29	USA	.13	.22	.29	USA
371 Iron & steel	.16	.16	.45	USA	.15	.29	.30	USA
372 Nonferrous metals	.12	.16	.45	USA	.15	.25	.29	USA
381 Metal products	.15	.10	.38	USA	.15	.18	.37	USA
3841 Shipbuilding & repair[d]	.05	.16	.34	USA	.06	.31	.30	JPN
39 Other manufactures nes	.06	.20	.39	USA	.04	.44	.30	JPN

Medium-tech industries[c]								
351 Industrial chemicals	.19	.11	.37	USA	.13	.17	.37	USA
3842 Railroad equipment[d]	.04	.06	.20	USA	.05	.13	.20	USA
3843 Motor vehicles[d]	.17	.18	.38	USA	.16	.29	.32	USA
3844 Motorcycles & bicycles[d]	.06	.19	.16	ITA	.06	.30	.12	ITA
3849 Other transport equipment[d]	.11	.27	.00	JPN	.09	.39	.00	JPN
High-tech industries[c]								
352 Other chemical products[e]	.15	.11	.48	USA	.11	.20	.43	USA
382 Nonelectrical machinery[f]	.16	.12	.38	USA	.10	.21	.45	USA
383 Electrical machinery[g]	.17	.02	.49	USA	.10	.40	.31	JPN
3845 Aircraft[d]	.03	.01	.74	USA	.04	.03	.73	USA
385 Professional goods[h]	.21	.05	.54	USA	.12	.12	.56	USA
GDP Share	.09	.13	.45		.09	.18	.42	
Correlation with United States	.07	−.57			−.06	−.42		
Correlation with Germany		−.33				−.23		
Rank correlation with United States	.17	−.49			−.01	−.28		
Rank correlation with Germany		−.34				−.09		

[a]The production share of country h in industry i is defined as

$$\mathrm{PRODHSR}_i^h = Y_i^h / \Sigma_h Y_i^h,$$

where the aggregation over h is based on 14 OECD countries with pertinent data: Australia (AUS), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (GER), Italy (ITA), Japan (JPN), the Netherlands (NET), Norway (NOR), Sweden (SWE), the United Kingdom (UK), and the United States (USA).

[b]Revision 2 ISIC codes.

[c]Division of industries into technology groups is based on the average R&D intensity of production of OECD countries in 1985 as follows: low tech, less than 0.5 times the mean R&D intensity; medium tech, from 0.5 to 1.5 times the mean R&D intensity; and high tech, over 1.5 times the mean R&D intensity.

[d]Calculations exclude Belgium.

[e]Includes drugs and medicines and other chemicals nec.

[f]Includes office and computing machinery and machinery & equipment nec.

[g]Includes radio, TV & communication equipment, and electrical apparatus nec.

[h]Includes scientific instruments.

0.5 to 1.5 times the mean R&D intensity; and *high tech,* over 1.5 times the mean R&D intensity.

In 1970, Germany accounted for 14 percent of total manufactures of this group of fourteen countries, Japan 13 percent, the United States 40 percent, and the three together two-thirds. Germany's share of total manufacturing was considerably greater than its share of the fourteen-country GDP (14 vs. 9 percent), Japan's share was almost identical to its GDP share (13 percent), whereas the U.S. manufacturing share was smaller (40 vs. 45 percent).

In 1970, Germany's manufacturing was particularly strong in petroleum refineries (28 percent), petroleum and coal products (22 percent), industrial chemicals (19 percent), motor vehicles (17 percent), electrical machinery (17 percent), and professional goods and scientific instruments (21 percent). Japan's strengths were in food products (20 percent), plastics (22 percent), glass and glass products (21 percent), motor vehicles (18 percent), and other transport equipment (27 percent). The United States accounted for about half the total fourteen-country output of tobacco products, wood products, paper and paper products, petroleum and coal products, other chemical products (including pharmaceuticals), electrical machinery, and professional goods and scientific instruments and three-fourths of the production of aircraft. Generally speaking, in 1970, the United States dominated the high-tech industries, particularly aircraft; both Germany and Japan were strong in the medium-tech transport equipment industries, such as motor vehicles; and the three countries each specialized in different industries within the low-tech group.

The fourth column of table 14.1 shows the leading producer in each industry in 1970. It is, perhaps, not surprising that the United States dominated almost all industries (twenty-nine of thirty-three) in 1970 since it was by far the largest economy. However, Germany was the leading producer of beverages, Italy of pottery and china and motorcycles and bicycles, and Japan of other transport equipment.

Between 1970 and 1993, both the German and the U.S. share of total manufacturing production declined by 3 percentage points, whereas the Japanese share increased sharply, by 10 percentage points. By 1993, Japan's manufacturing output was more than double Germany's and over 60 percent that of the United States. Germany's share of output remained the same or fell in almost every manufacturing industry. The U.S. share likewise remained unchanged or declined in almost all industries, with the major exception of textiles (rising from 28 to 36 percent), wearing apparel (from 36 to 41 percent), plastics (from 33 to 38 percent), and nonelectrical machinery (including office and computing machinery; from 38 to 45 percent).

Japan's share, on the other hand, increased in most of the industries—notably, electrical machinery, including radios, televisions, and communications equipment (rising from 2 to 40 percent), rubber products (from 9 to 20 percent), iron and steel (from 16 to 29 percent), shipbuilding (from 16 to 31 percent), motor vehicles (from 18 to 29 percent), motorcycles and bicycles (from

19 to 30 percent), and other transport equipment (from 27 to 39 percent). Japan's inroads were particularly marked in the medium- and high-tech industries. In contrast, Germany basically held its production shares in the medium-tech industries but declined in the high- and low-tech industries. The United States made its major gains in low-tech industries, such as food, apparel, and wood products; lost share in the medium-tech industries; but retained its share in the high-tech industries.

Despite the major gains of Japanese manufacturing, the United States still lead all producers in 1993 in twenty-four of the thirty-three industries. Japan was dominant in four industries (particularly, shipbuilding, transport equipment, and electrical machinery), Italy in four (leather products, footwear, pottery and china, and motorcycles and bicycles), and Germany in only one.

The bottom four rows of table 14.1 show the correlation and rank correlation between the distribution of production shares between the countries. There are, of course, statistical problems with using a correlation coefficient between two distributions since the individual elements in each distribution are not independent. In particular, if one share is high, one or more others must be low since the sum of productions shares within an industry and across countries must equal 1.0. The same is true for the ranking of industries. However, the correlation coefficient and the rank correlation do provide rough measures of the similarity between two distributions. What is, perhaps, most striking is the low correlation coefficients among the three countries—in 1970, 0.07 between Germany and the United States, −0.57 between Japan and the United States, and −0.33 between Germany and Japan and, in 1993, −0.06, −0.42, and −0.23, respectively. The rank correlations are similar. The three countries have specialized production in distinctly different industries, and there has been very little change over time in the degree of dissimilarity in their patterns of specialization.

While production shares reveal which countries are the major producers in each product line, they are not a good indicator of specialization since they also reflect the overall size of the economy. A better indicator of specialization is the share of the total production of a given commodity made in an individual country relative to its share of GDP:

$$\text{(2)} \qquad \mathrm{RELPSHR}_i^h = [Y_i^h/\Sigma_h Y_i^h]/(\mathrm{GDP}^h/\Sigma_h \mathrm{GDP}^h),$$

where the GDP figures, obtained from the OECD International Sectoral Database (ISDB), are in 1985 U.S. dollars. This index is analogous to Balassa's revealed comparative advantage (RCA) measure (Balassa 1965), which is used to measure trade specialization. The numerator of RELPSHR indicates country h's share of the total production of industry i, while the denominator measures country h's share of total GDP for these fourteen countries. A value above (below) one indicates that country h's share of the group's total production of product i is higher (lower) than its share of the total GDP of this group. This index indicates in which product lines a country's production is concentrated, which is taken as a measure of specialization. In general, some values of RELPSHR for a country will be greater than one, while others will be less than one.[5]

Calculations of RELPSHR for Germany, Japan, and the United States are shown in table 14.2. The rank order of industries within each country is the same as for PRODSHR, but the relative magnitudes across countries are quite different. The specialization of Germany in beverages, petroleum refineries, petroleum and coal products, industrial chemicals, and professional goods and scientific instruments (all values of RELPSHR exceed 2.0), as well as in motor vehicles and electrical machinery (both values exceed 1.8), in 1970 is now apparent. Japan in 1970 was particularly strong in plastics, glass and glass products, and other transport equipment (all values above 1.6). The major specialization of the United States was aircraft (a value of 1.7).

