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1 Comparing International Trade Data and Product and National Characteristics Data for the Analysis of Trade Models

Keith E. Maskus

1.1 Introduction

Empirical analysis of international trade models is a crude art. In part, this situation is due to the difficulty of articulating fully general trade theories that are amenable to rigorous testing with observable data. The empirical analyst is generally left making uncomfortable choices among functional forms, variable definition, and the like, in the hope of achieving a tolerable approximation of underlying economic relationships. The nature and validity of statistical inference in this context are often unclear (Leamer 1984).

A further difficulty, however, lies in the availability, quality, and comparability of international data needed to undertake trade analysis. This problem is literally huge. With the simultaneous existence of many countries and many competing trade theories (each theory with its suggested set of variables, aggregation levels, and so on), the researcher is faced with an enormous data-collection task in a comprehensive analysis. There is also the need to reconcile figures across the statistical reporting systems of countries or multilateral agencies. It is apparent that measurement problems and lack of full comparability across units (e.g., countries, industries, time) are likely to be endemic in empirical trade analysis.

This paper is focused on these data problems. Its main purpose is to illustrate several empirical hurdles that the researcher must surmount in assembling the data needed for a typical analytical project. In that regard, the paper resembles an extensive data appendix; the level of detail would in most studies be relegated to an uninformative page of supplementary text.

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The objective is to illustrate the major data-related problems facing the researcher in a particular area of trade analysis: models of production and trade inspired mainly by the factor-proportions theory. Because the thrust of the paper is on data issues, no attempt is made here to develop new analytical or econometric approaches to this branch of trade theory. Rather, I employ straightforward data analysis and descriptive devices to elucidate a variety of problems that surface in a typical research project: exchange-rate translation, adjustments for cyclicality, and measurement error.

The analysis begins in the next section with brief comments on developing an estimating framework from the factor-proportions model. That model predicts certain relationships among three types of economic variables across countries: technology, as embodied in factor intensities or factor productivities by industry; international trade; and factor endowments. Accordingly, in the subsequent three sections I consider data problems that emerge in separate forms of analysis found in the literature. I further use this tripartite split of empirical models to illustrate three significant data issues that surface in trade analysis. First, in section 1.3, I present indicators of technology similarity across 28 countries and 28 manufacturing industries in 1984, where these indicators are simply measures of factor productivity. The supplementary concern in this section is with the choice of market or purchasing-power-parity (PPP) exchange rates to translate factor productivities into a common currency. It happens that this choice makes a substantial difference in computing direct measures of labor productivity but does not fundamentally change international rankings of total factor productivity. Second, in section 1.4, I compute correlations between trade performance and factor intensities in each country across the set of manufacturing sectors. These correlations are taken mainly to be descriptive indicators of the input basis of international competitiveness. The supplementary consideration relates to the cyclicality of trade and intensity measures, which I examine with U.S. and Japanese data. The results suggest that factor shares are insensitive to cyclical influences, but that labor productivity varies over the business cycle. Third, in section 1.5, I estimate functions relating net exports in each industry to endowments across 38 countries, the model most closely suggested by the factor-proportions theory. Attention is paid there to the econometric issues of unequal error variances and measurement errors. The analysis suggests that inference in the trade-and-endowments model is sensitive to the existence of these problems.

I note here that the generic problems mentioned—exchange-rate measurement, cyclicality, and measurement errors—are neither exhaustive of potential difficulties nor unique to the models in which each is considered. Their empirical applications are limited here primarily to contain within reasonable bounds the volume of results to be reported. This study is highly data-intensive and yields a quantity of outcomes that likely will tax the patience of many readers. Further, the focus is on data problems, which I believe are adequately presented in the framework chosen.

1.2 Comments on Estimating Factor-Proportions Trade Models

To establish context for the data analysis, I begin with some comments on the state of the literature on empirical estimation of factor-proportions models (for recent reviews of this enormous literature see Deardorff 1984 and Leamer 1984). Interest centers on general variants of the model, with many goods, factors, and countries. The standard empirical framework has become that introduced by Leamer and Bowen (1981), based on Vanek's (1968) contribution.

Allow T_i to denote the vector of net exports across commodities for country i, A_i its matrix of total factor intensities, V_i its vector of endowments, s_i its share of world consumption, and V_w the vector of world factor endowments. Then equation system (1) follows immediately:

$$(1) \qquad T_i = A_i^{-1}(V_i - s_i V_w).$$

These equations state that commodity trade is a function of excess factor supplies, assuming the inverse matrix exists. This relationship depends not only on the distribution of endowments across countries, but also on different technologies and consumption patterns.

The Heckscher-Ohlin model places numerous restrictions on these relationships in order to focus strictly on factor endowments as sources of trade. Perhaps most significantly, it assumes that all countries have full access to all technological knowledge concerning production, resulting in the existence of identical production functions, which are themselves assumed to exhibit constant returns to scale. Moreover, countries are assumed to be sufficiently similar in their factor supplies that there emerges in general equilibrium a substantial overlap in the range of commodities produced. Under these conditions, factor prices are the same everywhere, and the country technology matrices all equal a common matrix, A. Under these and other assumptions, we can write the basic equations as

$$(2) \qquad T_i = A^{-1}(V_i - s_i V_w).$$

This system of equations is instructive in several regards. The Heckscher-Ohlin model consists of relationships among three variables: trade, factor intensities, and endowments. With respect to production techniques, general equilibrium under free trade is characterized by equal relative factor prices, factor intensities, and average and marginal factor productivities across countries. This prediction underlies the empirical comparisons made in the next section as simply and indirectly indicating differential technologies.

Further, the theory underlying equations (2) has inspired certain ad hoc empirical efforts to explain the structure of commodity or factor trade. First, many researchers have estimated the relationship between trade performance, such as scaled net exports, and factor intensities across industries within a country (Baldwin 1971, Branson and Monoyios 1977, Stern and Maskus 1981). It is clear from equations (2), however, that this technique provides no necessary inference on the structure of endowments or the validity of the theory. Moreover, the use of endogenous factor intensities as exogenous variables in regression analysis is questionable. Thus, such analysis is of descriptive value only, though it can be useful in that context. For example, cross-industry correlations can be informative measures of how differences in factor intensities are related to differences in trade performance, thereby serving as indicators of a particular definition of factor content. I perform in section 1.4 another such study on recent trade and production data across a set of 28 countries.

Second, other researchers have been inspired by the model to regress measures of net trade on factor endowments across countries within particular sectors (Leamer 1974 and 1984, Chenery and Syrquin 1975). This approach surely comes closer to the spirit of the Heckscher-Ohlin model, given the assumed exogeneity of factor supplies, but still admits no clear inference about the theory itself. Nonetheless, the results of such studies are informative estimates of the impacts of differences in endowments on trade. Again, I perform a similar analysis in section 1.5.

To be crassly empirical, I note that one sizable advantage of pursuing such ad hoc descriptive approaches is that the researcher is not constrained to satisfy the full requirements of the Heckscher-Ohlin model. The model, for example, is a proposition about trade across all commodities, rather than, say, across only manufactures, the typical focus of analysis and the one adopted here. Data availability for nonmanufactures is highly problematic, however, particularly for an analysis across countries. Data on trade in services are virtually absent. Thus, the researcher may proceed by considering subsets of goods (and factors and countries). However, it should be clear that statistical inference in such models is likely to be somewhat dubious.

This state of affairs is dissatisfying, though hardly unique to empirical international trade analysis. We can say relatively little about the empirical determinants of the pattern of trade in a rigorous way.[1] Yet we can say much about them in an informative way since we remain interested in examining suggested relationships in the data, even of an ad hoc nature.

It is in that spirit that I conduct the illustrative data analyses below. Again, the main point of this paper is to discuss practical data problems that emerge

1. Some analysts have performed fully articulated tests of the factor-proportions theory based on the factor-content version of equations (2) and independent measures of trade, intensities, and endowments (Bowen, Leamer, and Sveikauskas 1987, Brecher and Choudhri 1988, Maskus 1985). It is clear from these studies that the Heckscher-Ohlin theorem departs significantly from its exact quantitative predictions, which is hardly surprising given the extraordinary assumptions of the model. It is less clear how to interpret the severity of these departures; the consensus seems to be that factor endowments exert a positive and linear influence on the factor content of trade flows but that they hardly constitute the only important source of trade.

in the analysis of trade structure. This discussion takes place in the context of each approach in turn.

1.3 Factor Intensities, Factor Productivities, and Technology

As noted by Dollar, Wolff, and Baumol (1988), the factor-proportions model, or more accurately its cousin, the factor-price-equalization (FPE) theorem, implies numerous relationships that should be observable in comparative international production data in a free-trade equilibrium. The equalization of factor prices, in conjunction with identical constant-returns technologies, should result in identical factor intensities and factor productivities across nations within each tradable-goods industry. An interesting feature of this model is that labor productivity at the microeconomic level is unrelated to the aggregate capital-labor endowment, which plays a prominent role in macroeconomic explanations of productivity convergence (Baumol 1986, De Long 1988, Norsworthy and Malmquist 1983).

In the present context I focus on microeconomic labor, capital, and total-factor productivity in producing value added in 28 countries. The analysis is somewhat broader than that in Dollar, Wolff, and Baumol (1988), especially in terms of country coverage. That paper compared labor productivity in a set of 13 industrial countries across essentially the same set of manufacturing industries as those considered here. I add data on production and labor and capital inputs in 15 other countries, including several developing nations, in an attempt to examine technology indicators over varying levels of development.

Note that computations of international factor productivities do not constitute a rigorous test of the notion that technologies are linearly homogeneous and internationally common. For example, differences in productivities could be consistent with identical technologies if there exist impediments to trade or other influences that prevent FPE. Further, the FPE model presumes that factors are defined to be of homogeneous quality across countries, which presumption surely contradicts the facts in some degree. Finally, differences in observed productivities could simply result from measurement difficulties. Thus, computations of this sort are designed simply to investigate how prominently the predictions of the FPE model turn up in the data. If the FPE model appears consistent with the data, we might reasonably question the notion that technology differs markedly across countries.

1.3.1 Data Overview

For these purposes, data were assembled or constructed on value added, employment, and net capital stock (along with gross output and wages and salaries for later analysis) for the 28 3-digit industries of the International

Standard Industrial Classification (ISIC) in 28 countries for the year 1984. These data were taken from United Nations publications that attempt to present figures on industrial characteristics across countries on a consistent basis.[2] The countries and industries are given in table 1.1.

In studies of this sort, data-related problems of two general kinds emerge: the quality of the raw data themselves and conceptual difficulties in variable definition. Within the former problem we may consider international data availability and comparability, along with industry classification and aggregation.

The choice of countries was governed by the ability to assemble reasonably complete data sets from the U.N. volumes, along with a desire to include nations at different levels of industrialization or development. With 28 coun-

Table 1.1 **Countries and Manufacturing Industries Used in Productivity Comparisons**

Country	(Abbrev., n, Grade)	Industry	(ISIC Code, Abbrev., m, Grade)
Australia	(AU, 28, A)	Food products	(311/2, FD, 28, B)
Austria	(AS, 28, B)	Beverages	(313, BV, 27, B)
Canada	(CA, 28, A)	Tobacco	(314, TB, 26, D)
Chile	(CH, 28, C)	Textiles	(321, TX, 28, C)
Colombia	(CO, 28, C)	Wearing apparel	(322, AP, 28, C)
Cyprus	(CY, 24, C)	Leather and products	(323, LT, 28, B)
Denmark	(DE, 28, B)	Footwear	(324, FT, 28, C)
Ecuador	(EC, 28, B)	Wood products	(331, WO, 28, B)
Finland	(FI, 28, A)	Furniture and fixtures	(332, FU, 28, B)
West Germany	(GE, 24, C)	Paper and products	(341, PA, 28, B)
Greece	(GR, 28, C)	Printing and publishing	(342, PR, 28, C)
Indonesia	(IN, 25, D)	Industrial chemicals	(351, IC, 24, C)
Ireland	(IR, 24, C)	Other chemical products	(352, OC, 25, C)
Israel	(IS, 25, D)	Petroleum refineries	(353, PE, 21, D)
Italy	(IT, 21, C)	Petroleum and coal products	(354, PC, 20, D)
Japan	(JA, 27, A)	Rubber products	(355, RU, 28, B)
South Korea	(KO, 28, B)	Plastic products, nec	(356, PL 28, B)
New Zealand	(NZ, 26, C)	Pottery, china, etc.	(361, PT, 26, B)
Norway	(NO, 28, A)	Glass and products	(362, GL, 26, B)
Philippines	(PH, 28, C)	Nonmetal products, nec	(369, NM, 27, B)
Portugal	(PO, 27, B)	Iron and steel	(371, ST, 27, C)
Singapore	(SI, 24, C)	Nonferrous metals	(372, NF, 26, C)
Spain	(SP, 28, C)	Metal products	(381, MP, 28, B)
Sweden	(SW, 28, B)	Machinery, nec	(382, MA, 28, B)
Turkey	(TU, 28, C)	Electrical machinery	(383, EM, 28, B)
United Kingdom	(UK, 28, A)	Transport equipment	(384, TR, 28, C)
United States	(US, 28, A)	Professional goods	(385, PG, 27, B)
Venezuela	(VE, 28, C)	Other industries	(390, OT, 28, C)

Note: nec = not elsewhere classified; n = number of industry sectors per country; m = number of countries per industry sector; Grade = author's assessment of data reliability based on collection and reporting practices.

tries, 28 industries, and data on value added, employment, establishments, 15 years of gross investment and investment deflators (see below on construction of sectoral capital stocks), and two definitions of exchange rates, there are a maximum of 14,586 possible observations that could enter the analysis. As may be expected, however, some of these data were missing. My approach to missing data was twofold. If I believed that a reliable estimate of an unavailable figure could be generated from surrounding data (e.g., investment in a particular year from investment data in adjacent years or employment shares based on output weights), I made such an estimate. Otherwise, data were simply treated as missing. This approach resulted in 842 missing observations (5.8 percent of the maximum) and 1,004 constructed observations (6.9 percent of the maximum and 7.3 percent of the data used).

