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9 Empirical Tests of Alternative Models of International Growth

Laurence J. Kotlikoff and Edward E. Leamer

9.1 Introduction

Recent changes in patterns of international trade and growth have rekindled interest in the relationships among trade, growth, and the international distribution of income. Three alternative models can serve as a theoretical foundation for an empirical analysis of these relationships. The first is the standard Heckscher-Ohlin-Samuelson (HO) trade model with equal numbers of factors and goods and incomplete specialization. The second model allows complete specialization and more goods than factors. The third model posits short-run capital immobility. Each of these models has quite different implications for the determination of wage levels and growth rates.

The traditional even ($n \times$ n) HO model with incomplete specialization predicts instantaneous factor price equalization and equivalent growth rates of wages across countries. In contrast, altering the standard HO model to permit specialization of production potentially eliminates factor price equalization and allows growth rates of wages to differ, both in the short and in the long run. The third model, which assumes short-run costs to adjusting capital intensity, predicts short-run differences in the levels and growth rates of factor returns but long-run equalization of these variables.

Because these three models can have very different policy consequences, it is important to make an attempt to determine which is the most accurate approximation of the real world. Unfortunately, many observations can be rationalized within the context of any one of these

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models, and it is therefore difficult to determine which is the most accurate. Take, for example, the data reported in table 9.1 that show vast international differences in wages. If the even HO model is taken as the maintained hypothesis, then these data must be regarded to be wages averaged across skill groups. Wages within a given skill group are regarded to be the same in every country, and a country that has a relatively low reported wage is interpreted only to have a relatively

Table 9.1 Ratio of Foreign to U.S. Annual Earnings per Worker

	1958	1959	1960	1975	1976	1977	1978	1979
Western Europe								
Austria	—	—	—	0.63	0.59	0.65	0.74	0.78
Denmark	—	—	—	1.01	1.00	1.02	1.12	1.19
Finland	0.30	0.30	0.31	0.63	0.63	0.61	0.61	0.67
Ireland	0.03	0.03	0.03	0.10	0.13	0.15	—	—
Italy	—	—	—	0.51	0.45	0.49	0.54	0.61
Spain	—	—	—	0.46	0.46	0.49	—	—
Sweden	—	—	—	0.95	0.93	0.89	0.90	0.95
United Kingdom	—	—	—	0.51	0.44	0.45	0.51	0.61
West Germany	—	—	—	0.87	0.87	0.93	1.34	1.16
Pacific								
Australia		0.33	0.35	0.48	0.55	0.63	0.58	0.64
New Zealand	0.34	0.22	0.23	0.44	0.54	—	—	—
	0.22							
Asian								
Japan	0.13	0.14	—	0.54	0.61	0.19	0.87	0.87
Korea	—	—	—	0.08	0.10	0.12	0.16	0.19
South America								
Brazil	0.12	0.13	—	—	0.19	0.20	—	—
Chile	—	—	—	0.14	0.17	0.20	0.21	—
Colombia	0.13	0.13	0.14	0.11	0.11	0.17	0.20	0.16
Dominican Republic	0.09	0.09	0.09	0.13	0.14	0.12	0.12	0.12
Ecuador	—	—	0.15	0.16	0.17	0.17	—	—
El Salvador	—	—	—	0.13	0.14	0.13	—	—
Southeast Asia								
Hong Kong	—	—	—	—	0.19	0.19	0.22	—
Indonesia	—	—	—	0.04	0.04	0.05	0.05	—
Philippines	—	—	—	0.07	0.06	0.07	—	—
Singapore	—	—	—	0.23	0.21	0.21	0.22	0.24
Mideast								
Afghanistan	—	—	—	0.04	0.04	0.03	0.03	0.03
India	—	0.06	0.06	0.06	0.05	0.05	0.05	—
Israel	0.37	0.38	0.39	0.39	0.42	0.40	0.35	0.41
Jordan	—	—	—	0.13	0.14	0.14	0.18	0.23
Syria	—	—	—	0.07	0.06	0.08	—	—
Turkey	0.29	0.32	0.23	0.25	0.25	0.32	0.33	0.37

Sources: United Nations, *Yearbook of Industrial Statistics* (New York), various annual issues; and International Monetary Fund, *International Financial Statistics* (Washington, D.C.), various annual issues.

large supply of low-skilled workers. As a matter of fact, Krueger (1968) shows that a surprisingly large amount of the differences in gross wage rates can be accounted for by a bit of disaggregation.

On the other hand, if the uneven HO model is taken as a guide, the wage differences in table 9.1 are suggestive of countries with factor endowment vectors sufficiently different that they fall in different cones of specialization; in this case the increasing similarity of wages over time is regarded either as evidence of increasing similarity of factor endowments or as evidence of the blurring of the differences among the specialization cones associated, for example, with product price changes. These wage data can also be rationalized within the context of the third model—the even HO model with adjustment costs. Here the differences in wages are attributed to differences in initial conditions; and the tendency of wages to equalize over time is thought to be a consequence of increased domestic factor mobility over time.

Although the wage data can be rationalized within the framework of any one of these models, each model has very different implications concerning policies to raise wages in low-wage countries. In the even HO model the route to increased wages is increased training or, more generally, increased human capital. Physical capital deepening can have no effect on wages of a specific skill group, because the accumulation of physical capital leads only to an adjustment of the output mix and no change in capital per man within a given industry. For the uneven model, on the other hand, accumulation of physical capital can move a country from one cone of specialization to another and can raise wages paid to each of the skill groups. Policies to promote wage increases implied by the third model (the even model with adjustment costs) aim at reducing the effective adjustment costs, including policies that alter the path of net foreign investment.

The paper proceeds in the next three sections by briefly describing each of the models, pointing out in the process their different testable implications. Section 9.4 describes the data used to test the three models. Section 9.5 presents regressions of value added, factor demands, and factor returns on country-specific as well as industry-specific inputs. These regressions permit more formal tests of the three models. The final section summarizes the findings and suggests additional areas of research.

The conclusions that we draw from this research are rather mixed. Each of the models performs well on certain criteria and poorly on others. While the standard HO model clearly fails to satisfy certain cross-equation constraints, national endowments are remarkedly good predictors of the locus of international production. There are, however, significant nonlinearities in the relationship between factor allocations and national endowments. Such nonlinearities are predicted by the uneven version of the HO model. At odds with both of these models is our finding that lagged values of inputs provide an important explanation of current factor demands. Such correlations are suggested by the adjustment cost model.

The inability to clearly discriminate among the three models leaves open the issue of long- as well as short-run wage equalization. The partial support for each of the models offered here suggests that an un–even HO model with adjustment costs provides a better basis for discussing international trade than any of the three models on their own.

9.2 The Even Heckscher-Ohlin-Samuelson General Equilibrium Model

The traditional general equilibrium theory of production describes a country with a fixed endowment of a set of resources, facing commodity prices that are completely determined in international markets. Competition for scarce resources determines their allocation among industries and their rates of remuneration. The notation which we will use to describe this model is the following:

X = vector of outputs of m commodities,
V = vector of endowments of n resources,
p = vector of prices of m commodities,
w = vector of factor rents of n resources,
A = $n \times n$ matrix of factor input coefficients with elements equal to the amount of factor k used to produce one unit of commodity j.

The factor input matrix, the vector of outputs, and the vector of endowments necessarily satisfy the relationship

$$AX = V. \quad (1)$$

With a suitable list of assumptions, including identical linear homogeneous production functions for all countries, equal numbers of commodities and resources, and incomplete specialization, it can be shown that the matrix A is the same for all countries and, in particular, is independent of V. Under these conditions equation (1) may be inverted to obtain

$$X = A^{-1}V, \quad (2)$$

which expresses outputs as linear functions of the endowments, with X and V varying among countries but A^{-1} constant.

Equation (2), which maps factor endowments into commodities produced, also implicitly allocates the factors among the industries. The amount of factor k used to produce X_j of commodity j is $A_{kj}X_j$, where

A_{kj} is the (k, j) element of the input-output matrix. Thus, the allocation of factor k to a particular industry is proportional to output and can be described by an equation which is linear in the factor endowments V. This equation can be estimated by regressing factor allocation data on factor endowment data. To clarify this regression model, consider the system for the simple case of two factors, labor (L) and capital (K):

(3a) $$X_{ij} = a^{Lj} L_i + a^{Kj} K_i,$$

(3b) $$L_{ij} = A_{L_j} X_{ij} = A_{Lj} a^{Lj} L_i + A_{Lj} a^{Kj} K_i,$$

(3c) $$K_{ij} = A_{Kj} X_{ij} = A_{Kj} a^{Lj} L_i + A_{Kj} a^{Kj} K_i,$$

where a^{Lj} and a^{Kj} are elements of A^{-1} and i denotes the country. Because of the constancy across countries of output per man, X_{ij}/L_{ij}, and capital per man, K_{ij}/L_{ij}, in industry j, these three equations are proportional to each other. Linearity and proportionality are two strong implications of the even HO model. In addition, the assumption of costless interindustry factor mobility rules out any influence of past history. However, higher-order functions of national endowments, lagged values of national endowments, and lagged values of factor allocations do influence current factor allocations in the uneven HO model and the adjustment cost model in ways described below.

The factor demand system, equation (3), can be transformed into a factor expenditure system by multiplying each factor demand by its rental rate. Multiplying the L_{ij} equation by the wage, w, and the K_{ij} equation by the rental rate, r, on capital gives

(4a) $$E_{ij} = wL_{ij} = wA_{Lj} a^{Lj} L_i + wA_{Lj} a^{Kj} K_i,$$

(4b) $$R_{ij} = rK_{ij} = r A_{Kj} a^{Lj} L_i + r A_{K_j} a^{Kj} K_i,$$

where E_{ij} is the labor earnings in country i and industry j, and R_{ij} is the corresponding payment for capital services. Summing equations (4a) and (4b) yields the following expression for value added in country i, industry $j(V_{ij})$:

(5) $$V_{ij} = (wA_{Lj} + rA_{Kj}) a^{Lj} L_i + (wA_{Lj} + rA_{Kj}) a^{Kj} K_i.$$

Equations (4) and (5) indicate that factor payments as well as value added are each linear functions of national endowments. In addition, equations (3), (4), and (5) are proportional to each other.

Estimation of the factor payments and value-added relations may be less subject to bias from measurement error than estimation of factor demands. Consider, for example, labor effort, which is ideally measured as total effective hours worked but in our data is proxied by total employment. Assume that effective hours worked, L_{ij}, and employment, $\hat{L}_{ij}$, differ by a country-specific factor λ_i; i.e., $L_{ij} = \lambda_i \hat{L}_{ij}$, and $L_i = \lambda_i L_i$. The term λ_i may reflect cross-country differences in hours worked per employee, the intensity of work effort, or the effectiveness of work effort due to training and ability. It is likely that $\hat{L}_{ij}$ and λ_i are positively correlated, because larger countries, with several notable exceptions, have higher per capita income; the workers in these countries are typically better educated and better trained. If this description of the relationship between effective hours and employment is correct, the use of $\hat{L}_{ij}$ rather than L_{ij} will introduce complex biases in estimating equations (3). These biases will contaminate tests of the cross-equation restrictions in equations (3), although the estimated R^2 of the $\hat{L}_{ij}$ regression are likely to remain high if the R^2 from the unbiased L_{ij} regressions are also large.

The earnings equation (eq. [4a]) may be less sensitive to this bias. In principle, measured E_{ij} equals true E_{ij}, since factor payments to labor are for effective hours worked rather than payments for simply coming to work. In addition, wL_i in equation (4a) can be replaced by E_i, total national labor earnings, thus eliminating the problem of mismeasuring total national labor input. A straightforward test of the constant proportionality properties of this model that do not involve measurement of the labor input is to determine whether the ratios E_{ij}/K_i, E_{ij}/R_{ij}, and E_{ij}/V_{ij} are roughly constant across all countries i. This is equivalent to asking whether profit rates and factor shares are equal across industry.