The specialization patterns are quite different with this new measure. In 1970, Germany had the highest relative production shares among all fourteen countries in total manufacturing, all the high-tech industries except aircraft, motor vehicles, and seven low-tech industries. Italy had the highest value in five industries, including textiles, wearing apparel, footwear, and motorcycles and bicycles. Japan was the leader in only one industry (food products), the United States in only one (aircraft), Belgium in three (including industrial chemicals), Sweden in one (wood products), Finland in one (paper and paper products), Norway in two (including shipbuilding), Australia in two (including railroad equipment), and Denmark, the Netherlands, and the United Kingdom in one each.

By 1993, Germany remained extremely specialized in only three industries, including motor vehicles, and the United States in only aircraft, while Japan was now highly specialized in iron and steel, shipbuilding, motor vehicles, motorcycles and bicycles, other transport equipment, and, especially, electrical machinery (all values above 1.6). Japan now had the highest relative production share in total manufacturing and in two high-tech industries, nonelectrical machinery and electrical machinery, as well as other manufactures. Italy had the highest value in eight industries, the United Kingdom and Germany in three, the Netherlands, Finland, Belgium, and Australia in two, and Sweden, France, Denmark, Canada, Norway, and the United States in one.

I next investigated what has happened to the cross-country dispersion in relative production shares. The first three columns of table 14.3 show the coefficient of variation in country values of RELPSHR for each industry. If countries were becoming more alike in their patterns of production, then the coeffi-

5. I have defined RELPSHR as a country's share of the total output of a particular industry relative to its share of total GDP rather than relative to its share of total manufacturing output in order to reflect the fact that some countries, such as Germany and Japan, have specialized production in manufacturing relative to nonmanufacturing sectors. Countries with a large manufacturing sector will tend to have a large number of industries with values of RELPSHR exceeding one, and conversely. If I had used the share of total manufacturing output as the denominator in equation (2), then, by construction, if some values of RELPSHR for a country exceed one, others must be less than one (unless the country has exactly the same share of every product).

Table 14.2 **Relative Production Shares (RELPSHR) of Germany, Japan, and the United States and the OECD Country with the Highest Value, 1970 and 1993**[a]

	1970				1993			
Industry	GER	JPN	USA	Highest	GER	JPN	USA	Highest
Total manufacturing	1.48	1.01	.89	GER	1.22	1.27	.89	JPN
Low-tech industries								
Food	.93	1.56	.67	JPN	.84	1.16	.78	DNK
Beverages	2.15	1.51	.44	GER	1.62	.82	.61	UK
Tobacco	2.62	.18	1.12	GER	3.94	.24	.70	NET
Textiles	1.23	1.25	.63	ITA	.86	.68	.86	ITA
Wearing apparel	1.26	1.08	.81	ITA	.55	1.04	.97	ITA
Leather & products	1.47	1.15	.48	BEL	.86	1.12	.48	ITA
Footwear	1.30	.25	.74	ITA	.68	.27	.39	ITA
Wood products	.94	.81	1.08	SWE	.86	.59	1.23	SWE
Furniture & fixtures	1.84	1.21	.71	GER	1.31	.85	.82	ITA
Paper & products	.99	.80	1.06	FIN	.96	.88	1.09	FIN
Printing & publishing	.62	1.45	1.01	NOR	.53	1.15	.98	UK
Petroleum refineries	2.98	.47	.67	GER	2.30	.67	.60	FRA
Petroleum & coal products	2.37	.39	1.10	GER	1.66	.52	1.27	NET
Rubber products	1.68	.73	.94	GER	.94	1.12	.95	ITA
Plastic products nec	1.28	1.72	.74	AUS	1.31	1.31	.92	GER
Pottery, china, etc.	1.22	1.19	.26	ITA	.88	1.01	.28	ITA
Glass & products	1.11	1.65	.91	BEL	1.56	1.03	.75	BEL

(continued)

Table 14.2 (continued)

Industry	1970 GER	1970 JPN	1970 USA	1970 Highest	1993 GER	1993 JPN	1993 USA	1993 Highest
Nonmetal products nec	1.58	1.27	.65	DNK	1.50	1.22	.69	AUS
Iron & steel	1.67	1.28	1.00	GER	1.71	1.66	.72	GER
Nonferrous metals	1.25	1.28	1.01	NOR	1.65	1.41	.70	NOR
Metal products	1.63	.76	.85	ITA	1.69	1.02	.89	GER
Shipbuilding & repair	.54	1.26	.77	NOR	.72	1.73	.71	FIN
Other manufactures nes	.66	1.59	.87	UK	.40	2.46	.71	JPN
Medium-tech industries								
Industrial chemicals	2.07	.89	.84	BEL	1.49	.96	.88	BEL
Railroad equipment	.43	.48	.44	AUS	.54	.71	.49	AUS
Motor vehicles	1.83	1.38	.85	GER	1.82	1.64	.76	GER
Motorcycles & bicycles	.68	1.48	.35	ITA	.66	1.68	.30	ITA
Other transport equipment	1.15	2.07	.00	NET	1.03	2.20	.00	CAN
High-tech industries								
Other chemical products	1.57	.85	1.09	GER	1.19	1.13	1.03	GER
Nonelectrical machinery	1.74	.93	.86	GER	1.10	1.21	1.09	JPN
Electrical machinery	1.86	.19	1.11	GER	1.18	2.23	.74	JPN
Aircraft	.30	.11	1.66	USA	.40	.15	1.76	USA
Professional goods	2.29	.38	1.20	GER	1.35	.66	1.34	UK

[a]For additional details, see the notes to table 14.1. The relative production share of country h in industry i based on the 14 OECD countries is defined as $\text{RELPSHR}_i^h = [Y_i^h/\Sigma_h Y_i^h]/(\text{GDP}^h/\Sigma_h \text{GDP}^h)$.

Table 14.3 **Relative Dispersion of Indexes of Specialization across 14 OECD Countries for 33 Manufacturing Industries, 1970, 1979, and 1993[a]**

	Coefficient of Variation[b] of RELPSHR			Standard Deviation of LN(RELPSHR)[c]		
	1970	1979	1993	1970	1979	1993
Total manufacturing	.18	.18	.21	.16	.17	.22
Low-tech industries						
Food	.24	.24	.29	.26	.25	.29
Beverages	.37	.36	.39	.44	.43	.43
Tobacco	.81	.84	1.05	.76	.75	.86
Textiles	.55	.61	.93	.50	.48	.63
Wearing apparel	.31	.49	.65	.30	.56	.78
Leather & products	.74	.72	1.04	.64	.61	.70
Footwear	.77	1.16	1.50	.64	.77	.97
Wood products	.61	.59	.56	.68	.59	.54
Furniture & fixtures	.27	.34	.48	.27	.34	.43
Paper & products	.76	.77	.89	.61	.57	.64
Printing & publishing	.34	.28	.27	.34	.29	.28
Petroleum refineries	1.04	.99	.80	1.06	1.13	.81
Petroleum & coal products	.77	.78	.63	1.01	.95	.93
Rubber products	.44	.38	.41	.49	.48	.58
Plastic products nec	.67	.42	.31	.61	.39	.33
Pottery, china, etc.	.97	1.12	1.28	.79	.76	.85
Glass & products	.59	.59	.70	.48	.47	.56
Nonmetal products nec	.28	.25	.36	.29	.24	.38
Iron & steel	.51	.50	.44	.66	.63	.54
Nonferrous metals	.64	.62	.58	.76	.73	.69
Metal products	.42	.36	.36	.37	.32	.34
Shipbuilding & repair[d]	1.06	.90	.62	.95	.85	.62
Other manufactures nes	.67	.74	.83	.60	.68	.69
Medium-tech industries						
Industrial chemicals	.52	.62	.72	.50	.50	.49
Railroad equipment[d]	.86	.77	.67	1.15	1.10	.99
Motor vehicles[d]	.61	.69	.75	.86	.94	1.06
Motorcycles & bicycles[d]	.98	.98	1.22	1.30	1.28	1.23
Other transport equipment[d]	.90	.97	1.16	1.50	1.44	1.40
High-tech industries						
Other chemical products	.36	.33	.29	.35	.34	.34
Nonelectrical machinery	.41	.34	.31	.42	.35	.34
Electrical machinery	.41	.39	.70	.49	.35	.66
Aircraft[d]	.96	.86	.91	.98	.91	.89
Professional goods	1.01	.73	.68	.91	.79	.85

[a]For definitions of production shares (PRODSHR) and relative production shares (RELPSHR) and other technical details in the calculations, see the notes to tables 14.1 and 14.2.