On this score, it seems that unavailable data do not pose a significant problem here. Note, however, that missing and estimated data are not evenly distributed across countries, sectors, and variables (full details on such data problems are available on request). Two comments may be made. First, the input variable with the most significant number of missing or constructed observations is past gross investment. This result is hardly surprising; data become increasingly thinner in the U.N. volumes as the researcher goes back in time. Particularly problematic countries in this regard include Greece, Indonesia, Israel, New Zealand, the Philippines, Spain, Turkey, and Venezuela. I constructed few other production variables, lending more confidence to the accuracy of the data beyond gross investment. Second, certain sectors are prone to have missing data because several countries combine them into aggregates, from which it is impossible to disentangle the contributions of subsectors. Data in other sectors simply are not reported by a few nations. These problems are most prevalent in industrial chemicals, other chemical products, petroleum refineries, and petroleum and coal products; the countries with the most limited sectoral data include Germany, Indonesia, Ireland, Italy, Singapore, and Cyprus.[3] A summary of this situation is provided in table 1.1.

The next issue is the international comparability of the data. The major purpose of the ISIC is to establish a consistent classification of industrial activity within which countries may report their production characteristics. Inevitably, however, there is some divergence in the country classifications from which the ISIC data are compiled. Interestingly in this regard, there is gener-

2. See United Nations, *Yearbook of Industrial Statistics*, vol. 1, *General Industrial Statistics*, various years (formerly *The Growth of World Industry*, vol. 1). Detailed output data are available in volumes 2 of these series.

3. In fact, Cyprus has several "zero" entries in its data, indicating the absence of industries, even at this level of aggregation (petroleum and coal products, iron and steel, nonferrous metals, and professional goods). This specialization is interesting from the standpoint of trade theory, but the empirical focus on intensities and productivities prevents meaningful use of the data. Hence, observations for these industries are considered missing.

ally less consistency between the ISIC and the classification systems of the developed countries than between the ISIC and those of the developing countries, because the former nations have long since established their own categorization procedures while the latter nations have developed theirs under the guidelines of the ISIC.[4]

A detailed reading of the country notes in the U.N. *Yearbook of Industrial Statistics* reveals that countries construct their measures of the input and output variables differently.[5] The meticulous reader is referred to that volume and to supplementary statistical publications.[6] To provide a flavor for the problem, I now list what might be considered the "standard" U.N. brief definition for each of the variables in question. In turn, table 1.2 lists my assessment of whether the variables may be considered overstatements or understatements in each country relative to these standards. For example, Indonesia includes in its estimates of wages and salaries employer contributions to national health and pension insurance programs, whereas the U.N. definition excludes these supplemental labor costs. Thus, Indonesia's wages are overstated, though by an unknown amount.

Gross output or value of shipments is a comprehensive measure of all explicit and implicit receipts of the industry, not simply sales of the principal output. It clearly is overly inclusive from the standpoint of the international economist's ideal definition of "final-goods output." Typically, output is in producer prices, including all indirect taxes but excluding subsidies.

Value added is gross output less the cost of materials and supplies consumed, electricity purchased, and contract and commission work done by others. Value added generally includes capital-consumption allowances and is typically measured in producer prices.

Employment is the number of wage earners and salaried employees averaged over the year (12 months or four quarters), excluding homeworkers, unpaid family workers, and working proprietors; including the latter categories results in *persons engaged.*

Wages and salaries include all payments in cash or in kind made to employees, including direct wages and salaries and other payments and allowances. Social insurance contributions and the like paid by the employer are excluded, though they could be included in a concept of total labor cost.

Gross fixed capital formation or gross investment includes the value of pur-

4. See United Nations, *Final Draft of the Revised International Standard Industrial Classification of All Economic Activities (ISIC);* Revision 3, ST/ESA/STAT/SER. M/4/Rev. 3/Add. 2, December 12, 1988.

5. Reference to official national statistical publications would likely reveal even more discrepancies, but this task lies beyond my patience and resources and that of most other researchers.

6. United Nations, *International Recommendations for Industrial Statistics,* ST/ESA/STAT/SER.M/48/Rev. 1, 1983, and United Nations, *Recommendations for the 1983 World Programme of Industrial Statistics,* ST/ESA/STAT/SER.M/71 (Parts 1 and 2), 1981.

Table 1.2 **Threshold Numbers of Persons Engaged per Establishment for Inclusion and Qualitative Indicators of Discrepancies in Variable Definition and Industrial Classification, by Country**

Country	Threshold Nos. of Persons	Gross Output	Value Added	Employment	Wages and Salaries	Gross Investment	Industrial Classification
AU	4	O	?	—	U	—	Minor
AS	20	—	—	O	O	O*	Medium
CA	1	—	—	—	—	—	Medium
CH	50	—	—	—	—	—	None
CO	10	—	—	U*	U*	O*	None
CY	1	O*	—	U	U	—	Medium
DE	6[a]	?	?	—	O	?	Minor
EC	10	U	U	—	—	O*	None
FI	5	U	U	—	—	—	None
GE	1[a]	O*	?	—	—	O*	Significant
GR	10	?	U	—	O	—	Minor
IN	20	—	U	—	O*	O*	Medium
IR	3	U*	U	?	U*	—	Medium
IS	5	U*	—	—	O	O*	Minor
IT	20[a]	U	U*	—	—	O*	Significant
JA	4	—	—	?	O	—	Minor
KO	5	—	—	O	—	O*	None
NZ	2–10	U*	?	?	—	—	Minor
NO	3–5	O*	—	—	—	O	Minor
PH	10	—	—	—	—	—	Minor
PO	1[b]	—	—	?	O	—	None
SI	10	U*	U	?	O*	O*	Minor
SP	1	U	U	—	O	—	Medium
SW	5	U	?	?	—	?	None
TU	25	O	—	—	—	O*	Minor
UK	1[a]	O	?	—	U*	—	Minor
US	1[a]	U	U	—	—	?	Minor
VE	5	U	—	—	—	—	None

Note: U = understated; O = overstated; * = potentially significantly misstated; ? = either direction of misstatement is possible. All comparisons are made with respect to "standard" U.N. definitions. Descriptors in final column refer to extent of difference of country classification scheme from ISIC.

[a]Estimated from data gathered from surveys at more aggregative levels.

[b]Selected industries only.

chases of new and used fixed assets, plus internal construction or improvements of fixed assets, less corresponding sales of assets. This definition does not include revaluation or depreciation of cumulated past investments.

Number of establishments indicates the quantity of units that, in principle, engage in predominantly one kind of activity at a single location under single ownership. The establishment is the basic reference unit for the ISIC data. For purposes of comparison, I assume that the "standard" U.N. definition includes establishments with five or more persons engaged somehow in production at or for the site.

A glance at table 1.2 will demonstrate the qualitative variances in these definitions across countries. The most striking aspect of the table is that nations collect or estimate data for establishments of widely varying minimum sizes. This fact in itself generates concern over cross-country comparisons of inputs or outputs, since countries that exclude small establishments may be ignoring significant amounts of activity, perhaps by the cutting-edge new sectors. As it happens, however, in manufacturing this exclusion rarely eliminates more than 5–10 percent of employment and output.[7] However, it implies that international comparisons of, say, value added per establishment as measures of aggregate returns to scale are highly suspect.

The remaining entries in table 1.2 refer strictly to my qualitative assessments of differences in variable definitions, irrespective of the minimum threshold on size. The basic impression is of broad international consistency in most data groups, except for gross investment. The preponderance of overstatements in that category reflects the practice of about a third of these countries not to deduct asset sales from gross investment. These assessments should be kept in mind when considering the cross-country productivity comparisons listed below. Note, finally, that these judgments on data comparability are based solely on each country's definition, and presumed measurement, of the respective variables. It is not possible in this context to assess the inherent quality of the national data themselves. There are surely also substantive differences in internal data-collection methods (e.g., sampling versus full enumeration, mail versus in-person interviews, frequency of revisions) and subsequent data-manipulation techniques that influence the accuracy of the reported figures. This issue is not further considered here.[8]

Another issue worth brief discussion is industry definition or aggregation. Researchers working within the ISIC data-set on manufactures are constrained to using the 28 3-digit sectors, although a few countries report data on 9 additional 4-digit sectors. These categories are highly aggregative, and it might be preferable for the analyst to consult national statistical references in order to construct consistent definitions across countries of more detailed industry classifications—clearly a huge and complex task. The question of conceptually appropriate industry aggregation is complicated. In principle, we would like to know that subaggregates within a category are more alike in important ways than subaggregates are across categories. From the standpoint of the factor-proportions theory, inter alia, we would like factor intensities of sub-

7. See country notes in the *Yearbook of Industrial Statistics*.

8. We might expect that data quality is positively correlated with the level of development, which seems to be the case in the quality rankings in Summers and Heston (1984), but there is no written evidence to that effect in the U.N. publications.

aggregates within a sector to be identical, thereby defining an industry in those terms, and factor intensities across sectors to be as distinct as possible. There is no way to examine this question within the U.N. data-set across a broad sample of countries, although experimentation with available 4-digit detail suggests that within-aggregate intensities are marginally more similar than across-aggregate intensities. A related problem is that "enterprises" and "establishments," the main observational units in the ISIC data, undertake production in several activities that may be spread across different aggregate categories. The U.N., and presumably the statistical offices of the reporting countries, evidently take pains to allocate these activities appropriately, by principal sectors. Nonetheless, concern remains over the accuracy of the resulting industry classifications in this regard.

Beyond definition issues lies the fact that the cross-country distribution of inputs and outputs in each industry depends on sector-specific trade impediments or inducements. This problem is not easily quantified in any indirect context, and direct measures of the trade barriers and their economic impacts are scarce. I have incorporated a qualitative assessment of the severity of such barriers by sector (Nogues, Olechowski, and Winters 1986) into the rankings of the data quality discussed next.

The data problems discussed so far underlie the subjective grade I have assigned to each country and industry in table 1.1, which grades may be considered the sectoral analogues of the national data rankings in Summers and Heston (1984). These rankings are meant simply as warning markers to be kept in mind when considering the empirical results in the remainder of the paper.

The discussion so far has focused on difficulties in the reported data. There are also difficulties in matching measurement to theoretical concept. That is, even if the data were measured perfectly, the measured variables may not be completely appropriate for the estimation task. Consider, for example, the variables used here for the productivity comparisons. The output measure is value added, rather than gross output, for two reasons. First, it is not generally feasible to develop a measure of real use of materials and intermediates by constructing some price index of these inputs. Second, as noted earlier, gross output as given by the value of shipments is probably too inclusive a measure to serve as a clear indicator of production.

Using value added as output, however, carries the risk that different materials prices across countries will affect measured factor productivities. Equally troubling is that input productivity ideally should be measured as real output per unit of real input. The focus here, as in Dollar, Wolff, and Baumol (1988), is on the production of nominal value added. This usage is appropriate if the price of value added, an elusive concept, is equalized by trade and therefore serves simply as a scaling factor in comparative national outputs. Such equalization can be expected in the Heckscher-Ohlin model with free trade in outputs and intermediates, but the existence of such free trade is problematic, as noted earlier. A simple appeal to the Stolper-Samuelson theorem notes that output tariffs also will affect the international structure of factor productivity.