9.3 The Uneven Heckscher-Ohlin General Equilibrium Model

The simplest uneven model has many goods and two factors. A possible equilibrium of such a model has countries with sufficiently different factor supplies producing different subsets of the commodities and having different factor returns. Roughly speaking, the relatively capital-abundant countries produce the relatively capital-intensive commodities and have the higher wage rates and the lower returns to capital. This is illustrated in figure 9.1, where the first panel contains the unit value isoquants and expansion paths of three commodities: automobiles, textiles, and clothing. The second panel illustrates the levels of factor returns as a function of capital per man, and the third panel contains the corresponding outputs per man.

In the first panel, there are two unit isocost lines, each of which is consistent with the production of two of the three commodities. The hypothetical endowments of three countries are also indicated in this figure. The United States, which is capital abundant, has high wage rates and produces the two capital-intensive products—autos and textiles. Japan, which is less well-endowed in capitol relative to labor has lower wage rates and produces the two less capital-intensive products—

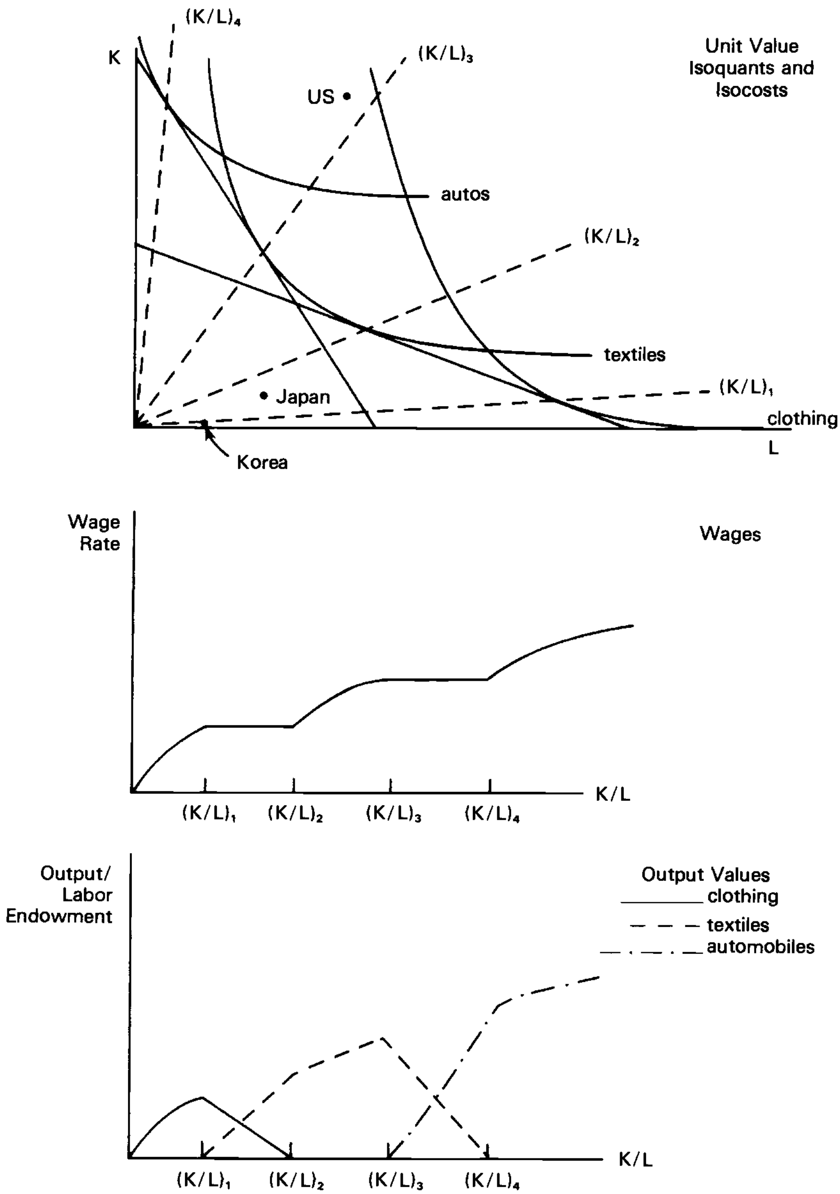

Fig. 9.1 The 3 × 2 Heckscher-Ohlin-Samuelson model

textiles and clothing. Korea, which is still less well endowed in capital, specializes in the least capital-intensive product (clothing) and has the very lowest wages. Note that although both the United States and Japan are producing textiles, the United States uses the more capital-intensive technique.

This figure provides a stylized picture of the situation in the 1950s and early 1960s. Figure 9.2 then represents the current situation and differs from figure 9.1 in two ways. First, both Japan and Korea have accumulated capital at a more rapid rate than the United States. Japan has moved into the same cone as the United States. Korea has moved into the cone where both textiles and clothing are produced. The other change that is evident in figure 9.2 is that the spread in wages between the two cones of diversification is less than in figure 9.1. What accounts for this change are the shifts in the world supply curves induced by the rapid accumulation of capital in Japan and Korea and the consequent change in the relative prices of the three goods. In figure 9.2 it is assumed that the relative supply of textiles increased and that of clothing decreased, and consequently, the price of textiles fell, and the price of clothing rose. This change is depicted in figure 9.2 by a shift outward of the textile unit value isoquant and a shift inward of the

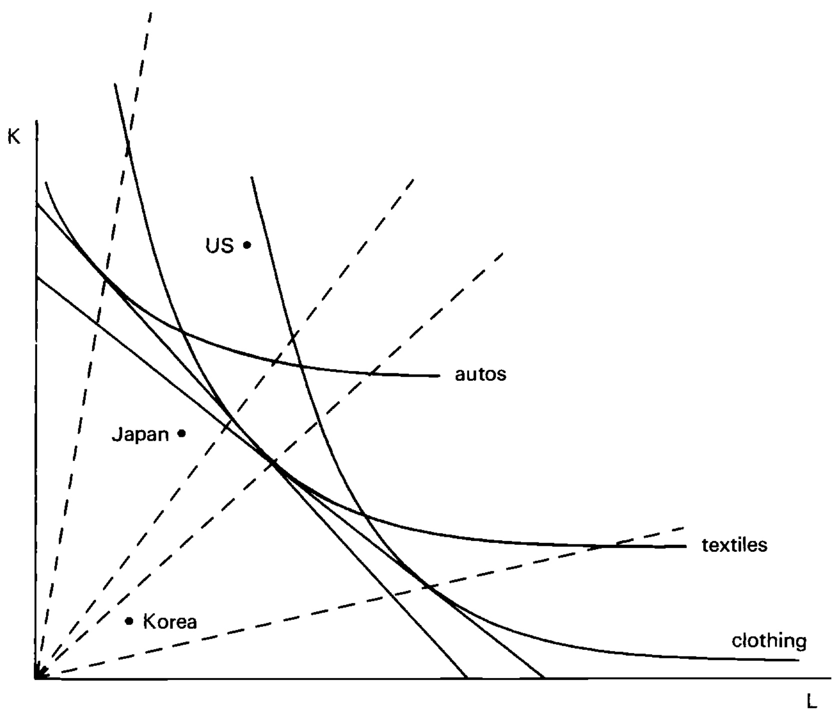

Fig. 9.2 Unit value isoquants and isocosts after product price changes

clothing unit value isoquant. This shift is accompanied by (1) a reduction in the wage in the United States, (2) a shift toward more labor-intensive techniques in the United States and a reduction in labor productivity, (3) an increase in the Korean wage rate, and (4) a shift toward more capital-intensive techniques in Korea and an attendant increase in labor productivity.

Worldwide accumulation of capital has generally the same effect in the even and the uneven model. Namely, supply curves of the relatively capital-intensive commodities shift outward, and as is indicated by the Rybczynski theorem, supply curves of the labor-intensive commodities shift inward. This will lead to a fall in the relative price of capital-intensive products and a general rise in wage rates. In the uneven model, however, wage rates of the most capital-abundant countries will fall if the supply curves of the most capital-intensive products shift outward less than the next most capital-intensive products. In terms of our stylized diagrams, this occurs if the supply of textiles increases more rapidly than the supply of automobiles.

Evidence in support of the uneven model would be wage, employment, or output data that conformed in a general sense to the second two panels of figure 9.1. Namely, wages depend on national endowments, and industry output and employment are nonlinear functions of the national endowments. Since the output and employment functions are linear within cones of diversification, a theoretically appealing data analysis would estimate linear models based on different subsets of the countries, possibly selected on the basis of similarity in factor returns.

A word of caution is in order here about aggregation effects. First it may appear that wage rates increase with capital abundance only because earnings include a return to human capital which naturally increases along with physical capital. On the other hand, the output and employment function may exhibit no clear nonlinearities because commodities with very dissimilar factor requirements are combined in a single aggregate. The textiles aggregate, for example, includes both capital- and labor-intensive products. Countries that are capital scarce produce the labor-intensive textiles, and countries that are capital abundant produce the capital-intensive textiles. As a result, there is relatively little variation in output of textiles overall associated with capital accumulation.

9.4 A Generalized Heckscher-Ohlin Model of Economic Growth with Adjustment Costs

The key feature that differentiates the adjustment cost model described here from the standard Heckscher-Ohlin model of international trade is the assumption that firms incur costs for altering their level of capital in any finite period of time. The adjustment cost technology we consider expresses adjustment costs as an increasing function of the rate of investment (or disinvestment). Since the rate of investment depends on both the absolute level of the firm's (industry's) existing capital stock and the absolute level of new investment, a firm's investment decision today will affect its capital stock tomorrow and, therefore, its marginal adjustment costs tomorrow. This formulation of the problem links the production and investment decisions of the firm at one point in time to these decisions at other points in time. Rather than equate the marginal product of capital to a common rental rate, as in the standard static trade model, firms in this environment alter their capital stocks over time to maximize the present value of profits where profits are net of adjustment costs. The relative immobility of physical capital does not preclude perfect national and international mobility of financial capital. In addition, the standard trade theory assumption of costless, domestic, interindustry labor mobility is maintained.

The assumption that altering levels of industry-specific capital is costly in the short run has several important implications. First, wage rates will differ across countries in the short run despite the facts that countries have identical technologies and are incompletely specialized in production and that financial capital is internationally mobile. The world relative price of the two commodities is not sufficient here to determine wage rates. In the short run, marginal revenue products of labor are equated across domestic industries, but marginal revenue products of capital are not. It is the satisfaction of both of these sets of conditions plus the assumption of identical constant returns to scale technologies that leads to factor price equalization. However, both conditions are satisfied in the long run when the economy has converged to a steady state characterized by incomplete specialization. Hence, if the economy converges to such a steady state, wage rates across different countries must converge as well.

A second feature of this model is that positive investment may take place even in those industries exhibiting low marginal revenue products of capital. The reason is simply that concentrating substantial levels of new investment in any given industry or set of industries within any year entails increasing adjustment costs; this will prove unprofitable relative to investing in low marginal revenue product, but low marginal adjustment cost, industries.

Even if disinvestment occurs, the rate of disinvestment will be slow, again because of the assumption of increasing costs to that activity. A consequence of this is that specialization in production will occur gradually if at all.