[b]The coefficient of variation is defined as the ratio of the standard deviation to the (unweighted) mean.

[c]LN is the natural logarithm. If RELPSHR equals zero, LN(RELPSHR) is set to −3.75. For details, see the text.

[d]Calculations exclude Belgium.

cient of variation should decline over time. There is no noticeable trend in this direction. Between 1970 and 1993, dispersion in the low-tech group of industries increased in thirteen industries and decreased in ten; in the medium-tech group, it rose in four and fell in one; while, in the high-tech group, dispersion grew in only one and declined in four. By 1993, the industries with the highest dispersion (coefficients of variation exceeding 0.9) were tobacco products, textiles, leather products, footwear, pottery and china, motorcycles and bicycles, other transport equipment, and aircraft. Those with the smallest dispersion (coefficients of variation less than 0.4) were food, beverages, printing and publishing, plastics, nonmetal products, metal products, other chemical products, and nonelectrical machinery. Both sets of industries span the gamut between low- and high-tech enterprises.

It is also of interest that changes in the degree of specialization were more pronounced between 1979 and 1993 than between 1970 and 1979. In the earlier period, the coefficient of variation changed by more than 0.10 in only six industries, whereas, in the later period, this occurred in sixteen industries. This seems to accord with casual observation that much more industrial restructuring occurred during the 1980s than during the 1970s.

One unfortunate property of the RELPSHR measure is that it is both asymmetrical and highly skewed, with a range from zero to infinity. As a result, industry production shares greater than average receive greater weight in the computation of the coefficient of variation than those less than average (which range in value from 0.0 to 1.0). An alternative measure is the LN(RELPSHR), the natural logarithm of RELPSHR, which has a more normal distribution and gives equal weight to below- and above-average production shares. Moreover, since the mean of LN(RELPSHR) is close to zero, I have used the standard deviation of LN(RELPSHR) in table 14.3 rather than its coefficient of variation to measure cross-country dispersion.[6] Results are very similar for the two measures of dispersion. Over the period 1970–93, the standard deviation of LN(RELPSHR) increased in fifteen industries, declined in fifteen, and remained constant (a change of 0.01 or less) in three.

One reason why the degree of specialization among manufacturing industries may have changed relatively little is that countries are maintaining specializations in different industries. To examine this idea further, table 14.4 lists for each country in 1993 the industries with the highest and lowest RELPSHR indexes. Inspection of this table indicates that these countries' production is generally concentrated in different industries. In general, if the RELPSHR for industry i is high in one country, it is low somewhere else. But there is no algebraic constraint on two or three countries having similar RELPSHR values. In 1993, Australia's and Denmark's production relative to its GDP was most

6. One unfortunate property of the logarithmic measure is that production shares of zero are not defined. I have arbitrarily chosen a value of -3.75 for the LN(RELPSHR) measure in this case because the minimum value observed is -2.75. Experimentation with other values, from -4.0 to -6.0, yields very similar results on the standard deviation of LN(RELPSHR).

Table 14.4 **Specialization in Manufacturing Industries by Country, 1993**

	Highest RELPSHR	Lowest RELPSHR
Australia	Railroad equipment, 4.10	Motorcycles & bicycles, .0
	Nonmetal products nec, 1.88	Aircraft, .24
Belgium	Industrial chemicals, 3.98	Professional goods, .18
	Glass & glass products, 3.35	Petroleum & coal products, .20
Canada	Transport equipment nec, 6.97	Motorcycles & bicycles, .0
	Railroad equipment, 2.51	Professional goods, .0
Denmark	Railroad equipment, 3.02	Motor vehicles, .0
	Shipbuilding & repairing, 2.39	Aircraft, .0
		Transport equipment nec, .0
Finland	Paper & paper products, 4.81	Aircraft, .10
	Shipbuilding & repairing, 3.52	Motor vehicles, .16
France	Petroleum refineries, 3.15	Transport equipment nec, .0
	Motorcycles & bicycles, 1.78	Professional goods, .44
Germany	Tobacco products, 3.94	Aircraft, .40
	Petroleum refineries, 2.30	Printing & publishing, .53
Italy	Footwear, 6.84	Tobacco products, .41
	Pottery, china, etc., 6.07	Aircraft, .43
Japan	Electrical machinery, 2.23	Aircraft, .15
	Transport equipment nec, 2.20	Tobacco products, .24
Netherlands	Tobacco products, 4.09	Railroad equipment, .0
	Transport equipment nec, 3.51	Motor vehicles, .22
Norway	Shipbuilding & repairing, 2.96	Motorcycles & bicycles, .0
	Nonferrous metals, 2.65	Motor vehicles, .07
Sweden	Paper & paper products, 2.93	Wearing apparel, .14
	Transport equipment nec, 2.42	Footwear, .15
United Kingdom	Beverages, 1.98	Nonferrous metals, .46
	Tobacco products, 1.78	Motorcycles & bicycles, .47
United States	Aircraft, 1.76	Pottery, china, etc., .28
	Professional goods, 1.76	Motorcycles & bicycles, .30

heavily concentrated in railroad equipment, Belgium's in industrial chemicals, Canada's in transport equipment, Finland's and Sweden's in paper and paper products, France's in petroleum refineries, Germany's and the Netherlands's in tobacco products, Italy's in footwear, Japan's in electrical machinery, Norway's in shipbuilding, the United Kingdom's in beverages, and the United States's in aircraft.[7]

The absolute size of the RELPSHR values is also of interest; small differences in production patterns would be indicated by RELPSHR values that deviate little from one. In table 14.4, however, there are quite a few in the two to eight range, indicating very substantial specialization, especially for the smaller economies. The high degree of specialization for the relatively small economies suggests that economies of scale may be important, either in direct

7. The other side of the ledger tends to be dominated by the various transport equipment products, such as motor vehicles and aircraft, which are produced in only a limited number of countries.

production or, more likely, in development of the specific capabilities such as knowledge and skilled labor needed to produce particular manufactures.

It is also striking that most countries retain their specialization over time. Table 14.5 shows correlation coefficients of both RELPSHR and LN(RELPSHR) values by industry between 1970 and 1979 and between 1970 and 1992. The correlations are generally stronger for the latter measures because, as noted above, the logarithmic form gives equal weight to industries in which production is very high and those in which production is very low. With only a few exceptions, these correlations remain very high over time. Between 1970 and 1979, the correlation coefficients of the logarithmic measure are 0.88 or greater for all fourteen countries, and, between 1970 and 1993, they are 0.79 or higher for ten of the fourteen countries. The exceptions are Belgium, Japan, Sweden, and the United Kingdom (although, even among them, the correlations exceed 0.60).

Rank correlations are also shown. They are almost as strong for the period 1970–79 as the correlations of LN(RELPSHR), exceeding 0.85 for all fourteen countries. However, they are weaker for the period 1970–93, exceeding 0.70 for ten countries, in the range of 0.58–0.69 for the other four countries (Finland, Japan, Sweden, and the United Kingdom). These results again suggest greater industrial restructuring in the 1980s than in the 1970s.