Two kinds of primary inputs are employed here. The first is simply employment by industry. Employment clearly does not fully capture the actual labor effort expended in production, and we might prefer a variable such as hours actually worked. The ISIC data-base provides data on hours worked by operatives (e.g., production workers plus clerical workers), but these data are not sufficiently inclusive of labor effort and are not available for enough countries to be useful. The International Labour Organisation[9] publishes data on average length of workweek across countries in some ISIC sectors; this data may be used with employment to construct an annual measure of total hours worked. The use of such measures here resulted in productivity computations that were nearly perfectly positively correlated with those simply using employment, so no additional information was provided. Hence, I report here results using employment only.

In my view, a more significant problem is that, ideally, one should find measures of labor inputs of identical quality both within and across countries. It is evident that laborers vary markedly with respect to education and skills and that the variance affects the measured productivity of the typical worker in each country. Attempting directly to adjust the data on an industry basis for this problem is virtually an impossible task, however.[10]

The second primary input is a constructed measure of real net capital stock by sector. These stocks are computed to avoid use of gross book value, which is a notoriously inconsistent concept across countries. One may approach this construction in a variety of ways, but in the context of the ISIC data I felt constrained to generate capital stocks based on accumulated and depreciated past investments. In particular, I assembled data on nominal gross fixed capital formation by industry for the 15-year period culminating in 1984. Net capital was computed as accumulated investment flows, assuming a 15-year asset life and a depreciation rate of 13.33 percent.[11] Annual investment figures were deflated by implicit capital deflators for each country (investment deflators by sector are unavailable) found in Summers and Heston (1988), which are based on PPP exchange rates for investment relative to the U.S. dollar. These deflators are expressed as indexes relative to the United States. Accordingly, a series of capital deflators (1984 = 1.0) for the United States[12] served as a basis for computing the country-specific investment-price indices, with 1984 as base year.

9. International Labour Organisation, *Yearbook of Labour Statistics*, various years.

10. See Clague (1991) for further discussion of the labor-quality issue and some efforts at adjustment.

11. For a few countries the investment series could not be extended backward the full 15 years, and so the depreciation factor was adjusted accordingly.

12. *Economic Report of the President* (Washington, D.C., 1989).

As with any measures of capital stock, this form of estimation is open to criticism. First, the use of 15-year investment flows forced me to push the data collection to periods well prior to 1984. As noted earlier, it seems that the U.N. data become thinner and less reliable the further back one examines them. There is the additional problem that classification schemes must be updated periodically to reflect changing economic activity. As it happened, the ISIC scheme was not varied during this period; all of the data here refer to ISIC Revision 2, which was adopted in 1968 and is only now being supplanted by Revision 3. However, individual countries effected changes in their classification systems over this period. The United States, for example, issued a major change in its Standard Industrial Classification in 1972, with subsequent revisions in 1977 and 1982. Where possible, I adjusted the investment data to reflect such changes, but otherwise I was forced to rely on the ISIC to report them consistently. In principle, of course, there should be consistency in each year because individual countries are supposed to report their data compatibly with the prevailing version of the ISIC. Second, and more fundamentally, the estimating procedure tends to overstate the capital stocks of countries that have experienced more recent investment growth relative to other countries, especially those with much larger initial stocks. That is, pre-1970 capital stocks are completely discounted here, which may not be fully sensible in mature economies and mature industries. Again, however, the informational requirements for assembling sectoral capital-stock estimates based on some vintage model are extraordinary. Third, the concept of capital itself is elusive in a world of changing relative prices (Leamer 1984). Finally, as with labor, there is the question of homogeneity of capital quality across nations, beyond simply the vintage issue. I cannot assess the severity of these problems with the given data. I simply note that the consistency with which the capital stocks have been computed should lend as much confidence as possible to their international comparability.

A final comment about the data is in order. The ISIC data are reported in the local currencies of each country, necessitating a conversion to dollars. As is well known, the choice of exchange rates for this purpose can have a substantial impact on measurements of productivity. Two cases are considered here. The first is simply the 1984 "market" exchange rate for each country's currency with the dollar.[13] It is likely that the value of the dollar was substantially in excess of many of its equilibrium bilateral values, however defined, in 1984. Thus, nominal value added outside the United States is presumably understated in dollars by conversion at these rates.[14] I therefore chose also to convert value data into dollars using the PPP rates for gross national product

13. See line *rf* in International Monetary Fund, *International Financial Statistics*, various years. I place the word "market" in quotation marks because for many countries this exchange rate is not determined in the foreign exchange markets.

14. Capital stocks would also be understated, but capital productivity, or value added per dollar of capital, would be unaffected by the choice of exchange rate.

listed in Summers and Heston (1988). Note, however, that PPP rates are not optimal for such comparisons because they are designed to equalize the local-currency value of a standardized basket of commodities with normalized international prices. Such equalization may bear little relationship to sectoral input productivity. In fact, the near hyperinflation that was experienced in the early 1980s in several of the countries in this study would argue for assigning substantially lower-than-market values to their currencies while the PPP rates generate substantially higher values for them. In turn, the PPP rates tend to overstate factor productivity in developing countries relative to the developed countries, as will be seen.

1.3.2 Comparisons of Factor Productivity

Armed with this lengthy list of caveats about the data, we turn now to the computations of factor productivity. To conserve space and to consider productivity at differing levels of industrialization, the 28 countries have been separated into three subgroups: a group of 12 industrialized nations (Australia, Austria, Canada, Denmark, Finland, West Germany, Italy, Japan, Norway, Sweden, the United Kingdom, and the United States); a group of 7 semi-industrialized nations (Greece, Ireland, New Zealand, Portugal, Spain, Cyprus, and Israel); and a group of 9 developing countries (Chile, Colombia, Ecuador, Indonesia, South Korea, Philippines, Singapore, Turkey, and Venezuela). Clearly, this classification is somewhat arbitrary, and complaints could be raised particularly about the placement of Korea and Singapore. The grouping seems instructive, however, and is maintained for the time being.

Measures of factor productivity and related variables are presented in table 1.3. For each industry and country group I note: average labor productivity, or value added per employee; average capital productivity, or value added per dollar of net capital stock; the average capital-labor ratio; and average value added per establishment. To examine dispersion of individual countries around these simple averages, I further list the coefficient of variation of each sample group in parentheses. These measures are computed using both market and PPP exchange rates, and this choice made a significant difference.

Considering first average labor productivity at market exchange rates, it is clear that in most sectors labor produced substantially higher value added in industrial countries (I group) than it did in semi-industrial countries (S group), while the latter laborers were marginally more productive than those in the developing countries (D group). Exceptions include most of those industries with unusually high capital-labor ratios (industrial chemicals, petroleum, petroleum and coal products, iron and steel, and nonferrous metal products) plus the other chemicals industry. In most of these cases labor productivity in Ds exceeded that in Ss, but still was below that of the industrial nations. In these industries the capital-labor ratios in the Ds were particularly high, perhaps reflecting more recent expansion of investment in that group. Note that the Is

Table 1.3 **Simple Averages and Coefficients of Variation of Industry Characteristics, 1984, at Market and PPP Exchange Rates for Country Groups**

Industry, Country		Value Added per Employee ($ thousands)		Value Added per Capital ($)	Capital per Employee ($ thousands)		Value Added per Establishment ($ millions)	
		Market	PPP	Market or PPP	Market	PPP	Market	PPP
311/2	I	30.8	34.5	1.7	19.2	22.1	1.9	2.2
FD		(.43)	(.36)	(.38)	(.24)	(.29)	(.56)	(.55)
	S	17.9	30.6	1.3	12.3	21.8	1.1	2.1
		(.38)	(.44)	(.23)	(.43)	(.58)	(1.09)	(1.48)
	D	13.2	26.9	1.1	14.3	28.5	1.0	2.4
		(.50)	(.51)	(.58)	(.64)	(.53)	(.96)	(1.08)
313	I	52.7	58.7	1.5	36.4	41.2	5.1	5.8
BV		(.36)	(.30)	(.29)	(.29)	(.27)	(.47)	(.45)
	S	27.0	48.2	1.3	19.7	35.4	2.0	3.6
		(.44)	(.46)	(.42)	(.60)	(.51)	(.85)	(1.00)
	D	27.7	57.4	1.7	20.5	41.5	3.9	8.7
		(.55)	(.45)	(.76)	(.51)	(.38)	(.68)	(.75)
314	I	138.8	162.8	4.6	26.8	30.4	35.5	40.9
TB		(1.04)	(1.11)	(.83)	(.57)	(.53)	(.73)	(.77)
	S	97.6	226.5	3.7	19.7	43.8	29.0	68.2
		(1.67)	(1.87)	(.66)	(1.14)	(1.37)	(1.78)	(1.94)
	D	91.1	200.5	7.8	21.2	41.7	29.4	66.4
		(1.49)	(1.71)	(1.32)	(1.02)	(1.11)	(1.52)	(1.65)
321	I	21.1	23.8	1.8	12.1	14.0	1.2	1.4
TX		(.25)	(.19)	(.28)	(.21)	(.26)	(.53)	(.55)
	S	11.3	19.1	1.5	7.7	13.0	0.8	1.7
		(.30)	(.33)	(.28)	(.42)	(.37)	(1.05)	(1.41)
	D	9.5	19.2	1.2	10.9	21.4	1.3	2.9
		(.58)	(.47)	(.91)	(.64)	(.35)	(.69)	(.76)
322	I	14.9	16.8	4.7	3.9	4.5	0.7	0.8
AP		(.27)	(.21)	(.66)	(.33)	(.40)	(.55)	(.50)
	S	8.4	14.5	3.0	2.8	5.1	0.4	0.8
		(.30)	(.43)	(.26)	(.32)	(.59)	(.95)	(1.25)
	D	6.2	13.0	2.8	2.7	5.7	0.5	1.1
		(.60)	(.63)	(.93)	(.52)	(.51)	(.70)	(.85)
323	I	19.8	22.4	2.9	7.7	9.0	0.7	0.8
LT		(.25)	(.21)	(.45)	(.31)	(.40)	(.53)	(.57)
	S	13.7	23.8	2.1	5.2	9.7	0.4	1.0
		(.36)	(.43)	(.08)	(.48)	(.59)	(1.38)	(1.65)
	D	8.6	18.3	1.7	5.8	12.4	0.5	1.2
		(.57)	(.61)	(.48)	(.57)	(.56)	(1.00)	(1.13)

(continued)

Table 1.3 (continued)

Industry, Country		Value Added per Employee ($ thousands)		Value Added per Capital ($)	Capital per Employee ($ thousands)		Value Added per Establishment ($ millions)	
		Market	PPP	Market or PPP	Market	PPP	Market	PPP
324	I	17.0	19.2	3.7	5.5	6.3	1.3	1.4
FT		(.25)	(.18)	(.57)	(.38)	(.38)	(.64)	(.60)
	S	10.8	17.5	3.2	3.3	6.2	0.6	1.1
		(.51)	(.37)	(.59)	(.48)	(.69)	(.88)	(1.20)
	D	6.2	12.7	1.5	4.9	10.2	0.5	1.1
		(.45)	(.43)	(.63)	(.57)	(.48)	(.90)	(1.03)
331	I	23.0	25.9	1.6	15.6	17.8	0.7	0.8
WO		(.24)	(.15)	(.39)	(.31)	(.30)	(.55)	(.54)
	S	12.1	20.9	1.4	7.5	13.2	0.4	0.9
		(.40)	(.34)	(.29)	(.40)	(.46)	(1.40)	(1.75)
	D	8.1	16.4	1.0	10.5	20.8	0.6	1.4
		(.52)	(.52)	(.76)	(.64)	(.47)	(.83)	(.95)
332	I	21.4	24.2	2.9	8.9	10.4	0.7	0.8
FU		(.22)	(.19)	(.59)	(.35)	(.39)	(.51)	(.50)
	S	9.4	15.2	2.0	4.3	7.5	0.2	0.4
		(.41)	(.30)	(.45)	(.26)	(.33)	(1.20)	(1.55)
	D	6.1	12.0	1.7	4.5	7.5	0.3	0.6
		(.52)	(.45)	(.82)	(.62)	(.52)	(.70)	(.85)
341	I	37.5	41.7	1.1	37.7	42.1	4.9	5.4
PA		(.34)	(.25)	(.32)	(.46)	(.42)	(.73)	(.68)
	S	27.2	52.6	1.1	26.5	53.6	3.5	7.9
		(.71)	(1.03)	(.45)	(.78)	(1.09)	(1.77)	(2.03)
	D	22.1	47.2	1.1	25.6	58.3	3.4	7.9
		(.90)	(1.06)	(.94)	(.78)	(.91)	(1.60)	(1.75)
342	I	30.4	34.2	2.7	11.9	13.7	1.2	1.5
PR		(.29)	(.23)	(.36)	(.29)	(.32)	(.47)	(.57)
	S	17.4	29.2	1.9	8.4	16.4	0.8	1.8
		(.47)	(.49)	(.30)	(.75)	(1.06)	(1.51)	(1.83)
	D	13.0	26.8	1.3	11.2	24.3	0.9	2.2
		(.49)	(.55)	(.60)	(.51)	(.58)	(1.20)	(1.32)
351	I	59.2	64.2	1.0	73.2	79.1	6.2	6.8
IC		(.44)	(.38)	(.28)	(.73)	(.68)	(.45)	(.41)
	S	26.2	52.2	0.9	32.6	64.4	2.4	5.1
		(.37)	(.53)	(.50)	(.30)	(.45)	(.71)	(.89)
	D	38.3	75.7	1.2	35.9	73.6	3.5	7.8
		(.82)	(.73)	(.73)	(.68)	(.57)	(.48)	(.63)
352	I	50.5	54.5	2.2	24.1	26.6	3.7	4.0
OC		(.56)	(.50)	(.41)	(.38)	(.36)	(.49)	(.45)