The supply relationships of this model are derived by noting that firms maximize the present value of profits. In country i, industry j, profits π_{ij} are given by

(6) $$\pi_{ij} = \int_0^\infty [P_{jt}F(K_{ijt}, L_{ijt}) - w_{it}L_{ijt} - I_{ijt}] \exp(-\int_0^t r_s ds)\, dt j = 1, 2.$$

In equation (6) P_{jt} is the period t price of output j, K_{ijt} and L_{ijt} are country i, industry j, year t capital and labor demands, r_s is the interest rate prevailing in period s, and $w_{it}L_{ijt}$ equals payments to labor in year t. The quantity I_{ijt} equals country i, industry j's total investment in year t inclusive of adjustment costs. Letting J_{ijt} stand for the actual installation of new units of capital, we parameterize the investment relationship in equation (7):

(7) $$I_{ijt} = J_{ijt} + \frac{\gamma}{2}\left(\frac{J_{ijt}}{K_{ijt}}\right) J_{ijt}.$$

The second term on the right-hand side of equation (7) reflects the costs of varying the level of industry's capital stock and exhibits increasing marginal costs to such activity. Ignoring depreciation, the industry increases its net capital stock according to formula (8):

(8) $$\dot{K}_{ijt} = J_{ijt}.$$

Maximization of equation (6) subject to equations (7) and (8) leads to the following first-order conditions:

(9) $$\frac{J_{ijt}}{K_{ijt}} = \frac{q_{ijt} - 1}{\gamma},$$

(10) $$P_{jt}\, F_{Lijt} = w_{it},$$

(11) $$P_{jt}\, F_{Kijt} = r_t q_{ijt} + \dot{q}_{ijt},$$

where q_{ijt} is the market value of capital relative to its replacement cost in country i, industry j, in year t.

In the steady state, $\dot{q}_{ijt} = 0$, $q_{ijt} = 1$, and

(12) $$P_{jt}\, F_{Kijt} = r.$$

In the steady state, equations (10) and (12) provide the standard HO relationship between marginal revenue products and factor prices. These relations hold for $j = 1, 2$, and suffice to determine factor returns, given constant returns to scale in production and output prices. Hence, assuming identical technologies in the foreign country, factor price equalization is satisfied in the long run.

In the short run, equations (10) and (11) together determine wage rates given the time path of q_{ijt}, the world interest rate, r_t, and the output prices P_{it}. Since the q_{ijt}'s differ, in the short run, across countries, short-run wage rates will also differ across countries.

According to equation (10) labor demand in the adjustment cost model depends on the fixed amount of capital in place at a point in time as well as the country's wage rate. In contrast to the HO model, the amount of capital in the rest of the economy should have no influence on labor demand. Hence, one test that can potentially discriminate between these models is to determine whether the economy's total capital endowment as opposed to the amount of capital in place in particular industries influences industry-specific labor demand. The economy's wage is another variable, whose inclusion in industry-specific labor demand regression is predicted by the HO model with adjustment costs but not by the non–adjustment cost model.

9.5 Data Descriptions

Data on number of workers, earnings, value of output, and investment expenditures for twenty-eight three-digit ISIC industries are compiled by the United Nations and published in the *Growth of World Industry*. The coverage of years and countries is very haphazard. The end years, 1963 and 1978, and the twenty-eight countries listed in the notes to table 9.2 were selected to assure a complete matrix of data. Even for this relatively short list of countries there are very substantial problems caused by the fact that various countries intermittently choose to aggregate two or more of the commodity classes together. In such cases, we split the reported number among the components in proportion to the size of the components in adjacent years. The capital stocks in 1978 were estimated from investment flow data beginning in 1963 using the perpetual inventory method (e.g., Leamer 1984). Missing intermediate investment data were imputed with straight-line interpolation methods. As a consequence of these imputation schemes, we are not altogether comfortable with the econometric analysis that follows, since it inappropriately ignores the possibility of gross or chronic measurement errors in the data.

Features of our data set are reported in tables 9.2–9.5. The first four columns of table 9.2 contain the total number of workers in each of the industries in each of the years and the share of these industries' workers in the total world work force included in our data. Over this period of time there was a 15% increase in employment in these industries, but the composition of world employment across industries did not change much. The one major exception to this statement is that employment in textiles dropped substantially, both as a share of

Table 9.2 **Labor Allocation Data** (in thousands)

	World Totals				Shares of World Totals					
			Shares		U.S.		Developed		Other	
ISIC	1963	1978	1963	1978	1963	1978	1963	1978	1963	1978
311 Food	5,372	6,261	.094	.094	.27	.21	.47	.42	.26	.36
313 Beverages	878	870	.015	.013	.22	.22	.58	.5	.19	.28
314 Tobacco	461	661	.008	.010	.16	.09	.37	.2	.46	.71
321 Textiles	6,512	5,918	.114	.089	.16	.18	.47	.31	.37	.51
322 Apparel	2,776	3,252	.048	.049	.41	.35	.51	.38	.08	.26
323 Leather	388	380	.007	.006	.23	.23	.53	.38	.23	.4
324 Footwear	668	640	.012	.010	.33	.24	.5	.33	.16	.43
331 Wood	1,983	2,077	.035	.031	.26	.26	.6	.51	.14	.23
332 Furniture	993	1,333	.017	.020	.31	.33	.49	.41	.19	.26
341 Paper	1,859	1,972	.032	.030	.31	.32	.57	.49	.11	.18
342 Printing	2,505	2,942	.044	.044	.36	.39	.5	.45	.13	.15
351 Ind. chem.	1,585	1,771	.028	.027	.27	.27	.56	.49	.16	.24
352 Other chem.	1,564	1,815	.027	.027	.29	.25	.51	.47	.19	.27
353 Petro. refin.	254	268	.004	.004	.46	.38	.37	.39	.17	.23
354 Petro., coal prod.	123	155	.002	.002	.28	.3	.53	.36	.2	.34
355 Rubber prod.	891	1,003	.016	.015	.28	.26	.54	.43	.18	.31
356 Plastics	642	1,521	.011	.023	.26	.32	.61	.5	.13	.18
361 Pottery	450	419	.008	.006	.09	.1	.59	.48	.32	.42

(continued)

Table 9.2 (continued)

ISIC	World Totals 1963	World Totals 1978	Shares 1963	Shares 1978	U.S. 1963	U.S. 1978	Developed 1963	Developed 1978	Other 1963	Other 1978
362 Glass	577	641	.010	.010	.25	.29	.49	.38	.26	.33
369 Nonmetal prod.	1,640	1,960	.029	.029	.23	.21	.53	.43	.24	.35
371 Iron and steel	3,266	3,213	.057	.048	.24	.25	.58	.5	.17	.25
372 Nonferrous metals	831	935	.014	.014	.3	.31	.58	.51	.12	.18
381 Metal prod.	3,925	4,750	.068	.071	.31	.31	.56	.5	.13	.19
382 Machinery	5,380	6,926	.094	.104	.3	.34	.61	.52	.09	.15
383 Electrical mach.	4,813	6,124	.084	.092	.3	.31	.62	.53	.07	.16
384 Transport equip.	5,140	6,328	.090	.095	.3	.32	.54	.51	.16	.17
385 Professional goods	946	1,409	.016	.021	.38	.42	.54	.43	.08	.15
390 Other	945	1,136	.016	.017	.38	.38	.53	.41	.08	.21
Total	57,367	66,680			.25	.29	.54	.46	.18	.25

Note: Developed countries are Australia, Canada, Denmark, Finland, Germany, Israel, Japan, Netherlands, Norway, Sweden, and the United Kingdom. Other countries are Brazil, Chile, Colombia, Cyprus, Ecuador, Greece, India, Ireland, Korea, Malta, Panama, Philippines, Portugal, Singapore, Spain, and Turkey. The "World" refers to these twenty-seven countries plus the United States.

Table 9.3 **Labor Earnings Data** (in thousands of dollars)

	World Totals				Shares of World Totals					
			Shares		U.S.		Developed		Other	
ISIC	1963	1978	1963	1978	1963	1978	1963	1978	1963	1978
311 Food	11,972	46,258	.077	.070	.62	.37	.32	.55	.05	.08
313 Beverages	2,302	9,163	.015	.014	.51	.24	.43	.57	.06	.1
314 Tobacco	736	3,276	.005	.005	.45	.24	.44	.57	.11	.18
321 Textiles	8,916	30,795	.057	.047	.45	.34	.42	.5	.12	.16
322 Apparel	5,805	18,297	.037	.028	.67	.46	.31	.45	.02	.09
323 Leather	785	2,369	.005	.004	.51	.33	.42	.51	.07	.16
324 Footwear	1,470	3,621	.009	.005	.55	.32	.39	.47	.06	.2
331 Wood	4,012	17,752	.026	.027	.53	.35	.43	.6	.03	.05
332 Furniture	2,292	10,679	.015	.016	.59	.42	.35	.49	.05	.09
341 Paper	5,831	22,394	.037	.034	.6	.44	.37	.51	.03	.05
342 Printing	8,387	33,659	.054	.051	.66	.46	.32	.5	.03	.04
351 Ind. chem.	5,255	24,099	.034	.036	.57	.36	.39	.57	.04	.07
352 Other chem.	5,335	19,798	.034	.030	.64	.37	.32	.55	.04	.08
353 Petro. refin.	1,284	4,643	.008	.007	.72	.48	.24	.43	.04	.09
354 Petro., coal prod.	367	1,625	.002	.002	.57	.47	.37	.44	.06	.09
355 Rubber prod.	2,520	9,700	.016	.015	.61	.39	.52	.05	.09	
356 Plastics	1,439	14,430	.009	.022	.58	.39	.55	.03	.06	
361 Pottery	630	2,747	.004	.004	.33	.17	.56	.64	.1	.19

(*continued*)

Table 9.3 (continued)

	World Totals				Shares of World Totals					
			Shares		U.S.		Developed		Other	
ISIC	1963	1978	1963	1978	1963	1978	1963	1978	1963	1978
362 Glass	1,487	6,377	.010	.010	.57	.43	.37	.48	.06	.1
369 Nonmetal prod.	3,990	17,224	.026	.026	.54	.34	.41	.56	.06	.1
371 Iron and steel	10,074	39,731	.065	.060	.56	.4	.4	.54	.04	.06
372 Nonferrous metals	3,284	11,610	.021	.018	.5	.42	.48	.53	.02	.06
381 Metal prod.	11,933	50,260	.077	.076	.61	.41	.35	.53	.03	.06
382 Machinery	17,355	84,638	.111	.128	.6	.44	.38	.52	.02	.04
383 Electrical mach.	14,596	66,770	.094	.101	.62	.39	.36	.56	.02	.05
384 Transport equip.	18,231	83,787	.117	.127	.63	.45	.34	.5	.03	.05
385 Professional goods	3,169	15,610	.020	.024	.71	.54	.27	.42	.02	.04
390 Other	2,336	9,207	.015	.014	.71	.49	.27	.45	.02	.06
Total	1.6e5	6.6e5			.60	.41	.36	.52	.04	.07

Note: Developed countries are Australia, Canada, Denmark, Finland, Germany, Israel, Japan, Netherlands, Norway, Sweden, and the United Kingdom. Other countries are Brazil, Chile, Colombia, Cyprus, Ecuador, Greece, India, Ireland, Korea, Malta, Panama, Philippines, Portugal, Singapore, Spain, and Turkey. The "World" refers to these twenty-seven countries plus the United States.