Although countries tend to retain their industries of specialization over time,

Table 14.5 **Correlation over Time in Relative Production Share (RELPSHR) in Manufacturing Industries by Country, 1970–79 and 1970–93**[a]

	Relative Production Share (RELPSHR)		Log of Relative Production Share (LN[RELPSHR])		Rank Correlation Relative Production Share (RELPSHR)	
	1970–79	1970–93	1970–79	1970–93	1970–79	1970–93
Australia	.97	.83	.97	.85	.94	.73
Belgium[b]	.80	.67	.88	.75	.86	.73
Canada	.98	.94	.98	.93	.95	.85
Denmark	.99	.92	.99	.94	.97	.85
Finland	.98	.88	.95	.79	.89	.67
France	.97	.90	.99	.98	.87	.84
Germany	.96	.76	.96	.82	.95	.77
Italy	.96	.91	.96	.89	.96	.86
Japan	.84	.58	.88	.71	.86	.64
Netherlands	.94	.75	.95	.88	.90	.78
Norway	.98	.78	.96	.79	.93	.77
Sweden	.98	.75	.95	.64	.92	.58
United Kingdom	.92	.59	.92	.61	.92	.60
United States	.96	.86	.98	.95	.93	.70

[a]Correlations are based on 33 industries unless otherwise indicated.

[b]All industries except shipbuilding & repair, railroad equipment, motor vehicles, motorcycles & bicycles, other transport equipment, and aircraft.

Table 14.6 Correlation of the Logarithm of Relative Production Shares (RELPSHR) between the United States and Other Countries and the Sum of Squared Values of RELPSHR, 1970, 1979, and 1993[a]

	Correlation of LN(RELPSHR) with the United States			Sum of Squared Values of LN(RELPSHR)		
	1970	1979	1993	1970	1979	1993
Australia	−.10	−.05	−.02	31.9	28.0	31.2
Belgium[b]	−.29	−.22	−.16	22.5	14.3	20.6
Canada	−.25	−.31	−.27	42.9	39.5	41.8
Denmark	.15	.19	.28	64.3	60.9	59.3
Finland	−.21	−.12	.05	20.4	18.5	19.3
France	.36	.36	.36	33.5	33.1	32.7
Germany	.05	.09	.03	10.9	8.8	8.4
Italy	−.41	−.39	−.37	18.5	18.8	20.4
Japan	−.42	−.38	−.33	18.3	12.3	12.1
Netherlands	−.33	−.22	−.25	31.1	32.8	33.2
Norway	−.15	−.01	.09	49.7	55.4	58.7
Sweden	−.40	−.34	−.08	13.1	13.4	18.6
United Kingdom	−.31	−.24	−.07	5.0	4.8	4.6
United States	1.00	1.00	1.00	20.4	20.9	21.2
All countries				382.5	361.5	382.2

[a]Correlations and sum of squared values are based on 33 industries unless otherwise indicated.
[b]All industries except shipbuilding & repair, railroad equipment, motor vehicles, motorcycles & bicycles, other transport equipment, and aircraft.

it is still possible that the production structures of countries have become more alike over time. This is a difficult issue to test formally. In table 14.6, I have presented two ways of looking at the question. The first three columns show the correlation in LN(RELPSHR) between the United States and other countries, calculated across industries. The correlations were positive for only three of the thirteen countries in 1970, and only in one case (France) did the correlation exceed 0.20. However, in 1993, the correlations were positive for five countries and exceeded 0.20 for two (France and Denmark). Moreover, between 1970 and 1993, the correlation coefficients increased for all but three countries. The results do suggest that other countries have been growing more similar in their industrial structure to the United States over the period, although, even by 1993, most countries still had very different industries of specialization than the United States.

This measure is, unfortunately, problematic for two reasons. First, the U.S. production structure may itself be unusual, and changes in the correlation coefficient may therefore reflect mainly changes in the U.S. production structure over time. Second, there is a bias toward showing negative correlations because, if the value of RELPSHR is high for the United States, it must, of necessity, be low for other countries. An alternative measure, the sum of squared values of LN(RELPSHR), where the summation is performed across industries within country, is also shown in table 14.6. This measure has the virtue, at least, of comparing each country's industry production with the cross-country average production of that industry. Since the cross-country average value of LN(RELPSHR) is generally zero (the average value of RELPSHR is close to one), the sum of squared values is similar to a variance measure, showing how different a country's industry production is from the average of the fourteen countries.[8] If countries are becoming less specialized over time, then their production structure should be converging on the overall average of the countries, and this index should decline.

In 1970, Denmark was the most specialized country, according to this index, followed by Norway and Canada, and the United Kingdom the least specialized. It is noteworthy that these indexes remain relatively stable over time, with the exception of Japan (for whom the index declines from 18.3 in 1970 to 12.1 in 1993), Norway (increases from 49.7 to 58.7), and Sweden (increases from 13.1 to 18.6). The total sum of squares (summed across all countries) is almost identical in 1970 and 1993 (about 382 in both years), although it does fall somewhat between 1970 and 1979 and then rise in the second period.

The general stability in industries of specialization over time would lend support to the IIRS approach and tend to contradict HO-type models. The IIRS model stresses the advantages of initial leadership in an industry and the consequent cost reduction emanating from increased production volume. In contrast, the HO model would predict that specialization among the advanced countries would become less marked over time as their relative factor abundance converged. The coefficient of variation in the overall capital/labor ratio (computed from the OECD ISDB) among these fourteen countries fell from 0.28 in 1970 to 0.17 in 1992. Despite the growing similarity in relative factor abundance, these countries tended to maintain specialization in the same industries in 1993 as in 1970.

14.3 Labor Productivity Differences

I next turn to a comparison of industry labor productivity levels among the same fourteen countries. Here, there are more problems with missing data, particularly for the transport equipment subsectors (ISIC codes 3841–3849). Let us first define the labor productivity level, LP, of industry i in country h as

$$\mathrm{LP}_i^h = Y_i^h / L_i^h, \tag{3}$$

where L_i^h is total employment in industry i in country h. The (weighted) average labor productivity of industry i in the fourteen countries is given by

$$\overline{\mathrm{LP}}_i = \Sigma_h Y_i^h / \Sigma_h L_i^h .$$

8. This measure is also similar to a chi-square distribution. However, because the values of RELPSHR observed in different countries are not independent (if RELPSHR is high in one country, it must be low in others), the sum of squared values does not meet the formal requirements for a chi-square distribution.

In analogous fashion to RELPSHR, I also compute

$$\text{(4)} \qquad \mathrm{RELLP}_i^h = \mathrm{LP}_i^h / \overline{\mathrm{LP}}_i,$$

which show productivity in industry i of country h relative to the average productivity in industry i of the fourteen countries.

In 1970, U.S. labor productivity in total manufacturing was about 50 percent greater than that in Germany and more than double that in Japan (see table 14.7). U.S. productivity was above average in every industry except beverages and particularly high in tobacco, wood products, paper products, rubber products, iron and steel, industrial chemicals, transport equipment, other chemical products, electrical machinery, and professional goods. Germany's labor productivity was above average in twelve of the twenty-eight industries and exceptionally high in petroleum refineries and petroleum and coal products. Japanese labor productivity exceeded the international average in seven industries and was particularly strong only in beverages, wearing apparel, leather products, and glass products—all low-tech industries. The U.S. led all countries in terms of labor productivity in twelve of the twenty-eight industries (including three of the four high-tech ones), Germany in two, and Japan in only one (wearing apparel). Canada lead in four, Australia and Belgium in three, Italy in two, and the United Kingdom in one.

By 1993, Japan had surpassed Germany in labor productivity in total manufacturing, but U.S. productivity was still a third greater than Japan's and 50 percent greater than Germany's. German labor productivity remained high in petroleum refineries and petroleum and coal products; Japanese labor productivity was unusually strong in iron and steel, nonferrous metals, shipbuilding, miscellaneous manufactures, and other transport equipment and U.S. labor productivity in textiles, wood products, rubber products, metal products, other chemical products, nonelectrical machinery, and professional goods. Although the United States remained the overall leader in labor productivity in total manufacturing, its lead was cut to only eight of the thirty-three industries (excluding 384, transport equipment); these eight, however, included four of the five high-tech industries. Belgium led in eight industries, Italy in six, France in five, and Germany, Japan, Australia, Norway, and Finland in one.

It is also of note that there was very little correlation in industry labor productivity between Germany, Japan, and the United States. The correlation coefficients in industry RELLP for both 1970 and 1993 are negative in every case (the rank correlations are negative in all but one case). These results indicate that the three countries were strong in different industries not only in terms of relative production shares but also in terms of productivity performance.[9]

9. As in comparing production shares, there are statistical problems with using a correlation coefficient between RELLP values in two countries since the individual elements in each are not independent. In particular, if RELLP_i is above unity in one country for industry i, the value of RELLP_i must be less than one in at least one other country since the weighted sum of RELLP_i across countries must equal 1.0. However, there is no algebraic constraint on two countries having similar RELLP values across industries.