Table 1.3 (continued)

Industry, Country		Value Added per Employee ($ thousands)		Value Added per Capital ($)	Capital per Employee ($ thousands)		Value Added per Establishment ($ millions)	
		Market	PPP	Market or PPP	Market	PPP	Market	PPP
	S	19.6	37.1	1.8	8.8	16.2	1.5	3.2
		(.70)	(.80)	(.50)	(.36)	(.51)	(1.28)	(1.52)
	D	25.6	48.8	1.9	14.6	27.8	2.3	4.8
		(.73)	(.49)	(.47)	(.64)	(.54)	(.63)	(.71)
353	I	123.0	136.0	0.9	158.6	173.9	44.7	49.1
PE		(.44)	(.43)	(.68)	(.55)	(.52)	(1.05)	(1.04)
	S	120.1	260.5	2.0	81.0	138.6	70.7	143.0
		(1.08)	(1.10)	(1.55)	(.72)	(.35)	(1.38)	(1.25)
	D	212.9	472.2	2.7	85.4	181.5	111.2	269.7
		(.73)	(.69)	(.78)	(.65)	(.54)	(.96)	(1.14)
354	I	50.0	54.0	1.5	45.2	49.2	1.7	1.9
PC		(.46)	(.43)	(.50)	(.87)	(.84)	(.53)	(.49)
	S	22.1	40.4	1.4	14.6	30.3	0.8	1.8
		(.50)	(.53)	(.59)	(.48)	(.77)	(.73)	(.89)
	D	31.4	68.2	1.5	24.6	51.7	1.9	4.5
		(.65)	(.60)	(.59)	(1.01)	(.90)	(.89)	(1.15)
355	I	28.1	31.4	1.6	17.6	20.0	3.9	4.5
RU		(.38)	(.30)	(.27)	(.32)	(.29)	(.74)	(.76)
	S	16.2	28.2	1.8	8.0	14.1	1.1	2.2
		(.34)	(.45)	(.44)	(.30)	(.24)	(.94)	(1.27)
	D	15.0	30.5	1.9	10.7	21.3	1.7	3.6
		(.73)	(.61)	(.86)	(.79)	(.63)	(.73)	(.67)
356	I	26.6	30.0	1.7	16.5	19.0	1.2	1.4
PL		(.28)	(.21)	(.38)	(.21)	(.23)	(.53)	(.57)
	S	18.0	28.6	1.4	10.4	18.1	0.7	1.2
		(.60)	(.41)	(.25)	(.38)	(.32)	(.77)	(1.08)
	D	10.6	21.5	0.9	14.3	30.8	0.7	1.5
		(.49)	(.42)	(.59)	(.52)	(.63)	(.64)	(.73)
361	I	22.2	24.4	2.3	12.7	13.9	2.0	2.3
PT		(.31)	(.24)	(.37)	(1.00)	(.95)	(.70)	(.70)
	S	11.8	19.4	1.6	8.1	13.8	0.8	1.6
		(.40)	(.28)	(.53)	(.57)	(.50)	(1.17)	(1.50)
	D	8.7	18.4	1.5	7.2	16.2	1.4	3.4
		(.63)	(.46)	(.77)	(.67)	(.57)	(.64)	(.74)
362	I	34.4	37.5	1.5	25.3	27.8	3.1	3.4
GL		(.39)	(.31)	(.27)	(.62)	(.58)	(.61)	(.56)
	S	17.8	30.9	1.5	16.9	31.5	1.2	2.3
		(.37)	(.52)	(.63)	(.67)	(.87)	(.82)	(1.09)

(continued)

Table 1.3 (continued)

Industry, Country		Value Added per Employee ($ thousands)		Value Added per Capital ($)	Capital per Employee ($ thousands)		Value Added per Establishment ($ millions)	
		Market	PPP	Market or PPP	Market	PPP	Market	PPP
	D	15.5	34.0	1.0	20.8	46.5	2.1	5.3
		(.48)	(.41)	(.75)	(.75)	(.65)	(.50)	(.68)
369	I	35.7	39.6	1.3	29.3	32.6	1.2	1.4
NM		(.24)	(.20)	(.28)	(.20)	(.19)	(.35)	(.44)
	S	24.9	42.1	0.9	34.8	70.3	1.1	2.3
		(.49)	(.57)	(.64)	(1.04)	(1.35)	(1.45)	(1.83)
	D	16.7	33.9	0.8	31.2	72.1	1.3	2.9
		(.62)	(.68)	(.89)	(1.00)	(1.12)	(1.05)	(1.21)
371	I	33.9	37.7	1.0	42.3	47.1	7.6	8.6
ST		(.39)	(.31)	(.33)	(.88)	(.81)	(.69)	(.70)
	S	21.4	37.4	0.6	43.3	68.8	3.1	6.7
		(.46)	(.65)	(1.08)	(.79)	(1.63)	(1.42)	(1.64)
	D	26.4	57.1	0.9	40.8	80.4	6.4	15.8
		(.34)	(.42)	(.60)	(.61)	(.50)	(.88)	(1.11)
372	I	35.8	40.1	1.1	46.0	49.3	5.2	5.9
NF		(.34)	(.28)	(.43)	(.85)	(.75)	(.77)	(.76)
	S	43.9	87.8	1.2	27.2	51.4	11.3	27.4
		(1.05)	(1.42)	(.61)	(.66)	(.85)	(2.30)	(2.40)
	D	41.5	87.8	1.6	26.7	53.0	10.8	26.0
		(1.12)	(1.33)	(.60)	(.61)	(.72)	(2.22)	(2.35)
381	I	25.7	28.8	2.0	14.0	16.0	1.2	1.4
MP		(.32)	(.24)	(.35)	(.46)	(.43)	(.60)	(.69)
	S	16.0	26.0	1.6	8.0	14.2	0.6	1.1
		(.51)	(.38)	(.31)	(.26)	(.42)	(.98)	(1.24)
	D	10.9	21.9	1.3	10.4	20.4	0.7	1.5
		(.48)	(.36)	(.52)	(.63)	(.44)	(.63)	(.73)
382	I	29.4	33.0	2.2	16.6	18.6	1.9	2.2
MA		(.35)	(.27)	(.33)	(.87)	(.81)	(.71)	(.77)
	S	19.7	30.5	2.1	8.3	14.4	1.0	1.8
		(.87)	(.71)	(.47)	(.67)	(.60)	(1.10)	(1.20)
	D	10.3	20.3	1.1	10.7	20.7	0.8	1.9
		(.57)	(.36)	(.53)	(.63)	(.43)	(.82)	(.98)
383	I	29.2	32.7	2.1	15.3	17.3	3.6	4.1
EM		(.35)	(.27)	(.32)	(.50)	(.45)	(.61)	(.63)
	S	20.9	35.2	2.0	9.6	17.9	1.7	3.1
		(.47)	(.44)	(.26)	(.50)	(.73)	(.68)	(.77)
	D	14.5	30.1	1.4	11.8	25.3	2.1	4.5
		(.50)	(.51)	(.64)	(.46)	(.49)	(.57)	(.48)

Table 1.3 (continued)

Industry, Country		Value Added per Employee ($ thousands)		Value Added per Capital ($)	Capital per Employee ($ thousands)		Value Added per Establishment ($ millions)	
		Market	PPP	Market or PPP	Market	PPP	Market	PPP
384	I	31.0	34.5	1.6	22.1	25.0	6.6	7.7
TR		(.50)	(.43)	(.43)	(.68)	(.63)	(1.05)	(1.10)
	S	14.8	24.8	1.5	10.5	19.0	1.9	3.3
		(.49)	(.48)	(.59)	(.66)	(.74)	(.97)	(.82)
	D	13.3	27.0	1.0	15.0	31.7	1.6	3.5
		(.43)	(.37)	(.57)	(.44)	(.38)	(.51)	(.69)
385	I	30.0	33.7	2.3	14.6	16.8	1.8	2.1
PG		(.41)	(.34)	(.39)	(.54)	(.57)	(.67)	(.61)
	S	18.5	29.3	2.1	7.1	12.3	1.0	1.6
		(.68)	(.51)	(.43)	(.46)	(.38)	(1.10)	(.94)
	D	10.5	20.0	1.7	8.9	15.4	0.7	1.4
		(.69)	(.60)	(.76)	(.99)	(.73)	(.64)	(.50)
390	I	24.1	27.1	2.4	11.1	12.7	0.9	1.0
OT		(.31)	(.24)	(.38)	(.42)	(.43)	(.64)	(.72)
	S	12.2	19.8	1.8	6.4	12.0	0.3	0.6
		(.43)	(.27)	(.45)	(.44)	(.69)	(.72)	(.93)
	D	7.9	15.7	1.5	7.0	14.9	0.4	0.9
		(.57)	(.47)	(.81)	(.61)	(.67)	(.45)	(.59)

Note: Coefficients of variation are in parentheses. Country groups: I = industrialized group; S = semi-industrialized group; D = developing-country group.

have substantial measured labor-productivity advantages in the most labor-intensive goods (textiles, apparel, leather goods, and footwear).

Regarding capital productivity, or dollars of value added per dollar of net capital stock, if techniques of production are not equalized internationally, because of the existence of barriers to trade in goods and factors, we would expect highest capital productivity in Ds under the factor-proportions model, given the presumed scarcity of capital in those countries. As may be seen, there were a number of such cases in the 1984 data, but we generally observe a capital-productivity ranking across country groups similar to that for labor productivity, suggesting that the Is enjoyed some generalized advantage in production in manufactures.

Further, the Is exhibited the highest capital-labor ratios in all sectors except for nonmetal products and iron and steel. Capital-labor ratios were similar between the Ss and the Ds, suggesting that this country grouping provides little discrimination on that score. Similar comments apply to the ratios of value added per establishment, except for some highly capital-intensive sectors (petroleum, petroleum and coal products, iron and steel, and nonferrous metals), plus nonmetal products. Note again, however, that these latter computations are highly suspicious because of the different minimum sizes reported per establishment across countries.

Further perspective is provided by the coefficients of variation in each sample. These coefficients are generally markedly lower in the I group than in either of the other groups, indicating that within the Is there is relatively little dispersion in techniques. Thus, the factor-proportions model, with its notion of identical technologies, is borne out at least indirectly among these nations. However, there is much wider variation in techniques among the Ss and Ds, as many of the coefficients exceed unity. In conjunction with the sizable gap that typically exists between average techniques in these groups and those in the Is, I conclude from this information that there is relatively little similarity in productivities at different levels of development.