Table 9.4 **Value of Output** (in billions of dollars)

ISIC	World Totals 1963	World Totals 1978	Shares 1963	Shares 1978	U.S. 1963	U.S. 1978	Developed 1963	Developed 1978	Other 1963	Other 1978
311 Food	111.6	493.8	.145	.127	.56	.39	.34	.47	.10	.13
313 Beverages	15.44	79.83	.020	.021	.40	.30	.52	.60	.09	.11
314 Tobacco	13.02	41.71	.017	.011	.34	.23	.55	.59	.11	.17
321 Textiles	47.33	167.5	.061	.043	.39	.31	.45	.46	.16	.23
322 Apparel	23.33	76.85	.030	.020	.63	.45	.33	.42	.04	.13
323 Leather	3.756	13.79	.005	.004	.40	.26	.46	.48	.14	.25
324 Footwear	5.129	15.22	.007	.004	.51	.30	.41	.46	.08	.24
331 Wood	17.78	97.44	.023	.025	.46	.36	.48	.57	.05	.07
332 Furniture	8.099	44.17	.010	.011	.57	.39	.36	.50	.07	.11
341 Paper	30.45	133.9	.039	.035	.54	.43	.42	.50	.04	.08
342 Printing	25.92	123.8	.034	.032	.62	.45	.34	.49	.04	.05
351 Ind. chem.	34.57	207.9	.045	.054	.54	.38	.40	.50	.06	.12
352 Other chem.	28.79	125.1	.037	.032	.57	.42	.36	.46	.07	.12
353 Petro. refin.	26.09	221.0	.034	.057	.63	.44	.31	.43	.05	.13
354 Petro., coal prod.	3.36	21.68	.004	.006	.45	.33	.47	.49	.08	.18
355 Rubber prod.	11.12	45.33	.014	.012	.54	.37	.36	.47	.11	.16
356 Plastics	6.391	74.91	.008	.019	.50	.36	.48	.56	.05	.08
361 Pottery	1.715	8.123	.002	.002	.29	.17	.59	.61	.12	.22

(*continued*)

Table 9.4 (continued)

ISIC	World Totals 1963	World Totals 1978	Shares 1963	Shares 1978	U.S. 1963	U.S. 1978	Developed 1963	Developed 1978	Other 1963	Other 1978
362 Glass	5.276	26.20	.007	.007	.54	.41	.38	.47	.08	.12
369 Nonmetal prod.	17.41	93.62	.023	.024	.52	.32	.41	.55	.07	.14
371 Iron and steel	48.01	230.0	.062	.059	.47	.33	.46	.54	.06	.13
372 Nonferrous steel	19.32	93.01	.025	.024	.52	.41	.43	.49	.05	.10
381 Metal prod.	46.49	225.9	.060	.058	.58	.41	.38	.51	.04	.09
382 Machinery	60.65	354.2	.079	.091	.57	.43	.40	.51	.02	.06
383 Electrical mach.	53.41	294.8	.069	.076	.55	.36	.42	.57	.04	.08
384 Transport equip.	86.77	458.0	.112	.118	.61	.45	.34	.49	.04	.07
385 Professional goods	10.26	62.28	.013	.016	.69	.55	.28	.41	.03	.04
390 Other	10.05	43.03	.013	.011	.59	.46	.39	.48	.03	.06
Total	771.5	3,873.			.54	.40	.39	.50	.06	.10

Note: Developed countries are Australia, Canada, Denmark, Finland, Germany, Israel, Japan, Netherlands, Norway, Sweden, and the United Kingdom. Other countries are Brazil, Chile, Colombia, Cyprus, Ecuador, Greece, India, Ireland, Korea, Malta, Panama, Philippines, Portugal, Singapore, Spain, and Turkey. The "World" refers to these twenty-seven countries plus the United States.

Table 9.5 Value of Capital, 1978

	World		Shares			Capital-Labor Ratios			
ISIC	Total[a]	Share	U.S.	Dev.	Oth.	World	U.S.	Dev.	Oth.
311 Food	66,019	.076	.33	.50	.17	10.54	16.57	12.52	4.98
313 Beverages	21,661	.025	.28	.58	.13	24.90	31.69	28.88	11.56
314 Tobacco	10,310	.012	.12	.82	.06	15.60	20.80	6.95	1.32
321 Textiles	37,292	.043	.29	.42	.29	6.30	10.15	8.54	3.58
322 Apparel	7,280	.088	.35	.43	.22	2.24	2.24	2.53	3.24
323 Leather	1,540	.002	.24	.43	.32	4.05	4.23	4.59	1.52
324 Footwear	1,490	.002	.26	.46	.28	2.33	2.52	3.25	4.90
331 Wood	19,496	.023	.38	.50	.12	9.39	13.72	9.22	2.41
332 Furniture	6,959	.008	.34	.54	.12	5.22	5.38	6.86	9.68
341 Paper	49,099	.057	.41	.51	.07	24.90	31.90	25.86	4.37
342 Printing	24,129	.028	.47	.45	.08	8.20	9.88	8.24	22.08
351 Ind. chem.	97,149	.112	.37	.52	.10	54.86	75.17	58.44	6.18
352 Other chem.	25,220	.029	.37	.50	.12	13.90	20.57	14.84	60.25
353 Petro. refin.	33,763	.039	.43	.46	.11	125.98	142.56	148.59	15.62
354 Petro., coal prod.	6,381	.007	.17	.71	.13	41.17	23.33	81.19	5.42
355 Rubber prod.	11,859	.014	.37	.48	.14	11.82		13.20	5.42
356 Plastics	17,577	.020	.40	.48	.12	11.56	16.83	11.09	7.90
361 Pottery	2,802	.003	.12	.56	.31	6.69	14.48	7.80	4.97
362 Glass	9,875	.011	.37	.51	.12	15.41	8.16	20.68	5.70
369 Nonmetal	40,344	.047	.23	.63	.14	20.58	19.66	30.16	8.23
prod.							22.54		

(continued)

Table 9.5 (continued)

	World		Shares			Capital-Labor Ratios			
ISIC	Total[a]	Share	U.S.	Dev.	Oth.	World	U.S.	Dev.	Oth.
371 Iron and	83,022	.096	.27	.63	.10	25.84		32.56	9.82
steel							27.91		
372 Nonferrous	24,023	.028	.34	.54	.13	25.69		27.20	17.84
metals							28.18		
381 Metal prod.	39,886	.046	.40	.50	.10	8.40		8.38	4.46
382 Machinery	71,347	.083	.40	.51	.09	10.30	10.86	10.10	6.18
383 Electrical	56,765	.083	.36	.54	.10	9.26	12.00	9.44	5.62
mach.							10.73		
384 Transport	80,913	.094	.36	.55	.09	12.79		13.79	6.84
equip.							14.34		
385 Professional	11,847	.014	.53	.36	.12	8.41		6.96	6.50
goods	6,763	.008	.45	.42	.13	5.95	10.53	6.05	3.63
390 Other							7.10		
Total			.35	.53	.12	12.97	15.89	14.99	5.98

Note: Developed countries are Australia, Canada, Denmark, Finland, Germany, Israel, Japan, Netherlands, Norway, Sweden, and the United Kingdom. Other countries are Brazil, Chile, Colombia, Cyprus, Ecuador, Greece, India, Ireland, Korea, Malta, Panama, Philippines, Portugal, Singapore, Spain, and Turkey. The "World" refers to these twenty-seven countries plus the United States.

[a]In billions of dollars.

total employment and in absolute numbers. Iron and steel experienced less extreme employment declines. On the other side of the ledger, plastics had very substantial growth, as did machinery.

The last six columns of table 9.2 contain the shares of the industrial employment located in each of three regions: the United States, other developed countries, and the rest of the world. The other developed countries are the eleven countries with the highest overall capital per man, as measured in our resource data set. Generally speaking, the large changes in the distribution of employment across these regions involve shifts in favor of the "rest of the world" and, to some extent, the U.S. at the expense of the other developed (Organization for Economic Cooperation and Development) countries. There were very substantial increases in the employment share of the "rest of the world" in tobacco and in the more labor-intensive products of textiles, apparel, and footwear. The U.S. share generally fell for these industries, though textiles is an interesting exception.

The industrial distribution of world labor earnings (table 9.3) also remained remarkably constant over the fifteen-year period 1963–78. Though the U.S. share of total employment rose roughly from .25 to .29 (table 9.2), the U.S. share of total earnings fell substantially from .60 to .41. In fact, the U.S. share of total world industrial earnings has fallen in every industry, reflecting the faster growth rate of wages over the fifteen-year period in the rest of the world relative to the United States. Developed countries other than the United States account for most of the gain in the non-U.S. world earnings share despite their decline in employment shares documented in table 9.2. These data thus conform to the data in table 9.1 in the sense of revealing much faster wage growth rate in these countries relative to the United States and less-developed countries.

The data in table 9.4 indicate little change over time in the industrial composition of world output just as the previous tables reveal slight changes in employment and earnings. In food, textiles, and apparel there is more than a one percentage point drop over the fifteen-year period in the share of world output. Industries whose output share rose by over one percentage point are industrial chemicals, petroleum refining, plastics, and machinery.

The capital data summarized in table 9.5 indicate that there are great differences in the capital intensity of production in the three regions, both overall and at the industry level. These suggest that in a few industries current U.S. production techniques may be less capital-intensive than those in the other developed countries (tobacco, furniture, petroleum refining, petroleum and coal production, nonmetal manufactured products, and iron and steel). While the high rates of investment in many of the countries in the developed-country aggregate are well documented, it is surprising that the U.S. advantage in capital per worker may have been eroded in many industries as early as 1978. There are, on the other hand, twelve industries out of the twenty-eight for which measured 1978 U.S. capital intensity is more than one-third larger than that for those industries in the other developed countries. These industries are food, textiles, wood, printing, industrial chemicals, other chemicals, rubber products, plastics, metal products, machinery, professional goods, and other industries. These capital-intensity figures must be viewed with great skepticism because of the unknown quality of the available investment data and their intermittent nature, and also because of the capital depreciation method which is used. In particular, (1) investment occurring before 1963 does not contribute to the measured 1978 capital stock, (2) the depreciation rate is taken to be the same in all countries, and (3) nominal exchange rates are used to convert foreign investment expenditures into dollar units.

With these caveats in mind it is interesting to note that the measured share of output in the United States (table 9.14) exceeds the measured share of both capital and labor. One may suspect that the proper inclusion of pre-1963 investment would raise the U.S. share considerably.

The similarity in relative capital intensities by industry among the three country groups is remarkably high, particularly given the great differences in these numbers across country groups. For each region, petroleum refining, beverages, petroleum and coal products, and industrial chemicals rank among the top industries in terms of capital intensity. The correlation coefficients between industrial capital intensities are .89 for the United States and the other developed countries, .96 for the United States and the less-developed countries, and .87 for the other developed and the less-developed countries. There are also several anomalies. Tobacco has a quite high ratio of capital to labor in the United States and a quite low ratio in the less-developed country group. A second example is the apparel industry; while the U.S. capital-labor ratio is 2.6 times that of the less-developed countries, it is only .2 times greater in apparel.

Assuming that the capital-intensity figures of table 9.5 are fairly accurate measures, the data provide strong evidence against the even HO model. The similarity in relative capital intensities across industries suggests, however, that systematic measurement error (in particular, in the measurement of human capital) could account for much of the disparity between the services. Similar evidence casting doubt on the even HO model appears in table 9.6, which presents correlation coefficients between each country's capital per worker and its industry-specific capital per man, value added per man, and earnings per man. While the even HO model predicts zero correlation coefficients between these variables, seventy-five of the eighty-four coefficients exceed .5, and thirty-three exceed .8.