Table 14.7 **Relative Labor Productivity (RELLP) of Germany, Japan, and the United States and the OECD Leader, 1970 and 1993[a]**

	1970				1993			
Industry	GER	JPN	USA	Leader	GER	JPN	USA	Leader
Total manufacturing	.97	.63	1.47	USA	.84	.93	1.26	USA
Low-tech industries								
Food	.76	.93	1.15	CAN	.64	.74	1.33	ITA
Beverages	.77	1.42	.87	CAN	.64	.90	1.15	ITA
Tobacco	1.25	.28	2.00	USA	2.01	.45	1.06	NOR
Textiles	1.09	.53	1.46	USA	1.11	.39	1.44	ITA
Wearing apparel	.90	1.35	1.11	JPN	.81	.98	1.10	BEL
Leather & products	.83	1.26	1.00	BEL	.84	1.17	.99	BEL
Footwear	.86	.74	1.27	BEL	.89	.68	1.13	BEL
Wood products	.92	.34	1.86	USA	.85	.47	1.43	USA
Furniture & fixtures	1.22	1.10	1.04	AUS	.86	1.12	.98	BEL
Paper & products	.79	.61	1.54	USA	.76	.80	1.36	USA
Printing & publishing	.68	.94	1.32	USA	.80	.91	1.05	ITA
Petroleum refineries	2.18	.59	.76	GER	1.83	.86	.68	FRA
Petroleum & coal products	9.88	.25	1.28	GER	6.01	.47	1.09	GER
Rubber products	1.05	.52	1.56	CAN	.69	.73	1.46	BEL
Plastic products nec	.77	.76	1.34	AUS	.88	.82	1.18	FRA
Pottery, china, etc.	.59	.64	1.27	BEL	.62	.75	1.12	BEL
Glass & products	.58	1.46	1.47	USA	.87	1.06	1.21	BEL
Nonmetal products nec	1.18	.65	1.33	CAN	1.09	.74	1.16	FRA
Iron & steel	.71	1.11	1.69	USA	.73	1.23	1.35	USA
Nonferrous metals	.66	1.15	1.46	AUS	.73	1.25	.96	FRA
Metal products	.88	.49	1.48	ITA	.88	.78	1.45	USA
Shipbuilding & repair	...	...	...	...	.85	1.37	.92	FRA
Other manufactures nes	.78	.78	1.20	UK	.64	1.74	.83	UK

Medium-tech industries								
Industrial chemicals	1.10	.65	1.52	USA	.68	1.10	1.35	BEL
Transport equipment	1.07	.72	1.57	USA	.89	1.05	1.27	USA
Railroad equipment	...	...	...	...	.30	1.06	1.37	AUS
Motor vehicles	...	...	...	...	.98	1.15	1.00	ITA
Motorcycles & bicycles	...	...	...	...	.51	1.07	.94	ITA
Other transport equipment	...	...	...	...	1.14	2.67	NA	JPN
High-tech industries								
Other chemical products	.90	.75	1.53	USA	.64	1.14	1.43	USA
Nonelectrical machinery	1.04	.55	1.47	USA	.71	.92	1.52	USA
Electrical machinery	1.06	.10	1.84	USA	.73	1.16	1.13	FIN
Aircraft	...	...	...	...	.60	1.08	1.26	USA
Professional goods	1.10	.29	1.59	ITA	.74	.64	1.44	USA
Correlation with United States[b]	.10	−.54			−.22	−.36		
Correlation with Germany[b]		−.33				−.39		
Correlation with United States[c]					−.19	−.41		
Correlation with Germany[c]						−.40		
Rank correlation with United States[b]	.14	−.53			−.16	−.35		
Rank correlation with Germany[b]		−.62				−.46		

[a]Relative labor productivity of industry i in country h defined as

$$\text{RELLP}_i^h = \text{LP}_i^h/\overline{\text{LP}}_i,$$

where the calculation of $\overline{\text{LP}}_i$ is based on 14 OECD countries with pertinent data: Australia (AUS), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (GER), Italy (ITA), Japan (JPN), the Netherlands (NET), Norway (NOR), Sweden (SWE), the United Kingdom (UK), and the United States (USA). The exceptions are as follows: (1) DEN, NET: 1991 data used for 1992 in all industries except total manufacturing (1992 data used). (2) GER: 1991 data used for 1992 in chemicals (351–356). (3) SWE: 1991 data used for 1992 in industries 353 and 354. (4) Industries 3841–3849: (*a*) BEL: missing data for all years; (*b*) FRA, ITA: missing data for 1970; (*c*) AUS: 3842, 3845, 3849 missing data for 1970, 1979; (*d*) GER: 3842, 3843, 3844, 3849 missing data for 1970; (*e*) JPN: 3842, 3844, 3845, 3849 missing data for 1970, 1979; (*f*) UK: 3842, 3844, 3845, 3849 missing data for 1970 (*g*) USA: 3842, 3844, 3845 missing data for 1970; (*h*) DNK: 3841, 3842, 3844 missing data for 1990–92. (*i*) 1991 data used for 1992, except CAN, SWE, which use 1990 data. For other technical details on the sectoring, see the notes to tables 14.1 and 14.2.

[b]Includes 384; excludes 3841–49.

[c]Excludes 384, 3849; includes 3841–45.

Table 14.8 Dispersion of Relative Labor Productivity (RELLP) across 14 OECD Countries for 29 Manufacturing Industries, 1970, 1979, and 1993[a]

	Coefficient of Variation of RELLP			Standard Deviation of LN(RELLP)		
	1970	1979	1993	1970	1979	1993
Total manufacturing	.25	.21	.19	.24	.21	.20
Low-tech industries						
Food	.28	.26	.30	.30	.26	.31
Beverages	.29	.40	.41	.32	.42	.42
Tobacco	.74	.80	.74	.77	.83	.84
Textiles	.26	.23	.30	.27	.27	.35
Wearing apparel	.30	.24	.29	.31	.25	.31
Leather & products	.53	.38	.41	.47	.34	.42
Footwear	.39	.24	.20	.42	.23	.20
Wood products	.42	.31	.31	.51	.35	.33
Furniture & fixtures	.29	.21	.25	.31	.23	.25
Paper & products	.37	.27	.23	.33	.26	.23
Printing & publishing	.27	.24	.22	.27	.24	.23
Petroleum refineries	.73	.82	.62	.93	.98	.66
Petroleum & coal products	1.80	1.71	1.22	1.04	.94	.79
Rubber products	.42	.34	.43	.39	.32	.41
Plastic products nec	.67	.37	.17	.54	.33	.18
Pottery, china, etc.	.49	.36	.48	.44	.34	.40
Glass & products	.39	.32	.33	.40	.33	.33
Nonmetal products nec	.27	.29	.27	.27	.28	.28
Iron & steel	.48	.48	.25	.45	.45	.25
Nonferrous metals	.46	.46	.37	.45	.51	.38
Metal products	.38	.30	.26	.36	.29	.24
Other manufactures nes	.54	.54	.76	.51	.56	.75
Medium-tech industries						
Industrial chemicals	.27	.32	.35	.26	.31	.36
Motor vehicles	.31	.36	.37	.31	.35	.38
Transport equip excluding vehicles[b]	.42	.29	.36	.36	.26	.34
High-tech industries						
Other chemical products	.35	.39	.32	.34	.39	.30
Nonelectrical machinery	.28	.22	.31	.28	.21	.31
Electrical machinery	.40	.31	.33	.68	.31	.38
Professional goods	.49	.37	.32	.58	.41	.30

[a]For definition of RELLP and other technical details in the calculations, see the notes to table 14.7.
[b]Includes ISIC codes 3841, 3842, 3844, 3845, 3849.

Table 14.8 shows the cross-country coefficient of variation in industry RELLP by industry. Considerable convergence had already been achieved in the overall level of labor productivity in total manufacturing among the fourteen countries by 1970. The coefficient of variation for 1970 is 0.25, compared to 0.36 in 1963 (see Dollar and Wolff 1993, 52). There was still some additional convergence after that, with the coefficient of variation declining to 0.21 in 1979 and 0.19 in 1992.