Clearly, however, this conclusion rests on the use of 1984 market exchange rates. Adopting PPP rates resulted in dramatic changes in measured labor productivity and capital-labor ratios across countries. The available PPP rates (Summers and Heston 1988) in 1984 suggested that the currencies for most of the Is were moderately undervalued relative to their PPP with the dollar. Thus, their use here resulted in slight increases in average labor productivities and capital-labor techniques for the Is. It also yielded reductions in the coefficients of variation on value added per employee by raising these figures for most countries relative to those for the United States and typically had the same effect on average capital-labor ratios. For the Ss and, especially, the Ds, on the other hand, PPP rates were typically far different from their (undervalued) market counterparts, and their use yielded large increases in measured value added and capital stocks in those countries.[15] In table 1.3 I show that this conversion typically doubled average labor productivities and capital-labor ratios in the Ds while raising those for the Ss on the order of 80 percent. This adjustment led to mean labor productivities that were much more similar across country groups and even resulted in higher figures for the Ds than for the Is in the most capital-intensive sectors (industrial chemicals, petroleum, petroleum and coal products, iron and steel, nonferrous metals), plus tobacco products and paper products. Moreover, the capital-labor ratios in the Ds became larger than those in the Is in 25 of the 28 sectors. Similar comments apply to the measures of value added per establishment. With these results, then, one might conclude that production techniques and direct factor productivities are generally similar across countries, in support of the factor-proportions model. Tempering this inference is the fact that use of PPP rates generated much larger adjustments for some Is and Ss than others, typically resulting in larger dispersion of techniques around their means.

15. The PPP exchange rates were those constructed for comparisons of GNP. However, in computing net capital stocks I used the country-specific investment deflators, which may be used to construct annual PPP rates for capital. These data may be found in Summers and Heston (1988).

To provide additional perspective on the structure of international productivity, I followed Dollar, Wolff, and Baumol (1988) in estimating translogarithmic production functions for each sector and for certain groups of industries (defined below) using both market and PPP exchange rates. The functions were estimated for each of the 28 sectors as follows:

$$\ln(VA/E) = C + a_1\ln(K/E) + a_2\ln E + a_3[\ln(K/E)]^2, \text{ and} \tag{3}$$

$$\ln(VA/E) = C + \Sigma c_j D_j + a_1\ln(K/E) + a_2\ln E + a_3[\ln(K/E)]^2. \tag{4}$$

Here, VA represents dollar value added, E indicates employment, K is the constant-dollar capital stock, and the D_j's are country dummy variables. Estimation of equation (3) in each sector presumes the existence of an internationally common production function in which each country serves as an observation. Its main usefulness is that the coefficient a_2 provides a measure of returns to scale; if the coefficient significantly exceeds 0 there is evidence of scale economies. Scale economies are a clear alternative candidate to the simple factor-proportions model of production and trade, which makes their estimation interesting.

In equation (3), the constant term is an index of total factor productivity (TFP) in each industry, assumed identical across countries, after controlling for national differences in capital and labor. Given the results discussed above, however, it seems likely that TFP varies across countries. Accordingly, equation (4) introduces country dummies to estimate differences in TFP as a further check on the international efficiency of factor use. For this purpose, the 28 sectors were pooled into three industry groups in estimating equation (4) to provide sufficient observations for estimation. Roughly following Dollar and Wolff (1988), these groups were: light industries (AP, LT, FT, FU, PT, PG, OT); medium industries (FD, BV, TB, TX, WO, PA, PR, RU, PL, GL, MP); and heavy industries (IC, OC, PE, PC, NM, ST, NF, MA, EM, TR). As will be seen later, in table 1.8, the raw-labor intensity of these industries tends to decline as they move up this tripartite classification. However, I did no formal statistical testing of the acceptability of this grouping.

The individual industry regressions of equation (3) (run with and without dummies for Ss and Ds; the figures are available on request) performed reasonably well, generally explaining between 40 and 60 percent of the variation in log value added per employee. There was weak evidence of scale economies in 17 of the 28 industries, though this result was sensitive to the definition of the exchange rate and the inclusion of regional dummies.

Because this weakness could be due to the limited number of observations by sector, I repeated the regressions with the data pooled across the three industry groups. These regressions are reported in table 1.4 along with those including the country effects. The last set of equations exclude refined petroleum products and petroleum and coal products because these data seem particularly questionable. Note first that the equations with country effects per-

Table 1.4 Translogarithmic Production-Function Estimates for Light, Medium, and Heavy Industries, 1984, with and without Country Effects, Using Market and PPP Exchange Rates

Industry Group	Exchange Rate	Country Effect	Constant	K/E	E	$(K/E)^2$	R^2
Light	Market	No	0.90*	0.94*	0.11*	−0.09***	.40
	Market	Yes	3.05*	0.22**	−0.02	0.02	.92
	PPP	No	2.27*	0.18	0.05*	0.03	.15
	PPP	Yes	3.26*	0.06	−0.02	0.04	.75
Medium	Market	No	1.76*	0.18	0.01	0.10**	.33
	Market	Yes	4.46*	−0.38**	−0.15*	0.16*	.76
	PPP	No	4.08*	−0.84*	−0.01	0.20*	.19
	PPP	Yes	5.53*	−0.90*	−0.14*	0.21*	.62
Heavy	Market	No	1.50*	0.48**	0.05**	0.01	.34
	Market	Yes	3.46*	0.33	−0.09*	0.01	.60
	PPP	No	3.22*	−0.25	0.03	0.10*	.27
	PPP	Yes	4.53*	−0.30	−0.09**	0.09*	.51
Heavy (excluding PE & PC)	Market	No	1.44*	0.47**	0.09*	0.00	.35
	Market	Yes	3.31*	0.36**	−0.05	−0.01	.75
	PPP	No	2.79*	0.01	0.05*	0.05	.22
	PPP	Yes	3.45*	0.26	−0.04	0.01	.57

Note: *** = significantly different from 0 at 10% level; ** = same at 5% level; * = same at 1% level.

form substantially better than those without, as suggested by the adjusted coefficients of determination. The equations without country dummies suggest the existence of increasing returns in both light and heavy industries, but this result disappears when the country effects are included. The constant term rises when country terms are added because the benchmark country is the United States, which generally has the highest measured productivity levels. Again, many of the coefficients are sensitive to the choice of exchange rate.

The indexes of TFP that resulted from estimation of equation (4) are presented in table 1.5. These results suggest that nearly all countries had TFP levels significantly below those of the United States, with only Canadian, German, and Japanese TFP approaching them. Differences in TFP were least marked in the group of heavy industries, with Chile, Israel, Spain, and Venezuela among the Ss and Ds registering insignificant differences with the United States. In my view, these estimated differences in TFP are surprisingly large, though they diminish markedly with the use of PPP rates. If we accept them as accurate indicators, they leave the strong impression that the efficiency with which primary inputs are converted into value-added differs significantly across countries. Among the primary explanations that could be advanced for this finding are international differences in factor quality, man-

Table 1.5 **National Indexes of Total Factor Productivity from Translog Production Functions with Country Effects, 1984, Using Market and PPP Exchange Rates, by Industry Group**

	Light Industries		Medium Industries		Heavy Industries[a]		Heavy Industries[b]	
Country	Market	PPP	Market	PPP	Market	PPP	Market	PPP
US	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AU	74.4**	67.9*	54.7*	45.1*	49.2**	44.8*	56.0**	52.2*
AS	36.7*	46.5*	34.9*	38.4*	32.0*	38.5*	34.6*	41.6*
CA	76.0**	77.6	66.6**	65.2**	68.5	69.7	73.0	75.6
CH	32.1*	63.4*	31.7*	45.7*	41.7*	75.1	45.0*	86.5
CO	28.9*	54.8*	33.2*	52.6*	31.1*	53.2**	31.5*	57.4**
CY	23.9*	41.4*	15.0*	20.9*	12.1*	19.2*	13.9*	22.6*
DE	58.3*	67.8*	37.5*	38.8*	42.6*	48.9**	45.0*	51.9*
EC	18.3*	29.9*	11.6*	15.1*	20.6*	31.8*	24.1*	38.0*
FI	51.7*	57.9*	32.4*	32.9*	38.2*	42.1*	37.8*	40.6*
GE	57.8*	71.2**	60.9*	66.4**	58.0	67.8	54.4*	63.4**
GR	23.1*	36.4*	18.1*	24.5*	19.8*	29.6*	21.7*	33.9*
IN	7.5*	18.4*	6.5*	11.6*	12.5*	25.9*	12.8*	28.3*
IR	39.1*	52.1*	32.2*	35.9*	35.2*	44.5**	41.2*	52.3**
IS	60.8*	65.1*	38.1*	36.5*	62.5	60.1	66.2	75.9
IT	49.2*	68.4*	37.9*	44.8*	40.3*	52.0**	38.3*	50.3*
JA	64.3*	67.0*	64.8**	64.0**	61.8	61.4	65.6**	66.9**
KO	22.9*	37.8*	25.1*	32.7*	30.9*	44.0*	26.9*	41.2*
NO	44.1*	50.6*	33.9*	34.8*	39.1*	43.9*	44.5*	49.2*
NZ	41.2*	47.5*	28.2*	28.6*	14.1*	15.0*	25.6*	30.0*
PH	8.2*	17.2*	11.4*	22.5*	17.7*	35.0*	15.0*	32.2*
PO	18.2*	34.9*	15.7*	25.3*	16.0*	27.3*	14.8*	27.1*
SI	23.6*	27.4*	17.6*	19.1*	32.2*	37.8*	37.5*	42.7*
SP	41.1*	67.4*	38.6*	51.6*	44.3**	60.2	43.3*	66.4
SW	58.2*	61.6*	48.2*	45.8*	57.6**	58.6	54.0*	55.7**
TU	20.8*	46.9*	20.1*	37.4*	28.8*	58.0**	21.3*	46.7*
UK	53.0*	69.1*	55.3*	62.9*	53.9**	65.6	51.4*	65.4**
VE	51.9*	68.6*	49.8*	55.5*	54.7**	70.0	50.3*	66.6

Note: ** = difference from U.S. estimate significantly different from 0 at 5%; * = difference from U.S. estimate significantly different from 0 at 1%; [a]Estimated including sectors PE and PC; [b]Estimated excluding sectors PE and PC.

agement capability, public infrastructure, and technology.[16] I have emphasized the last factor in the approach to these productivity measures, but the analysis here is incapable of discriminating among these influences. On a more mundane level, these differences in TFP might largely be due to the numerous data problems described earlier; that interpretation is more consistent with the tone of this paper. As Leamer notes in his comment, they could simply be the result of an underestimated U.S. capital stock under the 15-year accumulation procedure I applied.

1.4 Trade and Direct Factor Inputs

As noted earlier, a familiar descriptive approach to explaining trade structure is to relate cross-industry measures of trade performance to factor intensities. Such efforts attempt to characterize the input basis of international industry competitiveness in trade, though they do not follow rigorously from trade theory. For this purpose I report for each country simple correlations between industry net exports and factor shares, where the factors are defined as unskilled labor (U), human capital (H), physical capital (K), and materials and intermediate inputs (M).

1.4.1 Data Overview

With regard to data, I need to add consistent international measures of gross output, wages and salaries, and exports and imports to the data base. Output and wages, taken from the ISIC, were discussed in the previous section (see table 1.2). Incorporating trade data immediately raises the problem that production and trade figures are not reported on the same basis. The United Nations has developed a reporting system for trade, the Standard International Trade Classification (SITC) to accompany the ISIC. However, the systems are designed for distinct purposes and are not easily comparable at any level of aggregation.

Thus, the most vexing mechanical task for the researcher is to develop a concordance between the SITC and the ISIC. This problem exists in two dimensions. First, statistical classification systems must undergo periodic revision to reflect changing technologies, introduction of new products, and the like. This fact necessitates concordance building within each classification system over time if the analysis is of a time-series nature or if past observations are used to construct current data, as was done above to compute capital

16. On labor quality and management, see Clague (1991). From the standpoint of international data needs, one of the most glaring omissions is the near-absence of consistent information on industry employment of labor of distinctive skill levels. This absence forces the researcher to construct proxies of labor skills, as is done in the next section, or to rely on indirect and limited measures of skill, such as the occupation classification published by the International Labour Organisation.

stocks. The SITC is still reported under its second major revision[17] but a third revision was issued in 1988. Some countries still report their trade data on the basis of SITC Revision 1 (Chile is the only country included in this section of the paper that does so), providing another reason for a time-related concordance. The United Nations published such a concordance with Revision 2, but inevitably the changes were made at very disaggregated levels, imposing detective work and the need for making judgments on the researcher working at higher levels of aggregation.