Table 9.6 **Correlation of Capital per Worker with Industrial Characteristics, 1978**

ISIC	Capital per Man	Value Added per Man	Earnings per Man
311 Food	.65	.84	.91
313 Beverages	.80	.72	.89
314 Tobacco	.38	.49	.85
321 Textiles	.55	.85	.92
322 Apparel	.67	.79	.92
323 Leather	.44	.79	.92
324 Footwear	.65	.82	.91
331 Wood	.74	.90	.92
332 Furniture	.80	.89	.94
341 Paper	.66	.80	.89
342 Printing	.61	.85	.89
351 Industrial chemicals	.70	.69	.88
352 Other chemicals	.44	.67	.91
353 Petroleum refining	.54	.51	.66
354 Petroleum and coal production	.62	.51	.52
355 Rubber products	.69	.47	.89
356 Plastics	.66	.77	.93
361 Pottery	−.04	.83	.92
362 Glass	.57	.84	.89
369 Nonmetal products	.39	.87	.90
371 Iron and Steel	.60	.53	.84
372 Nonferrous metals	−.05	.66	.87
381 Metal products	.75	.81	.90
382 Machinery	.73	.83	.92
383 Electrical machinery	.79	.79	.90
384 Transport equipment	.63	.59	.87
385 Professional goods	.48	.82	.92
390 Other	.70	.83	.89

9.6 Regression Analysis

Table 9.7 reports industry-specific cross country results using 1978 data for four of the equations described in (3), (4), and (5). The four dependent variables are the industrial employment of capital and labor, factor payments to labor, and output. The explanatory variables are country endowments of capital, high-, medium-, and low-skilled labor (labor 1, labor 2, and labor 3, respectively), and land. Leamer (1980) describes the construction of these variables. National endowments are strikingly significant explanatory variables in each of the four regres-

Table 9.7 **Regressions on Five Endowments, 1978**

	Capital		Labor		Earnings		Output	
	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value
311 Food								
Capital	1.95	2.4	0.02	0.2	3.7	6.6	20.68	3.8
Labor 1	1,146.7	7.1	−4.4	−0.2	835	7.8	11,166.	10.4
Labor 2	−13.51	−0.5	15.9	4.7	−54	−2	−7,324.9	−1.7
Labor 3	−5.25	−5.3	−1.5	−1.3	−21	−3.1	−389.7	−5.9
Land	1.15	2.6	0.022	0.4	0.3	0.7	4.01	1.4
313 Beverages								
Capital	0.666	0.8	−0.03	−1	0.6	2.1	5.02	2.3
Labor 1	509.67	2.9	8.6	1.6	231	4.2	438.5	1
Labor 2	−23.43	−0.7	1.8	2	−19	−1.9	100.15	1.3
Labor 3	−16.32	−1.5	−1.07	−3.4	−3.5	−1.1	−62.9	−2.4
Land	−0.427	−0.9	−0.01	−0.9	−0.1	−0.7	−2.2	−2
314 Tobacco								
Capital	4.1	5.7	−0.008	−0.7	0.4	3.7	1.18	0.74
Labor 1	−1,241.	−9	2.14	0.9	−35	−1.9	−26.26	−0.1
Labor 2	108.6	4.4	0.669	1.6	5.6	1.6	116.5	2.1
Labor 3	14.7	1.7	1.52	11	−0.3	−0.3	−40.3	−2.1
Land	−0.283	−0.7	−0.011	−1.8	0	−1.2	−1.7	2
321 Textiles								
Capital	−0.101	−0.1	−0.121	−1.5	2.4	7.9	11.13	5.6
Labor 1	214.9	1.4	−27.7	−1.7	184	3.1	−867.4	−2.2
Labor 2	92	3.4	21.2	7.2	24	2.2	427.3	6.1
Labor 3	−44.98	−4.9	0.876	0.9	−14	−3.9	−87.3	−3.7
Land	−0.228	−0.6	−0.08	−1.8	−0.5	−3.2	−0.4	−0.3

322 Apparel								
Capital	−0.09	−0.6	−0.187	−4.1	0.7	2	1.237	0.9
Labor 1	171.8	5.1	55.7	6.2	636	10	2,377.4	8.6
Labor 2	2.94	0.5	8.99	5.6	−30	−2.5	−51.6	−1
Labor 3	−9.67	−4.7	−6.1	−11.	−19	−4.7	−94.5	−5.6
Land	0.036	0.4	0.006	0.3	0	0.1	0.739	1
323 Leather								
Capital	−0.075	−1.2	−0.025	−2.3	0.12	2	0.3507	1
Labor 1	23.7	2	1.3	0.6	37	3.2	3.782	0.1
Labor 2	2.59	1.2	1.51	4	0	0	35.19	3
Labor 3	−2.14	2.9	−0.54	−4.2	−1.8	−2.5	−12.36	−3
Land	0.019	0.6	5.5	0.1	−0.04	−1.3	−0.154	−0.8
324 Footwear								
Capital	−0.028	−0.4	−0.085	−3.4	−0.08	−0.6	−0.187	−0.4
Labor 1	33.15	2.5	9.2	1.8	106	−4.1	238.5	2.3
Labor 2	−0.193	−0.1	2.5	2.8	−1.3	−0.3	17.69	0.9
Labor 3	−1.6	−2	−1.37	−4.5	−4.7	−2.9	−19.05	−3
Land	0.004	0.1	0.025	1.8	−0.006	−0.1	0.19	0.7
331 Wood								
Capital	0.808	1.5	0.137	4.6	2.8	9.2	13.27	9.1
Labor 1	530.8	5.1	−28.4	−4.8	84	1.5	−32.06	−0.1
Labor 2	−38.7	−2.1	6.4	6.1	−26	−2.5	1.15	0
Labor 3	−12.5	−1.9	−1.13	−3.1	4	1.2	8.52	−0.5
Land	0.808	2.8	0.055	3.4	0.4	2.3	1.49	1.9
332 Furniture								
Capital	0.408	1.6	−0.048	−1.5	0.5	2.6	2.65	4.8
Labor 1	187.1	3.7	19.4	3	330	10	801.6	7.4
Labor 2	−14.9	−1.7	2.99	2.5	−16	−2.8	−12.95	−.7
Labor 3	−3.5	−1.1	−2.18	−5.4	−10	−4.7	−35.73	−5.4
Land	−0.016	−0.1	0.022	1.2	−0.04	−0.4	0.163	0.5

(continued)

Table 9.7 (continued)

	Capital		Labor		Earnings		Output	
	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value
341 Paper								
Capital	2.95	1.7	0.012	0.5	1.3	2.9	8.26	2.9
Labor 1	1,398.7	4.1	36.5	6.1	762	8.7	3,059.3	5.5
Labor 2	−110.6	−1.8	0.873	0.8	−58	−3.6	−126.8	−1.3
Labor 3	−27.9	−1.3	−1.74	−4.8	−15	−2.7	−101.0	−3
Land	1.55	1.7	0.007	0.4	0.3	1.3	1.67	1.1
342 Printing								
Capital	0.445	1.1	−0.0004	0	2	3	8.22	2.8
Labor 1	947	11.5	73.57	7.4	987	7.7	2,619	4.5
Labor 2	−44.2	−3	0.933	0	−47	−2	−37.37	−0.4
Labor 3	−28.2	−5.6	−3.34	−5.5	−29	−3.7	−111.8	−3.2
Land	−0.06	−0.3	−0.014	−0.5	−0.2	−0.6	−0.632	−0.4
351 Ind. chem.								
Capital	5.59	4.2	−0.0299	−0.5	2.2	2.4	10.35	2.8
Labor 1	2,238.1	8.6	29.87	2.7	636	3.5	3,818.5	5.3
Labor 2	−104.4	−2.2	2.19	1.1	−58	−1.7	16.5	0.1
Labor 3	−66	−4.1	−1.72	−2.5	−7	−0.6	−176.1	−4
Land	0.086	−0.1	−0.035	−1.1	−0.8	−1.6	−1.84	−0.9
352 Other chem.								
Capital	1.25	4.8	0.036	0.6	2	2.8	5.92	3
Labor 1	571.2	11.2	30.7	2.8	519	3.7	2,335.2	6
Labor 2	−18.4	−2	−0.148	−0.1	−55	−2.2	34.47	0.5
Labor 3	−19.5	−6.3	−0.42	−0.6	−2.9	−0.3	−108.8	−4.6
Land	−0.417	−3	−0.045	−1.5	−0.4	−1.2	−0.778	−0.7

353 Petro. ref.								
Capital	2.2	3.3	−0.003	−0.5	0.22	1.6	7.7	1.6
Labor 1	869.6	6.7	6.96	7.2	190	7.1	6,570.7	6.8
Labor 2	−53.8	−2.3	−0.054	−0.3	−14	−3	−244.1	−1.4
Labor 3	−22.5	−2.8	−0.302	−5.1	−3.5	−2.1	−211.6	−3.6
Land	0.66	1.9	0.01	3.9	0.1	1.5	0.243	0.1
354 Petro./coal								
Capital	0.593	1.5	−0.009	−2.8	0	0.1	1.58	3.8
Labor 1	−64	−.8	3.22	4.9	72	11.8	−0.953	0
Labor 2	11.1	0.8	0.293	2.5	−3.1	−2.8	38.74	2.7
Labor 3	0.064	0	−0.162	−4	−2	−5.5	−12.37	−2.5
Land	−0.326	−1.5	−0.002	−1	−0.04	−2.2	−0.22	−1
355 Rubber prod.								
Capital	0.487	2.9	−0.05	−1.9	0.5	3.6	1.85	4
Labor 1	207.8	6.3	8.5	1.6	249	8.7	633.2	7
Labor 2	2.4	0.4	3.32	3.5	−11	−2.1	33.33	2
Labor 3	−11.1	−5.6	−1.4	−4.4	−8	−4.2	−40.31	−7.1
Land	0.0005	0	−0.019	−1.4	−0.1	−2.3	−0.033	−0.1
356 Plastics								
Capital	1.27	5.1	0.093	5.1	2	9.4	12.17	20.3
Labor 1	280.2	5.7	2.297	0.6	154	3.8	−696.5	−5.9
Labor 2	−3.62	−0.4	2.71	4.2	−17	−2.3	84.93	4
Labor 3	−12.8	−4.2	−1.19	−5.4	−1	−0.5	−4.4	−0.6
Land	−0.04	−0.3	−0.008	−0.8	−0.2	−2	−0.99	−3
361 Pottery								
Capital	0.084	0.5	−0.013	−0.6	3	2	0.775	2.3
Labor 1	−26.9	−0.9	−9.91	−2.2	−49	−1.9	−237.7	−3.6
Labor 2	6.9	1.2	2.74	3.4	8.4	1.8	38.9	3.3
Labor 3	−1.8	−0.9	−0.511	−1.9	−1	−0.7	−4.23	−1.1
Land	−0.01	−0.1	−0.009	−0.8	−0.1	−2.1	−0.29	−1.7

(continued)

Table 9.7 (continued)

	Capital		Labor		Earnings		Output	
	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value
362 Glass								
Capital	0.44	1.9	−0.0129	−1.9	2.8	2	1.44	4.6
Labor 1	238.6	5.1	11.3	3.7	230	8.5	531.6	8.6
Labor 2	−10.6	−1.3	1.11	2	−13	−2.8	−4.3	−0.4
Labor 3	−7.7	−2.7	−731	−3.9	−5.5	−3.2	−23.3	−6.1
Land	−0.01	−0.1	0.003	0.4	−0.1	−1.6	−0.183	−1.1
369 Nonmetal								
Capital	3.7	1.3	0.05	1.3	2.1	11.8	11.07	12.7
Labor 1	308	0.5	−23.6	−3.1	87	2.6	−872.4	−5.1
Labor 2	−52.7	−0.5	7.24	5.3	−5.8	−0.9	171.2	5.6
Labor 3	2.2	0.1	−0.837	−1.8	−3	−1.3	−27.35	−2.6
Land	−0.25	−0.2	0.026	1.2	−0.2	0−1.7	0.017	0
371 Iron, steel								
Capital	13.9	7	0.114	1.1	4.1	4	31.28	11.8
Labor 1	−2,253	−5.8	34.98	1.8	933	4.8	−2,828	−5.4
Labor 2	254.4	3.7	1.485	0.4	−80	−2.3	472.12	5
Labor 3	3.76	0.2	−0.31	−0.3	−12	−0.99	−38.1	−1.2
Land	−0.45	−0.4	−0.053	−0.9	−0.8	−1.4	−2.54	−1.8
372 Nonfer. met.								
Capital	2.45	8.7	0.022	1.3	1	6.5	6.898	6.7
Labor 1	29.7	0.5	13.67	4.2	291	9.8	1,428	7.1
Labor 2	7.2	0.7	0.52	0.9	−23	−4.2	−16.11	−0.4
Labor 3	−7.06	−2.1	−0.726	−3.6	−6	−3.0	−64.1	−5.2
Land	0.932	6.1	0.004	0.5	0.07	0.9	1.36	2.4