On the individual industry level, the time patterns are quite different. Between 1970 and 1979, the coefficient of variation declined in nineteen of the twenty-nine industries, increased in seven, and remained constant in the other four, while, from 1979 to 1992, the index declined in thirteen industries, rose in fifteen, and stayed the same in one. Convergence in labor productivity on the industry level was thus much spottier than for total manufacturing over the period 1970–93.[10]

Another striking finding is that the actual value of the coefficient of variation is substantially higher in every industry (except one in each year) than the corresponding value for total manufacturing. For over half the industries, the index is more than 50 percent greater than that for total manufacturing. These results clearly support the argument that convergence in overall labor productivity in manufacturing has been achieved to a large extent through countries' specializing in different industries in terms of both production shares and productivity levels. This has been especially the case in the 1980s.

Correlations over time in industry relative labor productivity levels are shown by country in table 14.9. They are quite high for the period 1970–79, exceeding 0.70 in all fourteen countries, 0.79 on twelve countries, 0.88 in five. Rank correlations are quite similar. In contrast, the correlations are much weaker for the period 1979–92, exceeding 0.60 in only seven countries. In the case of Canada, Denmark, and the Netherlands, the coefficients fell below 0.30 and are not statistically significant. The rank correlations are even weaker for this period, exceeding 0.60 in only one case.

These results indicate that high performance in terms of productivity can erode over time and that poor performance can likewise improve. It is also of note that correlations are much weaker for relative industry productivity performance than for industry production shares, particularly for the period 1979–92. This suggests that there may be other factors, such as resource endowments and specialized skills, that contribute to competitive advantage and industry specialization but are not captured in standard productivity measures and that these factors may remain more stable over time than labor productivity.

Another important difference between relative productivity performance and production share is that, whereas countries have generally retained their industries of specialization in terms of production over the period 1970–93, they have become less differentiated in terms of labor productivity. Evidence for this is given in the last three columns of table 14.9, where I have computed the sum of squared values of industry values of LN(RELLP) for each country. If countries are becoming more similar to the overall (weighted) average in terms of labor productivity, then this index should decline. It is of note that all countries show a decline in the value of this measure between 1970 and 1992,

10. Results are very similar on the basis of the standard deviation of the natural logarithm of RELLP, also shown in table 14.8. This is partly due to the fact that the distribution of RELLP, unlike that of RELPSHR, is not highly skewed but quite symmetrical, with over 90 percent of the values in the range 0.5–1.5.

Table 14.9 **Correlation over Time in Industry Relative Productivity Levels (RELLP) by Country and Sum of Squared Values, 1970–93[a]**

	Correlation over Time in LN(RELLP)		Rank Correlation over Time in RELLP		Sum of Squared Values of LN(RELLP)		
	1970–79	1970–93	1970–79	1970–93	1970	1979	1993
Australia	.84	.45	.83	.33	6.0	3.9	5.4
Belgium	.87	.75	.78	.59	26.0	15.3	15.8
Canada[b]	.70	.12	.79	.19	3.7	1.9	1.9
Denmark	.79	.24	.64	.08	14.1	9.6	12.8
Finland	.79	.54	.73	.47	7.4	7.8	3.2
France[c]	.80	.77	.85	.79	1.9	2.2	2.5
Germany	.96	.88	.86	.51	7.5	7.4	6.2
Italy	.89	.67	.84	.54	7.8	7.1	5.1
Japan	.72	.44	.83	.60	15.3	7.2	4.0
Netherlands	.81	.04	.79	.12	3.1	2.4	2.2
Norway	.81	.39	.88	.23	6.7	12.4	8.6
Sweden	.90	.77	.84	.56	5.8	7.3	12.3
United Kingdom	.94	.68	.91	.59	7.9	9.0	4.6
United States	.88	.61	.87	.56	4.0	2.3	1.8
Total					117.3	95.8	86.4

[a]Correlations are based on the 28 3-digit ISIC industries (including 384, transport equipment), unless otherwise indicated.

[b]Excludes ISIC 385 (professional goods).

[c]Excludes ISIC 354 (petroleum & coal products).

with the exception of France, Norway, and Sweden. Declines are particularly marked for Belgium, Finland, and Japan (from 15.3 to 4.0). The total sum of squared values (summed across all countries) also shows a pronounced decrease, from 117.3 in 1970 to 95.8 in 1979 and 86.4 in 1992.

14.4 Changes in Relative Production Share and Productivity Growth

On the surface, at least, there appears to be very little correlation between RELPSHR and RELLP. The United States, for example, led in terms of labor productivity in a dozen or so industries but had the highest relative production share in only one, aircraft (see tables 14.2 and 14.7 above). The reason is that the larger economies tend to be more diversified than the smaller ones and that they are therefore not as likely to have as many high values of RELPSHR. As a result, the high labor productivity of the U.S. and Japanese manufacturing industries does not necessarily translate into large relative production shares. In fact, the simple correlation coefficient between RELPSHR and RELLP across all industries and countries is only 0.33 for 1970, 0.35 for 1979, and 0.40 for 1992. However, there may still be a close relation between changes in relative productivity levels and changes in relative production shares.

The linkage between changes in production share and productivity growth at the industry level is not an easy question to formalize. The reason is that the productivity growth of a particular industry in a particular country should be considered relative to the same industry in other countries and to other industries within the same country. In other words, rapid productivity growth may have no effect on relative production share if it is occurring in the same industry in every country. At the same time, rapid productivity growth in every industry of one country will also have little effect on relative production share since it would not enhance the competitiveness of any industry relative to other industries in the economy.

I now turn to regression analysis to provide a formal analysis of these relations. Two estimating forms are used. The first is

$$\text{DRELPSHR}_i^h = b_0 + b_1 \cdot \text{DRELLP}_i^h + b_2 \cdot \text{DRELWAGE}_i^h + b_3 \cdot \text{RELKFL}_i^h + \varepsilon_i^h. \tag{5}$$

DRELPSHR is the change in the natural logarithm of RELPSHR (relative production share) in industry i and country h, and DRELLP is the change in the natural logarithm of RELLP (relative labor productivity) in industry i and country h. $\text{DRELWAGE}_i^h = \Delta[\ln(w_i^h/\overline{w}_i)]$, where w_i^h is the average wage (in current U.S. dollars) in industry i and country h, and $\overline{w}_i$ is the (weighted) average wage in industry i among the fourteen countries. The conversion to U.S. dollars is based on the actual market exchange rate.

The variable $\text{RELKFL}_i^h = \ln(kfl_i^h/\overline{kfl}_i)$, where kfl_i^h is the ratio of average capital formation (kf) in 1985 U.S. dollars to average employment (l) over the period in industry i and country h, and $\overline{kfl}_i$ is the ratio of the (weighted) average capital formation in industry i among the fourteen countries to the (weighted) average employment in industry i among the fourteen countries.[11] The term ε_i^h is a stochastic error term, which is assumed to be independently but may not be identically distributed. The regressions reported in tables 14.10 and 14.11 below were estimated using the White procedure for a heteroskedasticity-consistent covariance matrix.

The logarithmic form is used for the dependent variable RELPSHR because, as noted above, the variable is highly skewed, with a range from zero to infinity, while the logarithm is more normally distributed. The rationale for using first differences for RELPSHR is that industry specialization may be highly dependent on historical developments in a country as well as its resource base. The levels equation can thus be interpreted as a fixed-effect model, and first differencing allows us to remove the unobservables from the equation.

Another rationale for using the first-difference form is that relative productivity growth is likely to be measured with greater accuracy than relative productivity levels. The reason is that comparing productivity levels across coun-

11. I used the capital formation deflator computed from the OECD ISDB to convert capital formation in local currency to 1985 U.S. dollars.

tries is sensitive to the choice of price deflators and PPP exchange rates. If there are biases in the productivity-level estimates, there is a good chance that these biases are relatively stable over time and that relative productivity growth rates may therefore be measured with less error than relative productivity levels.