The second dimension of the problem is simply the need to reconcile the SITC data to the ISIC basis. The United Nations recognized this need some years ago when it published a detailed concordance between the first revisions of both systems.[18] It is, therefore, possible to build a concordance between the second revisions of the ISIC and the SITC by using this source and the SITC mappings. Doing so carefully, however, is extremely tedious. At any level of disaggregation, some SITC categories will fit into two or more ISIC categories, requiring the development of an acceptable weighting system. The choice of the weights alone is not a straightforward question. Should they be based on shares of national or world trade, because of the SITC, or on shares of national or world output or capital stock, because of the ISIC? Should the weights change over time and across countries? Should there be separate weighting schemes for each bilateral trade flow? It is evident that the sheer volume of this task (recall that the U.N. concordances are at the 5-digit level of the SITC) would quickly overwhelm the resources of the researcher. This fact necessitates that some compromise concordance be developed that reflects the researcher's trade-offs between precision and tractability.[19]

In table 1.6 I present the crude concordance developed for the present work. The concordance is based on linkages between the 3-digit ISIC (28 sectors) and the 2-digit SITC (60 categories of relevance to manufactures). The weights are approximations, based roughly on contributions of trade in underlying 3-digit SITC categories to total 2-digit SITC trade in the United States in 1984.[20] These weights are applied to both the exports and imports of all countries, implying that the trade data employed below are measured with error beyond simple reporting and sampling error. It should be noted that the SITC trade data are reported in dollars at market exchange rates. Thus, the

17. United Nations, *Standard International Trade Classification*, Revision 2, ST/ESA/STAT/SER.M/34/Rev. 2, 1974.

18. See United Nations, *Classification of Commodities by Industrial Origin: Links between the SITC and the ISIC*, ST/STAT/Ser.M/43/Rev. 1, 1967.

19. A great many such concordances have been developed by different researchers in the field, indicating that the continued introduction of new ones is an inefficient use of research time. It would certainly be useful for practitioners to agree on a standardized concordance and method for updating it.

20. I experimented with an alternative concordance with weights based on the joint trade of the United States, Japan, and Germany. It resulted in no qualitative differences in the analysis below and is not discussed further.

Table 1.6 Concordance between the 3-Digit ISIC, Revision 2, and the 2-Digit SITC, Revision 2

ISIC	Industry Abbrev.	SITC (weight)
311/2	FD	01(1.0), 02(.75), 03(.5), 04(.5), 05(.5), 06(1.0), 07(.5), 08(.75), 09(1.0), 21(.25), 22(.25), 29(.125), 41(1.0), 42(1.0), 43(.5), 59(.1)
313	BV	11(1.0)
314	TB	12(.5)
321	TX	26(.5), 65(1.0), 84(.1)
322	AP	84(.9)
323	LT	61(.75), 83(.9)
324	FT	61(.25), 85(1.0)
331	WO	24(.75), 63(.9)
332	FU	82(.8)
341	PA	25(1.0), 59(.1), 64(.9)
342	PR	64(.1), 89(.3)
351	IC	23(.1), 26(.1), 51(1.0), 52(1.0), 53(1.0), 56(1.0), 58(.5), 59(.33), 43(.1)
352	OC	53(.25), 54(.9), 55(1.0), 57(1.0), 59(.33)
353	PE	33(.5), 34(.1)
354	PC	32(.25), 33(.125), 34(.1)
355	RU	23(.5), 62(.9)
356	PL	58(.5), 82(.1), 89(.1)
361	PT	66(.125), 81(.05)
362	GL	66(.5), 81(.05)
369	NM	27(.125), 66(.375)
371	ST	67(.95), 69(.2)
372	NF	68(.95), 69(.1)
381	MP	67(.05), 68(.05), 69(.5), 71(.1), 73(.25), 74(.05), 81(.9)
382	MA	69(.1), 71(.4), 72(1.0), 73(.75), 74(.8), 75(1.0), 77(.125)
383	EM	76(1.0), 77(.875)
384	TR	71(.5), 74(.1), 78(1.0), 79(1.0), 89(.1)
385	PG	54(.1), 59(.05), 74(.05), 87(1.0)
390	OT	69(.1), 83(.1), 89(.4)

analysis below is restricted to inputs valued at market rates, and PPP rates are ignored.

For the 28 countries in the sample, the basic industry data-set thus consists of observations on exports and imports (filtered through the concordance presented in table 1.6), gross output, value added, employment (in thousands), and wages and salaries. All value figures are expressed in millions of U.S. dollars.

A final comment about data requirements is in order here. It is evident that accumulating detailed data involving countries, inputs, and trade quickly mushrooms into an enormous effort. However, time is an important additional dimension to incorporate into empirical research. The analyst must replicate the data search for every year under consideration. Moreover, if a time-series study is to be performed, the researcher must come to grips with the need for price deflators for all nominal values (wages, capital costs, output values, trade values, and the like). It is in this regard that international data are least accessible.

1.4.2 Trade and Factor Shares

For each country, net exports in each industry were scaled by the sum of gross output (at producer prices or factor values) across 27 countries (Venezuela was eliminated) as an approximation to world market size (Deardorff 1984 suggests such a scaling). For the purpose of computing unskilled-labor and human-capital shares, data on total compensation and employment were used to calculate an average wage in each industry. The minimum average wage across all industries was then taken to reflect the compensation of unskilled laborers. The unskilled labor share is then this minimum wage times employment as a proportion of gross output. The share of human capital is defined as the difference between each industry's wage and the minimum wage, multiplied by employment, divided by gross output:

$$H_i = (\text{WAGE}_i - \text{MINWAGE}) \cdot E_i/Q_i. \tag{5}$$

Effectively, I assume the absence of human capital in the lowest-wage industry and standardize upon that industry. More direct measures of educational attainment by each industry's labor force would provide better indicators of skill distributions across industries, but such data are unavailable. The share of output paid to physical capital was taken to be nonwage value added as a proportion of output, under the assumption that value added comprises only payments to labor and capital. Ignoring land in this context is problematic and might be alleviated somewhat in a set of manufacturing industries by disaggregating capital into structures versus plant and equipment. To do so, however, one would need also data on appropriate depreciation factors and price deflators for capital types, plus some means of allocating residual value added. Finally, the materials share is simply cost of materials, as approximated by gross output less value added, as a proportion of output.

As discussed earlier, countries define their raw variables in the ISIC somewhat differently. Thus, the input shares computed here are not strictly comparable across countries because of further measurement problems. Nonetheless, it is of interest to compare the direct links between trade performance and factor shares in the various nations. Table 1.7 lists the simple correlations between scaled net exports and factor shares across all industries in each country. Thus, for example, Canadian manufactured net exports tended to be low in industries with high unskilled-labor (i.e., low-wage labor) and physical-capital shares but high in industries with high materials shares. In turn, though these correlations show nothing about the direction of dependence among the variables, they may be taken as indicators of the direct net factor content of trade. I also list the correlations of scaled net exports with scaled U.S. net exports to provide perspective on the similarity of each nation's trade pattern across industries to the U.S. trade pattern.

The figures in table 1.7 need little amplification, but a few comments are worth making. The trade patterns of some countries (Cyprus, Finland, New Zealand, and Turkey) are uncorrelated with any factor shares, suggesting essentially balanced net trade in all inputs. In contrast, some countries are distinctive in their relationships between factor shares and trade patterns, as evidenced by the positive correlations between net trade and low-wage labor for South Korea, the Philippines, Portugal, and Spain, and those between net trade and human capital for Germany, Japan, Sweden, and the United States. Indeed, these last four countries form a group in which the relationships between factor shares and trade patterns are highly similar, suggesting that they

Table 1.7 Simple Correlations between Scaled Net Exports and Factor Shares by Country and between Scaled Net Exports and U.S. Scaled Net Exports, 1984, Using Market Exchange Rates

Country	*n*	*U*	*H*	*K*	*M*	USNX
AU	28	−0.29	−0.48*	−0.15	0.38**	−0.65*
AS	28	0.19	0.23	0.14	−0.28	0.65*
CA	28	−0.53*	0.07	−0.31***	0.46**	−0.15
CH	28	−0.23	−0.18	0.24	−0.11	0.20
CO	28	0.21	−0.38**	−0.03	0.01	−0.37**
CY	24	0.14	−0.05	0.03	−0.07	−0.69*
DE	28	0.37**	0.26	0.06	−0.34***	0.78*
EC	28	−0.25	0.02	−0.07	0.17	−0.80*
FI	28	0.10	−0.01	−0.09	0.01	0.44**
GE	24	0.05	0.69*	0.24	−0.46**	0.73*
GR	28	0.28	−0.01	0.34***	−0.31***	0.53*
IN	25	0.07	−0.30	−0.22	0.25	0.07
IR	24	−0.56*	0.18	0.37***	−0.08	0.76*
IS	25	0.52*	−0.04	−0.25	−0.06	−0.27
IT	21	0.63*	−0.46**	0.16	−0.27	−0.90*
JA	27	0.22	0.41**	0.43**	−0.49*	0.79*
KO	28	0.46**	−0.21	0.02	−0.20	−0.04
NO	27	−0.34***	−0.02	−0.34***	0.24	−0.68*
NZ	26	0.12	−0.14	0.13	−0.12	0.37***
PH	28	0.45**	0.16	0.07	−0.32***	0.55*
PO	27	0.42**	−0.24	0.08	−0.18	−0.72*
SI	24	−0.19	−0.15	−0.16	0.26	0.22
SP	28	0.43**	0.15	0.00	−0.28	0.27
SW	28	−0.03	0.35***	0.20	−0.17	0.73*
TU	28	0.06	−0.07	−0.03	0.02	0.53*
UK	28	−0.48*	−0.01	0.02	0.21	−0.21
US	28	−0.15	0.38**	0.32***	−0.28	1.00*

Note: *** = significantly different from 0 at 10% level; ** = same at 5% level; * = same at 1% level. n = number of industry sectors. USNX = U.S. scaled net exports.

are mutual international competitors. Italy is a case unique among the industrial nations; it has a strong positive correlation of net trade with unskilled labor and a strong negative correlation with human capital. This distinctiveness is emphasized by the divergence in the U.S. and Italian trade patterns.

Perhaps the main conclusion to be drawn from this analysis is that the various computed correlations are generally weak, except those for the United States, Japan, Germany, and a few other isolated cases. These are precisely the three countries to which this model has been applied with some success in the literature (Stern and Maskus 1981, Urata 1983, Stern 1976). It therefore appears that this analysis of trade and intensities does not extend well to other countries. Note especially that for several developing countries (Chile, Ecuador, Indonesia, Singapore, and Turkey) there is no clear association of net exports with industries using greater amounts of unskilled labor, nor is there a clear association of net imports with industries using greater amounts of human capital; this result is contrary to what one might expect.

An important underlying empirical issue of interest is whether factor shares are sensitive to variations in the business cycle. If so, the researcher would need to exercise caution in the choice of years for analysis, while the traditional presumption that cross-section data reflect basically long-run influences would be challenged. In fact, one motivation for the choice of 1984 for the current paper is that it was a year of on-trend activity for many OECD countries.[21]

To examine the cyclicality issue, I assembled the production and input data for the United States and Japan in 1982, a trough year, and for the United States in 1978 and Japan in 1979, both peak years. I report in table 1.8 the average unskilled-labor and physical-capital shares for our three types of manufactures (light, medium, and heavy industries), on the possibility that cyclical influences may vary across these types (data for all industries are available on request). I also list figures for value added per laborer, expressed in 1980 prices for each country, to see if labor productivity is sensitive to the cycle.

From these data there appears to have been no cyclical effect on the levels of U.S. factor shares. Rather, the results are suggestive of secular declines in labor intensity and, perhaps, of secular increases in capital intensity in light and medium industries. In Japan, however, the lowest capital shares in each industry group were registered in 1982, the trough year, which is suggestive of cyclical impacts. Nonetheless, the differences are slight, and there seems little reason to discriminate among these years in computing factor shares for fear of cyclical distortions. Labor productivity, on the other hand, did seem to vary in both countries with the cycle, with 1982 seeing both the lowest average amounts and the highest relative variances of real value added per employee. I conclude that measured factor shares are likely to be relatively im-

21. See Organisation for Economic Cooperation and Development, *Main Economic Indicators*, various issues.

Table 1.8 Average Unskilled-Labor and Capital Shares by Industry Group, Average Real Labor Productivity across all Industries, and Coefficients of Variation for the United States and Japan, Various Years, at Concurrent Market Exchange Rates

			Light Industries		Medium Industries		Heavy Industries	
Country	Year	(Cycle)	*U*	*K*	*U*	*K*	*U*	*K*
U.S.	1978	(Peak)	.193(.23)	.287(.20)	.104(.37)	.276(.22)	.072(.51)	.258(.33)
	1982	(Trough)	.184(.23)	.298(.19)	.103(.41)	.281(.30)	.075(.51)	.231(.47)
	1984	(Trend)	.174(.25)	.308(.22)	.095(.40)	.299(.32)	.066(.51)	.250(.44)
Japan	1979	(Peak)	.142(.39)	.241(.16)	.084(.27)	.260(.24)	.048(.59)	.246(.37)
	1982	(Trough)	.143(.40)	.233(.12)	.080(.32)	.247(.24)	.044(.59)	.225(.43)
	1984	(Trend)	.138(.44)	.238(.18)	.080(.33)	.254(.24)	.043(.58)	.233(.43)
			Value Added per Employee, All Industries					
U.S.	1978	(Peak)	50,594(.62)					
	1982	(Trough)	48,329(.68)					
	1984	(Trend)	54,268(.62)					
Japan	1979	(Peak)	46,290(.80)					
	1982	(Trough)	39,536(.91)					
	1984	(Trend)	45,520(.79)					

pervious to cyclical variations, but that computations of the levels of outputs and inputs are sensitive to them.