381 Metal prod.								
Capital	2.2	5.8	0.051	0.6	3.7	6.3	16.75	13.2
Labor 1	959.4	12.8	62.4	3.9	1,299	11.6	3,632	14.5
Labor 2	−42.3	−3.1	6.36	2.2	−81	−4	29.45	−0.7
Labor 3	−31.04	−6.8	−4.93	−5	−31	−4.5	−166.4	−11
Land	0.032	0.2	−0.053	−1.2	−0.7	−2.3	−0.75	−1.1
382 Machinery								
Capital	4.9	2.6	0.172	1.1	7.6	3.7	29.54	6.3
Labor 1	1,701.5	4.6	138.5	4.3	2,611	6.7	7,688	8.3
Labor 2	−82.3	−1.2	1.67	0.3	−206	−2.9	−302.1	−1.8
Labor 3	−48.98	−2.1	−5.89	−3	−43	−1.7	−236.1	−4.2
Land	−1.26	−1.2	−0.129	−1.5	−2	−1.9	−6.14	−2.4
383 Elect. mach.								
Capital	5.73	4.9	0.333	2.7	8.1	5.3	42.95	13.3
Labor 1	579.2	2.5	35.94	1.5	1,252	4.3	−1,342	−2.1
Labor 2	−12.5	−0.3	8.72	2	−120	−2.2	271	2.4
Labor 3	−26.3	−1.8	−6.43	−3.7	−70	−4	−305.9	−4.4
Land	−0.533	−0.8	−0.144	−1.8	−1.5	−2	1	0.3

(*continued*)

Table 9.7 (continued)

	Capital		Labor		Earnings		Output	
	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value	Coef.	*t*-Value
384 Trans eq.								
Capital	8.9	7.4	−0.035	−0.2	4.4	3	39.81	7
Labor 1	363.5	1.5	155.05	5.4	3,240	11.7	8,880	7.9
Labor 2	26.6	6 0.6	1.39	0.3	−215	−4.2	−316.3	−1.6
Labor 3	−26.3	−1.8	−6.43	−3.7	−70	−4	−305.9	−4.4
Land	−0.533	−0.8	−0.144	−1.8	−1.5	−2	1	0.3
385 Prof. goods								
Capital	−0.15	−0.5	−0.027	−1.2	0.5	1.25	2.71	1.7
Labor 1	491.5	7.7	39.88	8.7	739	10.6	2,412	7.9
Labor 2	−8.88	−0.8	1.17	1.4	−38	−3	−91.2	−1.7
Labor 3	−19.8	−5.1	−2.218	−7.9	−19	−4.4	−76.8	−4.1
Land	0.117	0.7	−0.01	−0.8	−0.2	−1.2	−0.85	−1
390 Other								
Capital	0.008	0.1	−0.018	−0.7	0.6	2.5	3.3	2.8
Labor 1	1,620.8	5.6	8.18	1.6	204	4.4	498.9	2.2
Labor 2	6.11	1.2	3.97	4.3	−0.9	−0.1	48.42	1.2
Labor 3	−10.4	−5.8	−1.87	−6	−9.6	−3.3	−42.95	−3
Land	0.13	1.6	0.007	0.5	0	−0.03	−0.3	−0.5

sions for each of the twenty-eight industries. All but two of the 112 R^2-values equal or exceed .8; eighty-seven equal or exceed .95. The large values of R^2 may, however, simply reflect scale effects. Table 9.8 presents these R^2-values as well as R^2-values adjusted for scale effects. The adjusted R^2-values computed here are one minus the ratio of the error sum of squares of the table 9.7 regression to the error sum of squares resulting from regressions including only national capital endowment as an explanatory variable. Hence the adjusted R^2-values

Table 9.8 **R^2-Values: Regressions on Five Endowments, 1978**

	Including Scale Effects				Excluding Scale Effects			
	Out.	Lab.	Cap.	Wage	Out.	Lab.	Cap.	Wage
311 Food	.99	.97	.99	.99	.88	.89	.83	.78
313 Beverages	.95	.88	.87	.93	.24	.38	.30	.46
314 Tobacco	.88	.99	.90	.93	.26	.99	.82	.25
321 Textiles	.99	.98	.96	.99	.73	.97	.56	.63
322 Apparel	.98	.98	.96	.99	.84	.89	.71	.86
323 Leather	.95	.90	.82	.96	.36	.63	.40	.41
324 Footwear	.90	.83	.80	.90	.44	.64	.33	.54
331 Wood	.99	.98	.95	.98	.10	.68	.70	.41
332 Furniture	.99	.95	.91	.99	.80	.68	.42	.85
341 Paper	.98	.98	.93	.98	.68	.78	.56	.82
342 Printing	.98	.98	.99	.98	.57	.82	.89	.77
351 Ind. chem.	.98	.91	.99	.92	.65	.48	.81	.37
352 Other chem.	.99	.90	.99	.99	.74	.54	.87	.39
353 Petro. refin.	.98	.98	.98	.99	.74	.86	.76	.76
354 Petro., coal prod.	.98	.96	.68	.98	.31	.85	.17	.88
355 Rubber prod.	.99	.93	.99	.99	.83	.62	.76	.80
356 Plastics	.99	.99	.99	.99	.74	.54	.69	.45
361 Pottery	.86	.62	.55	.81	.50	.38	.07	.36
362 Glass	.99	.94	.96	.98	.83	.72	.60	.79
369 Nonmetal prod.	.99	.95	.56	.99	.58	.75	.01	.33
371 Iron and steel	.99	.91	.97	.97	.64	.55	.63	.52
372 Nonferrous metals	.99	.97	.99	.99	.82	.65	.68	.85
381 Metal prod.	.99	.98	.99	.99	.94	.66	.91	.87
382 Machinery	.99	.96	.97	.98	.78	.58	.51	.68
383 Electrical mach.	.99	.97	.98	.98	.47	.40	.26	.48
384 Transport equip.	.99	.96	.99	.99	.80	.68	.09	.87
385 Professional goods	.98	.99	.97	.98	.78	.87	.81	.86
390 Other	.97	.97	.98	.98	.37	.69	.79	.59

represent the fraction of the variance of the dependent variable explained by national endowments after controlling for scale effects. These scale-adjusted R^2-values are also quite large; eighty-one of these 112 R^2-values equal or exceed .5, and ninety-four exceed .4.

The coefficients in the rows labeled capital, labor 1, labor 2, labor 3, and land indicate the impact on the various dependent variables of raising these national endowments by specific amounts. As described above, the even HO model predicts that the coefficients of each of the four regressions of table 9.7 have the same sign. In addition the ratio of any two coefficients in any of the four industry regressions should equal the ratios of the corresponding coefficients of the same exogenous variables in each of the other three industry regressions. These predictions of the even HO model are sustained by many of the findings in table 9.7. Consider, for example, the twenty-eight pairs of capital and labor demand regressions. Of the 140 (28 times 5) pairs of coefficients, only forty-two pairs are opposite in sign, and only fourteen of these pairs of coefficients that violate the prediction about equal sign have corresponding pairs of t-values that are each greater than one in absolute value. In addition there are seven industries (nonferrous metals, food, beverages, tobacco, apparel, leather, and other chemicals) in which each of the pairs of capital and labor coefficients agree in sign. Note that the probability of five equal-sign coefficient pairs is 1/32 assuming an equal independent probability of each coefficient being positive or negative. In this case, the expected number of regressions with identical coefficient pairs in twenty-eight trials is .875, well below the seven actually observed.

The regressions of factor payments and output are potentially less plagued by systematic measurement error. Of the 140 pairs of coefficients in these two regressions only twenty-five exhibit opposite signs, and only thirteen of these coefficient pairs have t-values greater than one. Thirteen of the twenty-eight pairs of earnings and output regressions have pairs of coefficients each of which agree in sign.

As indicated, tests of proportionality of the four regressions may fail because of mismeasurement of both the endogenous and right-hand side variables. The nature of this mismeasure is, however, likely to be roughly constant in the two sets of results; the method of estimating industry-specific capital stocks as well as national endowments is quite similar for the two periods. As a consequence, differences in estimated coefficients across the two periods may provide more reliable evidence of changes in underlying production technologies and/or world relative commodity prices, either of which would alter the coefficients in equations (3), (4), or (5). Table 9.9 presents labor input and earnings regressions using 1963 data. A comparison of the estimated coefficients of this table with those for the corresponding 1978 regressions suggests

Table 9.9 **Regressions on Five Endowments, 1963**

ISIC	Labor Coef.	Labor *t*-Value	Earnings Coef.	Earnings *t*-Value
311 Food				
Capital	−2.7	−3.1	1.3	0.6
Labor 1	257.1	3.3	199	1.2
Labor 2	12.6	4.6	−5.3	−1.1
Labor 3	−6.6	−5.9	−3	−1.2
Land	0.07	1.9	0	1.3
313 Beverages				
Capital	−1	−3.5	0	−0.1
Labor 1	85.6	3.3	889	1.3
Labor 2	1.5	1.7	−1.8	−1
Labor 3	−2.5	−6.7	−1.7	−1.7
Land	0	.3	0	−0.2
314 Tobacco				
Capital	−0.2	−1.8	0.6	1
Labor 1	21.2	2.1	−41	−1
Labor 2	0.4	1.1	1.7	1.4
Labor 3	0.17	1.1	0.5	0.7
Land	0	−0.8	0	−0.2
321 Textiles				
Capital	−3.9	−3.4	11.6	10.1
Labor 1	175.9	1.7	−245	−3.1
Labor 2	31	8.7	4	1.8
Labor	−5.5	−3.8	5.8	4.9
9t9b 3	0	0.1	0	−6.2
Land				
322 Apparel				
Capital	−1.8	−3.3	0.5	0.7
Labor 1	290	5.9	82.1	1.5
Labor 2	−4.6	−2.7	−2.4	−1.6
Labor 3	−5.5	−7.8	−1.4	−1.7
Land	0	−0.3	0	−1.8
323 Leather				
Capital	−0.3	−1.7	0.64	3.8
Labor 1	30.4	1.9	8.1	0.7
Labor 2	0.3	0.5	−0.5	−1.4
Labor 3	−0.7	−2.9	−0.1	−0.8
Land	0	0.2	0	−3.8
324 Footwear				
Capital	−0.8	−3	1.1	3.6
Labor 1	100	4.2	32	1.4
Labor 2	−2.4	−2.9	−1.2	−2
Labor 3	−1.5	−4.5	−0.6	−1.8
Land	0	0.1	0	−6.5
331 Wood				
Capital	1.5	2	0.3	0.9
Labor 1	−183	−2.8	44.6	1.8
Labor 2	19	8.3	−0.3	−0.5
Labor 3	−2	−2.2	−1.1	−2.9
Land	0	0.6	0	1.2

(continued)

Table 9.9 (continued)