The coefficient b_1 is predicted to have a positive sign. The coefficient b_2 is predicted to have a negative sign since relatively higher labor costs in a country, measured on the basis of the market exchange rate, should reduce that country's competitiveness in that industry and hence its production share. The coefficient of RELKFL is predicted to have a positive sign. The rationale is that new technology may be embodied in new capital investment and that greater capital formation relative to employment should therefore be associated with more modern technology in an industry and thus with lower costs and greater competitiveness.

The second form is

$$\text{DRELPSHR}_i^h = b_0 + b_1 \cdot \text{DRELLPC}_i^h + b_2 \cdot \text{DRELWAGC}_i^h + b_3 \cdot \text{RELKFLC}_i^h + \varepsilon_i^h. \tag{6}$$

$\text{DRELLPC}_i^h = \text{DRELLP}_i^h - \Delta[\ln(\overline{\text{LP}}^h/\overline{\text{LP}})]$, where $\overline{\text{LP}}^h$ is the average labor productivity in country h (the ratio of GDP to total employment), and $\overline{\text{LP}}$ is the weighted average labor productivity of the fourteen countries (the ratio of total GDP to total employment in the fourteen countries). DRELLPC_i^h thus shows how an industry's productivity performance in a given country relative to the average productivity performance of that industry compares to the country's overall productivity performance relative to the overall average productivity performance of the fourteen countries. The variables DRELWAGC_i^h and RELKFLC_i^h are defined in like fashion: $\text{DRELWAGC}_i^h = \text{DRELWAGE}_i^h - \Delta[\ln(\overline{w}^h/\overline{w})]$, and $\text{RELKFLC}_i^h = \text{RELKFL}_i^h - \ln(\overline{kfl}^h/\overline{kfl})$. The second form is the preferred specification since it accords more closely with the underlying theory. The predictions for the coefficients b_1, b_2, and b_3 are the same as for the first specification.

It should also be noted that there are econometric difficulties with the specifications in equations (5) and (6). By construction, there may be introduced a correlation between RELPSHR and RELLP since, in both cases, the numerator is the industry's production share. Therefore, any errors in measurement in industry output will bias the coefficient estimates. Moreover, the two variables are likely to be procyclic, which will cause the same problem to arise. As a result, it would be desirable to use instrumental variables to perform the actual estimation, although, at the moment, no suitable instrument appears to be available.

Regressions are run separately for the periods 1970–79 and 1979–93. Besides the full set of industries, regressions are run separately on low-, medium-, and high-tech industries. Moreover, equation (5) is run with one variation, which is to substitute KFL, the ratio of average capital formation to average employment over the period, for RELKFL. Results for equation (5) are shown in table 14.10 and those for equation (6) in table 14.11.

The results show a very strong relation between the log change in relative production share (DRELPSHR) and the log change in labor productivity relative to the industry average (DRELLP). The coefficients are all positive and significant at the 1 percent level except among medium-tech industries in the period 1970–79. Likewise, the results in table 14.11 show an equally strong relation between DRELPSHR and the log change in labor productivity relative to both the industry and the country average (DRELLPC). These coefficients are all positive and significant at the 1 percent level except among high-tech industries in the period 1970–79.

The coefficient values can be interpreted as elasticities. Among all industries, a 1 percent increase in an industry's labor productivity relative to the international industry average is associated with about a 0.65 percent gain in the industry's market share. A 1 percent increase in the industry's labor productivity relative to both the international industry average and the country average is associated with a 0.25 percent gain in the industry's market share in 1970–79 and a 0.41 percent gain in 1979–93.

Wage changes relative to the international industry average (DRELWAGE) had a negative coefficient in every case. For the period 1970–79, DRELWAGE is significant at the 1 percent level among all industries and among the low-tech group but not statistically significant among medium- and high-tech industries. For the period 1979–92, the coefficient is significant in only one case—at the 5 percent level among low-tech industries. In contrast, the coefficient estimates for DRELWAGC, wage growth relative to both the industry and the country averages, are significant in only one case—at the 5 percent level among medium-tech industries in the period 1979–93. These results suggest that relative labor costs played a strong role in determining a country's relative production share only among low-tech industries during the 1970s. The effect was very weak during the period 1979–93. Moreover, it also appears that industries in a given country tend to lose market share if their wages are growing faster relative to the international industry average, not the country average, than the same industry in other countries.

Average investment per worker has a uniformly positive effect on relative production share. The results are generally significant among all industries and among low-tech industries as a group but less significant among medium-tech industries and not significant at all among high-tech industries. RELKFL, average capital formation per worker, relative to the industry average, is statistically significant, at the 5 percent level, only for low-tech industries in the period 1970–79 and medium-tech industries in the period 1979–92. KFL, the ratio of capital formation to employment, is significant at the 1 percent level among low-tech industries in both periods and at the 5 percent level among medium-tech industries in the first of the two periods. RELKFLC, the ratio of

Table 14.10 **Regressions of the Change in RELPSHR on the Growth in Labor Productivity, Wages, and Capital Formation Relative to the Industry Average**[a]

Constant	DRELLP	DRELWAGE	RELKFL	KFL	R^2	Adj. R^2	Standard Error	Industry Sample	Sample Size
				A. 1970–79					
.003	.666**	−.177**	.049*		.425	.421	.209	All	377
(.27)	(9.73)	(4.13)	(2.24)						
−.031*	.678**	−.161**		5.43**	.439	.435	.207	All	377
(2.25)	(17.0)	(4.66)		(3.71)					
.003	.748**	−.255**	.055*		.475	.470	.189	Lo tech	293
(.25)	(12.6)	(6.75)	(2.43)						
−.035*	.774**	−.241**		6.25**	.502	.496	.185	Lo tech	293
(2.57)	(16.8)	(6.64)		(4.57)					
−.059	.193	−.144	.014		.111	.007	.278	Med. tech	28
(.93)	(1.06)	(.98)	(.15)						
−.198*	.224	−.194		17.61*	.257	.164	.254	Med. tech	28
(2.52)	(1.46)	(1.22)		(2.17)					
.086**	.745**	−.105	.035		.621	.599	.213	Hi tech	56
(2.91)	(7.34)	(1.26)	(.56)						
.092	.738**	−.008		56.73	.620	.598	.213	Hi tech	56
(1.28)	(8.84)	(.85)		(.21)					

B. 1979–93

−.021	.672**	−.033	.044		.454	.450	.254	All	404
(.45)	(11.5)	(.59)	(1.60)						
−.079**	.636**	−.027		9.24**	.501	.498	.243	All	404
(5.45)	(17.5)	(.59)		(6.49)					
−.045**	.773**	−.129	.037		.468	.463	.255	Lo tech	299
(3.12)	(10.2)	(1.90)	(1.90)						
−.101**	.726**	−.122*		9.10**	.527	.522	.240	Lo tech	299
(6.13)	(15.5)	(2.09)		(6.25)					
.038	.388**	−.052	.153*		.424	.384	.226	Med. tech	47
(1.19)	(4.10)	(.48)	(2.09)						
−.107	.329**	−.013		13.66	.385	.342	.233	Med. tech	47
(1.71)	(4.10)	(.12)		(1.91)					
.019	.945**	−.176	−.004		.687	.670	.203	Hi tech	58
(.66)	(10.7)	(1.36)	(.09)						
.009	.940**	−.179		27.55	.688	.671	.203	Hi tech	58
(.17)	(10.2)	(1.28)		(.25)					

[a]The dependent variable is DRELPSHR. The absolute values of *t*-ratios are shown in parentheses below the coefficient estimate. The estimation uses the White procedure for a heteroskedasticity-consistent covariance matrix. DRELPSHR$_i^h$: change in the logarithm of RELPSHR (relative production share) of industry *i* in country *h*. DRELLP$_i^h$: change in the logarithm of the ratio of LP (labor productivity) of industry *i* in country *h* to the 14-nation average LP in industry *i*. DRELWAGE$_i^h$: change in the logarithm of the ratio of wages of industry *i* in country *h* to the 14-nation average wages in industry *i*. KFL$_i^h$: the logarithm of the ratio of capital formation to employment of industry *i* in country *h* (index). RELKFL$_i^h$: KFL$_i^h$ minus the logarithm of the ratio of the 14-nation average of capital formation to employment in industry *i*.

*Significant at the 5 percent level (2-tailed test).