To conclude this section, I note that it is possible to expand the analysis to incorporate alternative ad hoc trade models, in which industries and countries may be combined in other arbitrary fashions to examine the influences of crude measures of scale economies, consumer-goods characteristics, and the like. Experimentation in those directions was largely unrewarding and is not further pursued here.

1.5 Trade and Factor Endowments

The discussion surrounding equation (2) earlier noted that the partial approach that comes closest to the true specification of the Heckscher-Ohlin model is a regression of net trade on excess factor endowments. Here, I regress net exports on the levels of factor endowments, which procedure may be considered, along with a relationship between GNP and endowments (not shown), to be the reduced form of equation system (2). Because factor intensities do not enter into this analysis, there is no need to develop data on input usage. This fact is a substantial advantage for this approach since it allows the direct use of SITC trade data, at the chosen levels of aggregation, in the equations without recourse to concordances. It also invites the inclusion of a greater number of countries in the analysis.

1.5.1 Data Overview

In table 1.9, I list the countries included in the analysis, along with an aggregation scheme of 2-digit SITC trade categories. There are 38 countries in the sample, again at all levels of development. The choice of countries was determined by the availability of appropriate endowment and trade data for 1984.

The international trade data, all based on SITC Revision 2, were taken from sources published by the OECD and the United Nations.[22] A few concerns about these figures should be raised. First, the SITC lists trade of all countries in current dollars, regardless of the currency of denomination of trade contracts. The trade transactions in local currencies are presumably translated into dollars at market exchange rates by the reporting countries, though there is little information in this regard. The existence of internationally traded goods argues for the use of market rates for conversion anyway, so perhaps this absence of information is unimportant. This fact allows me to convert endowment data in value terms to dollars at market rates also, without considering here any PPP conversions. Nonetheless, it would be interesting to know how accurate the dollar figures are, strictly on the basis of exchange-rate measurement. Second, it is not possible to tell how inclusive the trade data are for all countries. For example, countertrade has become prevalent in some of the developing countries in this sample, and it is not clear whether such trade is included and in what valuation. Third, there are some international discrepancies in the data because the United Nations allows countries to choose whether to report trade on a "special" or "general" (including entrepot-trade) basis and whether to value exports and imports on a c.i.f or f.o.b. basis. Some care has been taken here to account for reexports, but this task is not always straightforward. Fourth, import data tend to be more reliably collected in most countries than export data because they loom larger in the customs-revenue scheme. This problem seems especially acute in bilateral trade data, where one country's reported imports from a partner often exceed markedly the partner's reported exports, as is well known from the U.S.-Canadian reconciliation exercises.

Finally, there remains the fundamental question of aggregation. The SITC data are available at finely disaggregated levels. In principle, one could undertake to relate trade in each of these categories to factor supplies, but that task would be tedious for researcher and reader alike and would likely not be very

22. For OECD members, OECD, *Foreign Trade by Commodities, 1984*, vol. 1, *Exports*, and *Foreign Trade by Commodities, 1984*, vol. 2, *Imports* (Paris, 1986). For other countries, United Nations, *Commodity Trade Statistics, 1984*, ST/ESA/STAT/Ser.D, various issues. Countries that reported on the basis of Revision 1, necessitating adjustments to their trade figures, were Chile, Brazil, and Mexico.

Table 1.9 **Countries in the Analysis of Trade and Endowments and SITC Aggregation**

Country (Abbrev.)	Industry (Abbrev.; Included SITC Classes)
Argentina (AR)	Food, beverages, and tobacco (FDBV; SITC 00–09, 11–12)
Australia (AU)	Raw materials (MATE; SITC 21–23, 26–29, 41–43)
Austria (AS)	Petroleum and coal products (PECO; SITC 32–34)
Belgium (BE)	Chemicals (CHEM; SITC 51–59)
Brazil (BR)	Wood products (WOOD; SITC 24–25, 63–64)
Canada (CA)	Light industries (LITE; SITC 61, 65, 82–85, 87–89)
Chile (CH)	Machinery and transport equipment (MACH; SITC 71–79)
Colombia (CO)	
Cyprus (CY)	
Denmark (DE)	
Ecuador (EC)	
Egypt (EG)	
Finland (FI)	
France (FR)	
West Germany (GE)	
Greece (GR)	
India (ID)	
Indonesia (IN)	
Ireland (IR)	
Israel (IS)	
Italy (IT)	
Japan (JA)	
South Korea (KO)	
Malaysia (MA)	
Mexico (ME)	
Netherlands (NE)	
New Zealand (NZ)	
Norway (NO)	
Philippines (PH)	
Portugal (PO)	
Singapore (SI)	
Spain (SP)	
Sweden (SW)	
Switzerland (SZ)	
Thailand (TH)	
Turkey (TU)	
United Kingdom (UK)	
United States (US)	

instructive.[23] On the other hand, significant aggregation runs the risk of misidentifying trade flows that should be classified on an industry basis inspired by the factor-proportions model. I employed three aggregation levels for the present paper, though only the results of the last one are presented. These

23. Such detail would be useful for many other empirical purposes, such as studies of intra-industry trade, substitution elasticities in demand, and computations of unit values and quality indices.

levels were: first, the 57 separate 2-digit categories in SITC levels 0 through 8; second, the 28 three-digit ISIC-equivalent manufacturing industries identified earlier; and third, an aggregation of the 2-digit categories into the groups listed in table 1.9. This final grouping was arbitrary, relying on no statistical aggregation scheme such as that used in this context by Leamer (1984). My intent was to adopt a limited set of commodity aggregates that made some sense a priori as potentially having identifiable endowment-based sources of trade.

In defense of the trade data one can say that they are, in principle, collected on a reasonably consistent basis and reported in a standardized form. The situation is different for factor endowments, the measurement of which is, in any case, no simple task. First, we would like to have data on total potential supplies of inputs (e.g., proven reserves of minerals and energy), but we often must settle for factors actually in use. The latter variables clearly are endogenous to factor prices (as may be the former). Similarly, factor use may vary with the business cycle; it is unclear how to define capital endowment and labor force when there are multiple shifts, for example. Second, there is little likelihood that similar factor supplies across countries are of substantially equal quality. There is great variation in international definitions of labor types, for example. Further, a high-school graduate in one country may have far different skills on average than a high-school graduate in another country. Quality differences in capital, land, and minerals are also likely to be marked. And, finally, countries are likely to define various factors differently. For these reasons, we may expect significant errors of measurement to arise in computing endowments.

This study incorporates measures of seven factor endowments. The first two are LABORS, the sum of occupational categories 0/1 (professional, technical, and kindred workers) and 2 (administrative and managerial workers) as a measure of higher-skilled labor endowment, and LABORU, the sum of the other occupational categories (clerical and related workers, sales workers, service workers, agriculture, forestry, and fisheries workers, and laborers and production and related workers) as a measure of lower-skilled labor endowment (both measured in thousands).[24] The third endowment is CONG, an aggregate of the value (in millions of dollars) of production of coal, oil, and natural gas in metric ton equivalents.[25] The fourth factor is MIN, an aggregate of the value (in millions of dollars) of production of bauxite, primary aluminum, copper, iron ore, lead, manganese, nickel, potash, tin, and zinc in metric tons of mineral content.[26] As value aggregates of current output levels of heterogeneous

24. See International Labour Organisation, *Yearbook of Labour Statistics*, various years. These data are based on national surveys, which are often of sketchy temporal and sectoral coverage. Thus, a number of the observations on labor forces have been estimated; details are available on request.

25. See OECD, *Coal Information*, various issues and United Nations, *Energy Statistics Yearbook*, various issues.

26. See U.S. Bureau of Mines, *Minerals Yearbook*, various issues, for international production

commodities, CONG and MIN are conceptually quite weak as proxies for supplies of natural resources. Unfortunately, there appear to be no reasonable alternatives to this usage. The next two endowments are LAND1, the area of arable land and land under permanent crops or permanent pasture, and LAND2, the area of forests and woodland, both measured in thousands of hectares.[27] Again, this definition merges several presumably different forms of productive and nonproductive land (e.g., tropical land, temperate land, tundra) but is maintained for empirical tractability. Finally, the net capital stock, KSTOCK, is the accumulated, depreciated, and deflated series (15 years, 13.33 percent depreciation rate) of gross fixed capital formation in each country.[28] Data on gross national product in 1984 dollars were gathered as well.[29] Problems with international comparisons of GNP are well known.

1.5.2 Estimation Results

The estimation procedure follows that in Leamer (1984). In previous sections I examined problems that emerge in simple computations of variables for analysis, including exchange-rate valuation and cyclicality. Here, I focus on econometric problems that clearly affect inferences in the regressions of net trade on the levels of endowments. In particular, countries in the sample are of radically different sizes, suggesting the presence of heteroskedastic error variances. Further, measurement error is surely endemic in the endowments data described above, generating inconsistent least-squares estimators of the reduced-form coefficients.

The influence of heteroskedasticity is detailed in table 1.10. The first row in each pair of equations provides the coefficients from ordinary least-squares (OLS) estimation, where the net-exports variables were entered in thousands of dollars. Judging from the relatively high coefficients of determination, the endowments model explains variations in net exports rather well. The contributions of individual endowments to trade in the various sectors is evident from the coefficients and their significance levels. A high capital endowment, for example, is associated with high net trade in machinery, while a high endowment of arable land is a detriment to net exports in wood products. To account for the presence of heteroskedasticity, a simple procedure was followed in which the log of the squared residuals from each OLS equation was regressed on the log of each nation's GNP. The coefficients from these regressions, listed in the *w* column, were near unity except in the chemicals indus-

data, and International Monetary Fund, *International Financial Statistics*, various issues, for prices. Prices were taken here as the prevailing average price in the appropriate international commodity markets and were assumed to represent common international prices. No attempt was made to gather prices in individual countries.

27. See Food and Agricultural Organization, *Production Yearbook*, various years.

28. See Summers and Heston (1988) for investment deflators, and International Monetary Fund, *International Financial Statistics*, various years, for gross fixed capital formation (row 93e).

29. International Monetary Fund, *International Financial Statistics*, various years (row 99a).

Table 1.10 **Ordinary Least-Squares (OLS) and Weighted Least-Squares (WLS) Regressions of Net Exports on Endowment Levels, 1984**

Industry	Regressions	LABORS	LABORU	KSTOCK	LAND1	LAND2	CONG	MIN	R^2	W
FDBV	OLS	−106	−0.3	−4.9*	16**	11**	88**	−319	.69	.98
	WLS	−53	−4.7	−3.1	16**	12**	−12	−194	.40	
MATE	OLS	−384***	−0.6	−3.7*	9.3***	2.5	149*	100	.78	.96
	WLS	−312	5.0	−3.3	3.8	2.6	70***	460	.43	
PECO	OLS	−2753*	151*	−23*	−32***	2.1	313*	2136**	.93	.89
	WLS	−3228*	144*	−24*	−17***	5.0	633*	1101***	.79	
CHEM	OLS	519***	−27***	−0.2	−6.3	−2.8	−10	178	.40	.26
	WLS	461***	−27***	0.2	−4.4	−2.0	−11	54	.32	
WOOD	OLS	−470***	23***	−1.3	−23*	9.0**	48***	1167*	.63	.73
	WLS	−308	13	−0.9	−14**	10**	19	658**	.30	
LITE	OLS	814***	−4.2	1.1	4.7	4.4	−303*	−573	.79	1.12
	WLS	432	8.7	1.8	2.7	3.0	−151**	−510	.26	
HEAV	OLS	118	3.3	4.9*	−12***	6.5	−259*	717***	.85	.90
	WLS	−49	−2.1	4.5**	−4.7	6.0	−139*	341	.36	
MACH	OLS	−1705***	44	44*	−4.8	20	−764*	−841	.89	1.06
	WLS	−1461***	8.4	34*	5.4	14	−381*	−1349***	.59	

Note: *** = significantly different from 0 at 10% level; ** = same at 5% level; * = same at 1% level.

try, suggesting that error variances were proportional to GNP. These coefficients were used to develop inverse weights for the weighted least-squares (WLS) regressions in the second rows of each equation pair. In general, this adjustment tended to reduce the magnitudes and significance levels of the coefficients but did not alter their signs. It also reduced the explanatory power of the equations. Such results indicate the need for caution in using such equations for prediction or policy analysis.