ISIC	Labor		Earnings	
	Coef.	t-Value	Coef.	t-Value
332 Furniture				
Capital	−0.5	−2.1	2.3	4.5
Labor 1	59.2	2.7	17.3	0.5
Labor 2	1.7	2.2	−1.1	−1.1
Labor 3	−1.9	−5.9	−0.5	0.8
Land	0	0.9	0	−6.6
341 Paper				
Capital	−1	−2.6	1.8	5.9
Labor 1	114.1	3.3	−10.2	−0.5
Labor 2	3.2	2.6	0	−0.1
Labor 3	−3.5	−7	0	0.3
Land	0	0.5	0	−1.9
342 Printing				
Capital	−2	−5.3	1.4	1.9
Labor 1	240	7.3	74	1.4
Labor 2	0.4	0.3	−2	−1.5
Labor 3	−4.9	−11	−1.1	−1.5
Land	0	−0.3	0	−2.5
351 Ind. chem.				
Capital	−1.5	−3.6	2.6	6.5
Labor 1	133	3.6	4	0.1
Labor 2	4	2.8	−0.3	−0.4
Labor 3	−4	−7	−0.2	−0.5
Land	0	−0.8	0	−0.7
352 Other chem.				
Capital	−0.8	−1.4	2.6	6.5
Labor 1	100	2	4.4	0.2
Labor 2	1.6	0.9	−0.4	−0.5
Labor 3	−2.3	−3.1	−0.2	−0.5
Land	0	−0.4	0	−0.3
353 Petro. ref.				
Capital	0.1	2.5	0.3	2.1
Labor 1	5.2	1.3	−12.2	−1.5
Labor 2	−0.09	−0.7	0.5	2.3
Labor 3	−0.8	0.1	0.9	0.9
Land	0	2	0	7
354 Petro./coal				
Capital	−0.3	−8.2	0.4	7.3
Labor 1	25.5	8.7	−6.2	−1.6
Labor 2	−0.3	−3.1	0.1	1.3
Labor 3	−0.5	−11	0	0.8
Land	0	0.7	0	−7.7
355 Rubber prod.				
Capital	−0.5	−2.7	1	2.5
Labor 1	46.2	3	0.8	0.03
Labor 2	2.5	4.5	0.2	0.2
Labor 3	−1.6	−7.1	0	−0.2
Land	0	−0.9	0	−2.8

Table 9.9 (continued)

ISIC	Labor Coef.	Labor *t*-Value	Earnings Coef.	Earnings *t*-Value
356 Plastics				
Capital	0	0.02	0.9	6.6
Labor 1	−7.4	−0.4	2.2	0.2
Labor 2	4	6.6	−0.3	−1.3
Labor 3	−1	−4.2	0	−0.4
Land	0	−1.6	0	−10
361 Pottery				
Capital	−0.4	−1.5	2.1	6.3
Labor 1	15.3	0.7	−18.3	−0.8
Labor 2	2.4	3.1	0	−0.1
Labor 3	−0.9	−2.8	0.2	0.5
Land	0	−0.6	0	−11
362 Glass				
Capital	−0.3	−1.7	1.3	7
Labor 1	35.7	2	−12	0.1
Labor 2	0.8	1.3	0	0.1
Labor 3	−0.8	−3	0.2	0.8
Land	0	−0.1	0	−4.2
369 Nonmetal				
Capital	−0.9	−2.3	2.8	6.6
Labor 1	58	2	−15.5	−0.5
Labor 2	5.9	5.7	−0.2	−0.3
Labor 3	−2.5	−6	0.2	0.4
Land	0	0.2	0	−4.6
371 Iron, steel				
Capital	−2.5	−1.4	5.9	5.1
Labor 1	235	1.5	−15	−0.2
Labor 2	6.5	1.2	−1.7	−0.8
Labor 3	−5.6	−2.5	1	8
Land	0	−0.8	0	−5.7
372 Nonfer. met.				
Capital	−1	−4.3	1.3	7.7
Labor 1	281.6	3.6	−33.3	−0.6
Labor 2	0.2	0.3	0.2	0.7
Labor 3	−2	−7.4	0.3	2
Land	0	1.1	0	2.5
381 Metal prod.				
Capital	−2.7	−3	6.8	9.1
Labor 1	281.6	3.6	−33.3	−0.6
Labor 2	8	2.7	−0.6	−0.4
Labor 3	−8	−7.4	0	0.1
Land	0	−1	0	−9.4
382 Machinery				
Capital	−5	−2.2	3.7	4.8
Labor 1	520	2.5	6	0.1
Labor 2	11.7	1.9	−2.1	−1.6
Labor 3	−12	−4.7	−0.7	−0.9
Land	−0.1	−1.2	0	−4.6

(*continued*)

Table 9.9 (continued)

	Labor		Earnings	
ISIC	Coef.	*t*-Value	Coef.	*t*-Value
383 Elect. mach.				
Capital	−3.7	−1.9	2.7	3.9
Labor 1	365	2.1	55.3	1.2
Labor 2	11.7	1.9	−2.1	−1.6
Labor 3	−12	−4.7	−0.7	−0.9
Land	−0.1	−1.2	0	−3.3
384 Trans. eq.				
Capital	−9.5	−7	5.6	4.1
Labor 1	928	8	26.8	0.3
Labor 2	−11.7	−2.8	−3	−1
Labor 3	−14.6	−8.7	0.5	0.3
Land	0	−0.1	0	−5
385 Prof. goods				
Capital	−0.8	−3.2	0.3	1.7
Labor 1	101	4.4	14.8	1.1
Labor 2	0.3	4	−0.5	−1.4
Labor 3	−2.3	−6.9	−0.2	−0.9
Land	0	−1.8	0	2.2
390 Other				
Capital	0.1	0.2	0.2	2.2
Labor 1	3.2	0.1	10.5	1.4
Labor 2	4.7	4.3	−0.4	−2
Labor 3	−1.5	−3.4	−0.1	−1.2
Land	0	−0.3	0	2.3

substantial changes in technologies or relative prices across the two periods.

While the regression findings of tables 9.7–9.9 are broadly supportive of the even HO model, tests to distinguish between the even and uneven HO model provide strong support for the uneven version. The uneven HO model suggests factor price equalization among countries with similar relative factor endowments. This implies that subgroups of countries with similar relative endowments will satisfy equations (3), (4), and (5) for a given set of coefficients. As one shifts from one subgroup to another, however, the predicted coefficients will change.

Table 9.10 reports tests of structural differences in coefficients in the factor demands, output, and earnings regressions, where the sample of countries was split between the fifteen countries with the largest and the twelve with the smallest 1978 capital-labor ratios. The table provides both F statistics testing for structural differences as well as the posterior probabilities of structural breaks. The posterior probability is calculated using a prior probability that is diffuse with respect to coefficient values and specifies a 50% chance that there is a structural

Table 9.10 *F*-Values and Posterior Probabilities in Favor of Hypothesis of Structural Difference

	F-Values			Posterior Probabilities			
ISIC	Lab.	Cap.	Wage	Out.	Lab.	Cap.	Wage
311 Food	35.62	5.01	4.76	.89	1.00	.99	.99
313 Beverages	37.11	29.02	20.37	1.00	1.00	1.00	1.00
314 Tobacco	1.47	42.41	2.59	1.00	.02	1.00	.38
321 Textiles	2.10	1.34	5.26	.84	.13	.01	.99
322 Apparel	1.64	8.74	22.14	1.00	.04	1.00	1.00
323 Leather	10.76	25.51	17.60	1.00	1.00	1.00	1.00
324 Footwear	30.71	21.44	12.65	1.00	1.00	1.00	1.00
331 Wood	1.62	2.11	1.66	.02	.03	.14	.04
332 Furniture	5.17	21.31	9.02	1.00	.99	1.00	1.00
341 Paper	2.24	2.49	3.40	.99	.19	.32	.82
342 Printing	12.76	22.71	19.43	1.00	1.00	1.00	1.00
351 Ind. chem.	27.77	5.39	23.04	1.00	1.00	1.00	1.00
352 Other chem.	25.96	8.43	24.39	1.00	1.00	1.00	1.00
353 Petro. refin.	3.39	3.56	8.89	.98	.82	.87	1.00
354 Petro., coal prod.	1.00	3.20	4.91	.28	.00	.74	.99
355 Rubber prod.	3.11	8.63	24.63	.93	.70	1.00	1.00
356 Plastics	11.60	9.52	8.27	.96	1.00	1.00	1.00
361 Pottery	30.30	15.80	24.17	1.00	1.00	1.00	1.00
362 Glass	31.65	2.20	15.18	1.00	1.00	.17	1.00
369 Nonmetal prod.	48.97	0.45	7.95	1.00	1.00	.00	1.00
371 Iron and steel	22.74	10.33	9.95	1.00	1.00	1.00	1.00
372 Nonferrous metals	17.81	4.74	8.56	1.00	1.00	.99	1.00
381 Metal prod.	32.46	4.98	14.18	1.00	1.00	.99	1.00
382 Machinery	11.27	9.34	8.45	.98	1.00	1.00	1.00
383 Electrical mach.	7.32	14.18	16.16	1.00	1.00	1.00	1.00
384 Transport equip.	19.70	2.89	9.28	1.00	1.00	.57	1.00
385 Professional goods	2.44	26.81	15.72	1.00	.29	1.00	1.00
390 Other	2.13	9.75	38.30	1.00	.15	1.00	1.00

break (see Leamer 1978, chap. 4). The posterior probability is computed as $\delta/1-\delta$, where δ is given by

$$\delta = \left(\frac{\text{ESS}}{\text{ESS}_D + \text{ESS}_U}\right)^{T/2} T^{-K/2},$$

and T is the number of observations, K is the number of parameter restrictions, ESS is the error sum of squares in the regression including the entire sample, and ESS_D and ESS_U are the respective error sums of squares from the separate regressions for the high- and low-capital-intensity country samples. Holding the sample size and parameter restrictions constant, the posterior probability of structural differences is an increasing function of the calculated F statistic.

The critical F-value at the 95% confidence level is 2.74. Virtually all of the F statistics in table 9.10 exceed this critical value; many exceed 15. The corresponding posterior probabilities of structural differences are also very large. Over three-quarters of these 112 probabilities are essentially unity. With the exception of the wood industry, there is a strong rejection of the structural equivalence of the two samples for at least one of the four dependent variables. The equally strong rejection of structural similarities in the case of the earnings and labor input regressions indicates that these tests are probably picking up more than differential measurement error.

The fact that significant structural differences are found for virtually each industry suggests that dividing the sample based on capital per worker is a fairly good proxy for distinguishing countries lying in different cones of diversification. However, since there are five factors in our data set rather than two, there is no theoretical rationale to split the sample on the basis of capital divided by the sum of the three types of workers. In a multifactor setting there appear to be no simple rules for segmenting the sample. In the absence of a theoretical guide to splitting the sample, we also tested for structural differences across countries by including higher-order terms in the regressions. More precisely, we added the squares of the country's endowments as well as the cross products of the country's capital and each of its three types of labor. Table 9.11 presents tests of the significance of these additional variables. Like table 9.10, the F-values as well as the posterior probabilities, which the regression properly includes, are typically quite large. They also constitute a fairly strong rejection of the linearity prediction of the even HO model.

Additional regression results are presented in table 9.12 that also contravene the even HO model but that are consistent with both the uneven HO and the adjustment cost models. The dependent variable here is earnings per worker in particular industry and country. According to the even HO model, earnings per worker in an industry should be unrelated to a country's endowment of capital per worker. In addition, given domestic labor mobility, an assumption of all three models, industrial wages should be unrelated to the capital in place in the particular industry.