**Significant at the 1 percent level (2-tailed test).

Table 14.11 **Regressions of the Change in RELPSHR on the Growth in Labor Productivity, Wages, and Capital Formation Relative to Industry and Country Averages**[a]

Constant	DRELLPC	DRELWAGC	RELKFLC	R^2	Adj. R^2	Standard Error	Industry Sample	Sample Size
				A. 1970–79				
−.458**	.247**	−.065	.102**	.180	.173	.250	All	377
(7.24)	(7.20)	(.67)	(3.78)					
−.482**	.252**	−.186	.111**	.191	.183	.235	Lo tech	293
(7.29)	(7.38)	(1.89)	(4.07)					
−.427**	.242**	.339	.076	.277	.187	.251	Med. tech	28
(2.91)	(3.17)	(1.06)	(1.11)					
−.420	.275	.249	.079	.198	.152	.310	Hi tech	56
(1.85)	(1.97)	(.76)	(.54)					
				B. 1979–93				
.758**	.408**	.006	.108**	.301	.295	.288	All	404
(11.0)	(10.5)	(.08)	(3.56)					
−.845**	.453**	.073	.102**	.298	.291	.293	Lo tech	299
(8.78)	(8.41)	(.68)	(2.64)					
−.448**	.263**	−.182*	.170*	.517	.483	.207	Med. tech	47
(3.59)	(4.31)	(2.02)	(2.23)					
−.796**	.438**	−.225	.134	.291	.252	.306	Hi tech	58
(5.20)	(4.64)	(1.06)	(1.85)					

[a]The dependent variable is DRELPSHR. The absolute values of t-ratios are shown in parentheses below the coefficient estimate. The estimation uses the White procedure for a heteroskedasticity-consistent covariance matrix. DRELPSHR$_i^h$: change in the logarithm of RELPSHR (relative production share) of industry i in country h. DRELLPC$_i^h$: DRELLP$_i^h$ relative to the log change of overall labor productivity (LP) in country h minus the log change of the 14-nation average LP. DRELWAGC$_i^h$: DRELWAGE$_i^h$ relative to the log change of overall average wages in country h minus the log change of the 14-nation average wages. RELKFLC$_i^h$: RELKFL$_i^h$ relative to the logarithm of the ratio of total capital formation to total employment in country h minus the logarithm of the 14-nation ratio of total capital formation to total employment.

*Significant at the 5 percent level (2-tailed test).

**Significant at the 1 percent level (2-tailed test).

capital formation to employment, relative to both the industry and the country averages, is significant at the 1 percent level among low-tech industries in both periods and at the 5 percent level among medium-tech industries in the later period.

For both equations (5) and (6), the goodness of fit, as measured by the adjusted R^2 statistic and the standard error of the regression, is almost uniformly superior (with the exception of one case) for the period 1979–93 than for the period 1970–79. Moreover, the coefficient estimates for DRELLP and DRELLPC are also uniformly higher (again with the exception of one case) for the later period than for the earlier one. Differences in results between the two periods are particularly marked for the medium-tech industries. These results suggest that competitive advantage has become more dependent on relative productivity performance over time.

There are also important differences among the three industry groups. Capital formation clearly plays a much more important role in explaining market share for low-tech industries than the other two groups and a somewhat more significant role for medium- than high-tech industries. These results suggest that low-tech industries, which, by definition, engage in relatively little R&D, acquire much of their new technology through capital investment, whereas medium-tech industries acquire some new technology through this venue and high-tech industries, who invest intensively in R&D, acquire very little.

For equation (5), at least, the goodness of fit is markedly superior for high-tech industries than for the other two groups. Moreover, the coefficient estimate of DRELLP has the highest value for the high-tech group, suggesting that relative productivity performance plays the most important role in determining international competitiveness in this group of industries, which includes computers, televisions, and communication equipment. The estimated coefficient of DRELLP is also more than twice as great for the low-tech industries than the medium-tech ones. This suggests that, in the latter group, which includes automobiles and other transport equipment, "quality" differences, which are not captured in standard productivity measures, may matter a great deal in determining international competitiveness.

It is also of note that, in equation (5), changes in relative wages (DRELWAGE) are significant only among the low-tech industries for the period 1970–79. In these industries, which include apparel, textiles, metal products, and basic chemicals, relative labor costs and price competition played an important role in determining market share in this period, whereas, in the other two technology groups, superior productivity performance and technology played the crucial role. Moreover, in the 1980s, by which time the intercountry variation in wages had become quite small, relative labor costs were no longer a significant influence on relative production shares.

It is also notable that, although equation (6) is the theoretically preferred specification, the goodness of fit is greater for equation (5), with the exception of medium-tech industries. These results appear to indicate that competitiveness depends more on how an industry in a given country is performing relative to the same industry in other countries rather than to other industries in the same country. This result is consistent with the models developed by Gomory (1992) and Gomory and Baumol (1992), which show that industry output shares of a given country depend on absolute productivity and technology advantage rather than comparative productivity and technology performance (i.e., relative to other industries in the same country).

14.5 Summary and Concluding Remarks

Three principal findings emerge from this study. First, despite the continued convergence of overall productivity and capital intensity in manufacturing (the coefficient of variation fell from 0.25 in 1970 to 0.19 in 1992 for labor productivity and from 0.28 to 0.17 for the capital/labor ratio), the major industrialized countries in the world tended to specialize manufacturing production in very different industries, and most countries retained their specialization over the period 1970–93. This was particular so for the three largest economies—Germany, Japan, and the United States. On net, there was no tendency over this period toward greater similarity in industries of specialization, as measured by relative production shares, among the fourteen countries. These results appear to be more supportive of an IIRS type of model than one based on the HO theorem.

Second, these countries also tended to be strong in different industries in terms of labor productivity performance. However, whereas countries have generally retained their industries of specialization in terms of relative production share over the period 1970–93, correlations over time in relative industry labor productivity performance within country are considerably weaker than those for relative production shares. These results suggest that high performance in terms of labor productivity can erode over time and that poor performance can change for the better. They also suggest that there are other factors, such as resource endowments, specialized skills, and history, that contribute to industry specialization and remain more stable over time than labor productivity.

Third, despite the apparent differences in the stability of production shares and that of relative productivity performance over time, the regression results strongly support the central thesis of the paper that there is a positive and significant relation between changes in relative industry market shares and the industry's relative productivity growth. The results are generally stronger for the period 1979–93 than for the period 1970–79, suggesting that market share is becoming more dependent on relative productivity performance and technology levels over time. The estimated elasticity of relative market share with respect to relative labor productivity is somewhat higher for high-tech industries than for low-tech ones and markedly greater for these two groups than for medium-tech industries. The results suggest that unmeasured quality differences in this latter group, which includes automobiles and other transport equipment (except aircraft), may play a crucial role in determining international competitiveness.

The results on capital formation per worker are consistent with the embodiment hypothesis—namely, that new technology is embodied in new machinery and equipment. Gains in market share appear to depend directly on the new technology embodied in recent investment. Capital formation clearly plays a much more important role in explaining market share for low-tech industries than medium-tech industries and more for the latter than the high-tech group. This result is consistent with the argument that the latest vintage of technology embodied in new capital investment is a major vehicle for productivity gain in low-tech industries, whereas medium-tech industries also rely on their own R&D investments and high-tech ones rely almost exclusively on R&D for new technology.

The results also show that relatively higher labor costs in a country (measured relative to the international industry average) generally reduce that country's competitiveness in that industry and hence its production share but that this effect is very significant only among low-tech industries in the period 1970–79. In these industries, which include apparel, textiles, and basic metal products, it appears that relative labor costs and price competition played an important role along with relative productivity gains in determining market share in the 1970s, whereas, for medium- and high-tech industries and for low-tech industries in the later period, superior productivity performance and technology played the crucial role. These results are consistent with those reported in Dollar and Wolff (1993), who found that, among OECD countries, differences in labor costs were not important determinants of differences in unit costs by the 1980s.

The fact that changes in specialization are generally significantly related to productivity changes does support the view that productivity growth encapsulates the expansion of industry-specific productive factors that contribute, at least to some degree, to competitive advantage. Moreover, this analysis redirects attention to the determinants of high levels of productivity. To the extent that it reflects technology-related assets owned by the firm or embodied in technical labor, investment in research and development and the training of skilled labor is clearly an important ingredient in promoting rapid productivity growth.

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