The t-values in the second column of table 9.12 quickly dismiss the notion of wage equalization across countries within particular industries. If there is error in measuring labor input, such error apparently goes beyond industry-specific differences in skills. While high capital-

Table 9.11 ***F*-Values and Posterior Probabilities in Favor of Second-Order Model**

	F-Values				Posterior Probabilities			
ISIC	Out.	Lab.	Cap.	Wages	Out.	Lab.	Cap.	Wages
311 Food	3.55	30.02	6.47	4.47	.90	1.00	1.00	.99
313 Beverages	11.11	23.00	21.74	24.00	1.00	1.00	1.00	1.00
314 Tobacco	24.11	3.17	193.62	11.92	1.00	.76	1.00	1.00
321 Textiles	7.23	3.39	3.79	8.13	1.00	.85	.94	1.00
322 Apparel	13.68	2.42	6.73	17.20	1.00	.24	1.00	1.00
323 Leather	9.48	5.28	15.54	15.16	1.00	1.00	1.00	1.00
324 Footwear	17.11	23.15	19.38	17.42	1.00	1.00	1.00	1.00
331 Wood	1.11	2.20	0.79	0.87	.00	.13	.00	.00
332 Furniture	6.13	8.79	19.17	8.03	1.00	1.00	1.00	1.00
341 Paper	2.19	1.27	1.01	1.03	.12	.00	.00	.00
342 Printing	24.27	29.60	24.07	32.40	1.00	1.00	1.00	1.00
351 Ind. chem.	7.58	12.86	3.18	22.53	1.00	1.00	.76	1.00
352 Other chem.	26.35	27.08	4.45	38.64	1.00	1.00	.99	1.00
353 Petro. ref.	2.74	2.19	2.03	3.55	.47	.12	.07	.90
354 Petro./coal	2.93	4.67	3.14	11.34	.61	.99	.74	1.00
355 Rubber prod.	3.02	3.59	3.59	10.75	.67	.91	.91	1.00
356 Plastics	2.46	4.79	7.09	7.44	.26	.99	1.00	1.00
361 Pottery	46.42	34.37	28.33	27.43	1.00	1.00	1.00	1.00
362 Glass	8.64	14.46	1.59	19.30	1.00	1.00	.01	1.00
369 Nonmetal	13.47	21.42	0.52	8.57	1.00	1.00	.00	1.00
371 Iron, steel	4.49	13.83	12.24	10.49	.99	1.00	1.00	1.00
372 Nonfer. met.	6.74	10.62	3.38	4.48	1.00	1.00	.85	.99
381 Metal prod.	4.33	11.64	2.44	9.67	.98	1.00	.25	1.00
382 Machinery	3.13	5.63	6.81	8.28	.74	1.00	1.00	1.00
383 Elect. mach.	4.77	5.62	10.20	16.37	.99	1.00	1.00	1.00
384 Trans. eq.	5.20	9.08	2.77	9.07	1.00	1.00	.49	1.00
385 Prof. goods	62.93	2.07	28.70	22.58	1.00	.08	1.00	1.00
390 Other	29.71	4.30	16.78	36.65	1.00	.98	1.00	1.00

labor ratio countries have higher within-industry earnings per worker, the particular amount of capital in place in the industry typically has a negligible effect on this variable. Only five of twenty-eight industry-specific capital coefficients are significant explanatory variables in table 9.12. The evidence here is broadly supportive of the domestic labor mobility assumption.

Tables 9.13 and 9.14 provide two different tests of the adjustment cost model. In contrast to the even and uneven HO models, the assumption of adjustment costs implies that lagged industry-specific inputs should be significantly correlated with current input demand. To test this we added the industry's 1963 labor input to the list of country endowments in cross-industry regressions explaining 1978 labor demand. We also included 1963 output in the regression of 1978 output on national endowments. Lagged employment enters significantly for

Table 9.12 **Regressions of ISIC Earnings per Worker on National Capital per Worker and ISIC Capital per Worker, 1978**

	Capital per Worker		ISIC Capital per Worker		
ISIC	Coef.	*t*-Value	Coef.	*t*-Value	R^2
311 Food	.31	7.90	.06	0.80	.83
313 Beverages	.34	5.30	.06	0.90	.81
314 Tobacco	.29	8.00	.05	3.80	.83
321 Textiles	.27	9.20	.08	0.90	.85
322 Apparel	.22	8.20	.31	1.40	.86
323 Leather	.27	10.10	.12	0.90	.85
324 Footwear	.25	8.40	.07	0.40	.84
331 Wood	.32	7.60	.05	0.60	.85
332 Furniture	.32	8.40	−.04	−0.40	.87
341 Paper	.35	7.40	.02	0.40	.80
342 Printing	.31	7.00	.33	2.10	.81
351 Ind. Chem.	.39	6.00	.03	1.40	.79
352 Other Chem.	.36	9.80	.02	0.60	.83
353 Petro refin.	.34	3.30	.06	13.00	.93
354 Petro., coal prod.	−.39	−1.00	.55	11.00	.88
355 Rubber prod.	.30	0.67	.10	1.00	.81
356 Plastics	.32	9.50	.06	0.60	.88
361 Pottery	.31	11.80	−.01	−1.00	.85
362 Glass	.35	7.60	.04	0.12	.81
369 Nonmetal prod.	.37	9.40	.00	0.00	.80
371 Iron and steel	.37	6.00	.02	0.50	.71
372 Nonferrous metals	.37	9.00	.00	0.00	.76
381 Metal prod.	.36	6.30	.09	0.50	.81
382 Machinery	.32	7.20	.22	1.50	.86
383 Electrical mach.	.34	6.10	.08	0.40	.82
384 Transport equip.	.37	6.60	.04	0.30	.75
385 Professional goods	.35	10.10	.25	2.10	.87
390 Other	.26	10.10	.21	1.10	.80

virtually all of the industries, but lagged output has a generally insignificant effect on output. This suggests that labor is rather immobile compared with capital, which is opposite to the mobility assumption that we have made so far.

A second prediction of the adjustment cost model, tested in table 9.14, is that current industrial labor demand is positively related to the amount of capital installed in the industry and negatively related to the economy's wage rate. In addition, given these variables, the adjustment cost model described in section 9.4 ascribes no explanatory power to national endowments in explaining current labor demand. The results shown in Table 9.14 provide some support for the adjustment cost model; seventeen of the twenty-eight industry-specific capital coefficients have *t*-values in excess of 2, and twenty-seven of the twenty-eight coefficients are positive. In contrast, the country's wage rate is

Table 9.13 Regressions on Five Endowments and 1963 Value

	1978 Labor Equation			1978 Output Equation		
ISIC	Coef.	t^a	Prob.	Coef.	t^a	Prob.
311 Food	.87	15.5	1.00	.002	0.2	.16
313 Beverages	.71	16.8	1.00	−.001	−0.05	.16
314 Tobacco	.82	5.4	1.00	−.001	−0.04	.16
321 Textiles	.21	2.6	.90	−.001	−0.1	.16
322 Apparel	−.06	−0.3	.17	.007	0.4	.17
323 Leather	.49	4.9	1.00	−.002	−0.2	.16
324 Footwear	.67	3.1	.9	−.001	−0.1	.16
331 Wood	.5	4.2	1.00	.003	0.1	.16
332 Furniture	.96	5.1	1.00	−.01	−0.2	.16
341 Paper	.7	7.8	1.00	.01	0.4	.17
342 Printing	.78	4.8	1.00	.02	0.5	.18
351 Ind. chem.	.93	9.3	1.00	−.003	−0.1	.16
352 Other chem.	1.1	13.1	1.00	.01	0.4	.17
353 Petro. refin.	.5	3.3	.98	.02	0.4	.17
354 Petro., coal production	.18	1.3	.36	−.001	−0.03	.16
355 Rubber prod.	.69	3.1	.97	−1e-4	−0.01	.16
356 Plastics	.76	4.9	1.00	.02	0.4	.17
361 Pottery	.77	10	1.00	−.006	−0.1	.16
362 Glass	.69	6.6	1.00	.004	0.3	.17
369 Nonmetal products	.69	5.8	1.00	−.003	−0.2	.16
371 Iron and steel	.63	23.2	1.00	.006	0.2	.16
372 Nonferrous metals	.56	11.8	1.00	.03	1.7	.53
381 Metal prod.	.69	8.3	1.00	.004	0.5	.18
382 Machinery	.67	9	1.00	.05	0.6	.19
383 Electrical machinery	.62	9.9	1.00	.005	0.1	.16
384 Transport equipment	.73	13	1.00	.04	0.9	.24
385 Professional goods	.33	1.8	.58	.1	1.1	.29
390 Other	.62	3.2	.98	.05	0.7	.21

Note: Probability refers to the posterior probability that the respective 1963 variable enters the equation.
[a]t = 1963 labor variable.

insignificant in all twenty-eight regressions. Furthermore, t-values for aggregate national endowments are typically quite large. While the posterior probabilities that the industry's capital and national wage influence labor demand exceed 50% for eighteen of twenty-eight industries, the small explanatory power of national wage rates and the significance, for numerous industries, of country-wide endowments in explaining labor demand weaken the case for the adjustment cost model.

9.7 Conclusion

These preliminary tests of three alternative models of transitional international growth provide partial support for each view of the evolution of international trade and factor prices. While we intend to ex-

Table 9.14 Labor Regressions on Five Endowments

	ISIC Capital		National Wage		Capital		Labor 1		Labor 2	
	Coef.	*t*	Coef.	*t*	Coef.	*t*	Coef.	*t*	Coef.	*t*
Food	11	0.4	4,060	1.1	0	−0.7	−21	−0.6	19	4.4
Beverages	27	10	262	0.6	0	−3.7	−5.6	−2.2	3	5.6
Tobacco	4.2	1.2	385	0.9	0	−1.5	7	1.4	.5	0.8
Textiles	80.8	0.5	1,975	0.9	−.16	−2.1	−47.4	−3.8	15.4	5.2
Apparel	112.4	2.3	−1,956	−1.3	−.15	−3	384	3.3	8	4.4
Leather	158.3	10.3	40.3	0.2	0	−2.5	−2.5	−2.7	1.2	5.7
Footwear	282	5	−85.4	−0.1	0	−3.6	−.1	0	2.7	3.4
Wood	21	2	143.2	0.1	.1	3.2	−39.3	−4.7	7.2	5.3
Furniture	32	1.1	225.3	0.2	0	−1.6	13.2	1.6	4	2.4
Paper	8	2.1	1,086	1	0	−0.7	25	3.3	2.4	1.8
Printing	48	1.9	205.1	0.1	0	−0.4	28	1.1	3.2	1.3
Ind. chem.	22	2.6	1,267	0.7	−.2	−2.4	−21	−1	6	2.4
Other chem.	171	5.3	1,189	0.8	−.2	−3.4	−68	−3.5	4.1	2.4
Petro. refin.	5.4	4.1	−9	−0.1	0	−2.4	2.3	1.6	.3	1.3
Petro., coal prod.	3.1	1.6	−23	−0.2	0	−2.7	3.4	5	.3	1.7
Rubber prod.	107	4.2	1,449	2	−.1	−4.8	−15.4	−2.3	4	4.8
Plastics	39	2.6	270.3	0.4	0	1.3	−9	−1.6	3	4
Pottery	121	6.5	−13	0	0	−1.5	−7	−2.4	2	3.1
Glass	33	2.5	−118	−0.2	0	−2.3	4	0.8	1.5	2.3
Nonmetal prod.	1	0.3	553	0.3	0	0.7	−24.3	−3	8	4.3
Iron and steel	21.3	2.1	2,940	0.8	−.2	1.3	79	2.7	−2	−0.4
Nonferrous metals	13	1	591.2	0.9	0	−0.5	13	3.7	.8	1.1
Metal Prod.	−23	−0.5	2,621	0.8	0	0.3	82	1.7	7	1.6
Machinery	61.4	4.6	3,419	0.8	−.2	−1.2	30	0.9	9.2	1.7
Electrical mach.	75	4.3	2,852	0.8	−.2	−1	−11	−0.5	12	2.9
Transport equip.	68	2.9	7,071	1.5	−.8	−2.8	121	4.5	5	0.9
Prof. goods	27.3	1.7	−521	−0.6	0	−0.5	27	2.8	1.1	1
Other	166	8.7	763	1.5	0	−2.3	−20	−4.7	4	6.5

plore these data more closely in the future, our current assessment is that each of the three models plays an important role in determining trade, growth, and factor returns.

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