This last conclusion is reinforced by consideration of measurement error in the data. Reverse regressions of each endowment on sectoral net exports and the remaining endowments were run, allowing for the existence of errors in each factor supply. Each equation was solved for the implied coefficients relating trade to endowments. If they are of the same sign, the minimum and maximum resulting coefficients provide a confidence interval for the true regression parameter (Leamer 1984, Kmenta 1986). If the bounds on this interval are close to the OLS estimates, we may infer the estimates to be reliable. If the sign changes between the minimum and maximum coefficients, however, the interval is unbounded and the regression parameters cannot be estimated reliably.

The ranges of estimates from the reverse regressions are reported in table 1.11. Forty-six of the 56 ranges cover both positive and negative numbers, indicating that the corresponding OLS coefficients cannot be confidently accepted. Seven of the remaining ten ranges are so wide that the OLS coefficients provide only qualitative indicators of a relationship and their use in, say, a forecasting model would be highly questionable. In only three cases (the negative effects of CAPITAL and LAND2 in CHEM trade and of LAND1 in WOOD trade) is there evidence of a reliably estimated parameter.

Thus, it appears that available data on factor supplies are either so poorly measured that they provide no evidence on the trade-and-endowments model, or, if measured adequately, cast doubt on the model. As noted earlier, it is the most appropriate indirect approach to the factor-proportions theory. One source of the difficulty is collinearity in the underlying true endowments, generating volatility in the trade estimates from measured proxies. The standard remedy is to place constraints on the error variances of the regression and the measured endowments in order to provide additional information (Leamer 1984), but the mismeasurements here appear to be so gross that such an approach would provide little benefit and is not further considered here. For present purposes, the point has been made that available endowments do not support precise estimation of the link between trade and factor stocks.

1.6 Concluding Remarks

It may be useful to conclude this paper with a "wish list" of steps that might be taken by data suppliers and data users to improve our ability to understand the relationships among trade, factor endowments, and factoral and sectoral

Table 1.11 **Range of Coefficients from Reverse Regressions in the Endowment Model, 1985**

Industry		LABORS	LABORU	KSTOCK	LAND1	LAND2	CONG	MIN
FDBV	max.	392307	1085	92	2718	1078	2575	537
	min.	−32697	−25381	−846	2.3	1.2	−32335	−103450
MATE	max.	110377	2533	12	775	167	1094	33333
	min.	−5780	−7246	−239	−467	−157	−9109	−29341
PECO	max.	−56	447	111	264	1887	1981	17544
	min.	−31887	−86	−37	−385	−72	211	−73566
CHEM	max.	42000	132	−0.2	52	−23	79	29412
	min.	519	−1016	−233	−429	−278	−3448	−866
WOOD	max.	4211	218	99	−13	54	490	4065
	min.	−4902	−88	−26	−72	−13	−116	−658
LITE	max.	57407	445	102	826	324	−21	657
	min.	−18060	−3711	−119	−15	−22	−5030	−36000
HEAV	max.	30303	2381	83	5.2	114	2744	10381
	min.	−35714	−1000	−91	−262	−90	−2576	−7857
MACH	max.	13214	1650	104	875	333	1287	153571
	min.	−26238	−313	−71	3571	−179	−1190	−62500

income distribution. The list might be useful in guiding future deliberations in this area.

First, there is a need for standardized concordances at higher levels of aggregation. With the advent of the Harmonized Commodity Description and Coding System and the issuance of the third revisions of the ISIC and SITC, detailed concordances will be available. I understand the reluctance of authorities to construct higher-level concordances, however, since doing so inevitably requires some arbitrariness. Thus, this may be an issue for data users to resolve.

Second, there is a pressing need for the development of international price deflators on a consistent basis for outputs, inputs, and trade. Such information would be of great use far beyond the kinds of models used here.

Third, available measures of sectoral labor requirements, such as the use of operatives versus other labor, are grossly deficient, while occupational detail for sectoral workers is limited. It would be useful to improve the information published on occupational employment, with a view to standardizing definitions of labor input and effort expended (e.g., hours worked). Similar comments would apply to different forms of capital input. Such standardization would ease concern over the differential-quality issue and make more meaningful the computation of factor prices. Of course, it will never be possible to measure inputs fully in quality-standardized units.

Fourth, it was demonstrated earlier that neither market exchange rates nor PPP rates serve effectively to compare inputs and productivity, and that measurements were very sensitive to the choice. The development of exchange rates for this purpose would aid in the understanding of international technology levels and in sorting out components of technology.

A final comment is in order here. International data are not collected on a basis suggested strictly by trade or microeconomic theory. This fact is unsurprising, given that economists are not the primary users of the data. Perhaps what is required is a greater effort by economists to settle on appropriate definitions themselves before expecting data authorities unilaterally to provide them on the preferred basis. An example might be the measurement of endowments. It is unsurprising that endowments are measured so poorly when we cannot agree on appropriate definitions for them, even in principle. Surely, however, the collection effort can be instructed by the specification of the most useful proxies a priori. Absent such efforts we will continue to construct approximations that are of questionable relevance to underlying variables.

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Comment Edward E. Leamer

This excellent paper is a fine way to start a conference on a subject that is sadly neglected by economists: the collection and dissemination of economic data. I can think of no other "scientific" discipline that pushes the division of labor so far that the activities of data collection and data analysis are performed by completely separate groups of individuals. This is not a healthy situation. Lacking training in data collection, the data analysts have very little appreciation of how inaccurate the data actually are. Though data analysts may "know" that there are imperfections in the data, they prefer to allocate their scarce time to other problems and to act as if the measurements were perfect. This creates a market for new data series but no market for improvements to existing series. Data collectors respond accordingly. I take the goal of this conference to be improved communication between users and collectors, which hopefully will improve both the use and the collection. I will make the point in this comment that there is still a lot of room for improvement in this communication.

Maskus's paper makes two contributions. He illustrates how the data are used to study the international structure of output and consumption. And he offers a comprehensive catalog of difficulties with the data. A point that I will make is that these two contributions are almost completely separate—just as are data collection and data analysis in our profession. What we need to do is to bridge the gap. More on this below. First I will comment on the problems with the data.

If you read Maskus's catalog of data problems it is hard to understand why we spend so much time on unit roots, cointegration, nonparametric tests for nonlinearities, and the like. Here is a list of problems that I have pulled out of Maskus's discussion:

(i) There are missing data. In one sample, 5.8 percent are missing, 6.9 percent are "constructed." Price data are often not available at all, and unit values are used instead.
(ii) The data are internationally noncomparable because methods of collection differ by countries.

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(a) Definitions differ.
  i. The form of compensation of inputs varies across countries. For example, retirement benefits, vacation pay, and health benefits can differ substantially.
  ii. The treatment of taxes on outputs and inputs varies.
  iii. The definition of employment varies across countries depending on factors such as hours worked or nature of contract with the firm.
  iv. Some countries value trade c.i.f., others f.o.b.
(b) Methods of sampling differ.
  i. Sampling frames differ (e.g., minimum establishment size).
  ii. Sampling methods differ (some use a census, others a stratified sample, etc.)
  iii. The questionnaire design differs (sometimes it is conducted by mail, sometimes by interview). The kind of people who provide the information varies.
(c) The data are sorted and processed differently. For example, multi-output establishments are disentangled differently.

(iii) The data are internationally noncomparable due to aggregation problems.
  (a) Industrial aggregation combines industries with drastically different technologies. Apparent differences in productivities may be due to different industrial mixes.
  (b) Capital aggregation combines vastly different equipment of vastly different vintages in different countries.
  (c) Labor aggregation combines laborers with different skills. When education is used to sort workers, the resulting categories may be noncomparable because of vast differences in the meaning of a year of schooling.

(iv) Data are internationally noncomparable due to currency conversion problems, which are especially difficult in periods of extreme exchange-rate gyrations.

(v) There are substantial concordance problems since, for example, trade and production data are collected using different product classifications.

(vi) The classification systems change over time. ISIC Revision 2 was completed in 1968; Revision 3 is in process (SIC was revised in 1972, 1977, and 1982).

(vii) The treatment of re-exports can differ by country. This is an especially difficult problem when transactions occur entirely within a multinational firm.

(viii) Value-added data are internationally noncomparable if the prices of intermediate inputs differ. To express this differently, the value-added production function should depend on the prices of these intermediate inputs, as well as on the physical quantities of labor and capital.

Good heavens! That is quite a list. It leaves one wondering if these data are useful for anything. This concern is not put to rest by Maskus's report on how these data are used. First he apologizes for the lack of close connection between the theory and the data analyses. What this seems to imply is that more complete and more accurate data would not have a decisive impact, since the link between the theory and the data analysis is sufficiently weak that no "intellectual capital" is genuinely at risk when the data are examined. That should be the subject of another conference—improved communication between theorists and data analysts, who are almost as separated as data collectors and data analysts.

Concerns about the theory and the data notwithstanding, Maskus reports in table 1.5 a remarkable finding: total factor productivity is almost 50 percent higher in the United States than in any other country. I don't believe this, and neither does Maskus, who reports: "Among the primary explanations that could be advanced for this finding are international differences in factor quality, management capability, public infrastructure and technology. I have emphasized the last factor in the approach to these productivity measures, but the analysis here is incapable of discriminating among these influences." I would have looked elsewhere for the explanation. My guess is that the U.S. capital stocks are substantially underestimated because of the 15-year life that Maskus is forced by data limitations to assume. If you prefer, you may dismiss the finding by referring to other items on the list of data problems. But if that is your attitude, what can you learn from a data-set?

Now I want to make my most important point: *The methods that we use to analyze data need to make explicit reference to the possibility of measurement error, if we are going to learn anything from data that we suspect are subject to measurement error.* Otherwise we will merely use data to support our prior beliefs, dismissing contrary findings by referring to measurement errors. There is only one data analysis that explicitly refers to measurement errors in Maskus's paper, indeed in this whole collection of papers. Otherwise the data are analyzed as if they were free of error. For that reason, I think this conference has not been wholly successful in the creation of communication links between users and collectors.

The analysis to which I refer are the errors-in-variables bounds presented in table 1.11. If you are familiar with the traditionl discussion of errors-in-variables in econometrics, you probably have a mistaken viewpoint about the consequences of measurement errors. That literature deals with a bivariate problem in which measurement error of a certain kind causes "attenuation" of the estimates (downward bias). This leaves the impression that correcting for errors in variables can be done by enlarging the coefficients. This is a mistaken idea, first of all because attenuation in the bivariate case is associated with one special kind of measurement error. But more importantly, the attenuation result doesn't apply if more than one right-hand side variable is measured with error. Another theorem applies in the multivariate case.[1] A minimal set of

1. Reported in Steven Klepper and Edward E. Leamer, "Consistent Sets of Estimates for Regressions with All Variables Measured with Error," *Econometrica* 52 (1984):163–83.

estimates that in large samples will surely capture the true regression vector is found in three steps. First, one computes a set of regressions with each of the possible variables treated as the "left-hand" (dependent) variable. Then these estimated linear functions are reexpressed to have the same left-hand variable. If the signs of the coefficients are the same for each of these estimates, then the minimal set is the set of all weighted averages of these estimates, and in particular an errors-in-variable bound is the interval between the smallest and the largest coefficient. (Incidentally, this interval will include estimates that are both larger and smaller than the ordinary regression and in that sense the attenuation result does not apply in the multivariate setting.) On the other hand, if, as is the case of the results reported in table 1.11, there are *any* sign changes, then the minimal consistent set is unbounded and in that sense the data are informationless about individual coefficients. This occurs because the measurement error is treated by subtracting from the observed covariance matrix that part of the variability that is due to measurement errors. If the data are quite collinear already, removing a little of the observed variability can produce a perfectly collinear data set which cannot be used to produce estimates of individual coefficients.

I am afraid that the unboundedness result is most likely to occur with the kinds of multicollinear data-sets that we usually analyze. What that means is that in the absence of knowledge of the probable measurement errors, our data-sets are worthless for estimating regressions. Thus my point: We need to improve the communication from collectors to users of data. *The users need to be informed about the accuracy of the data.* They need standard errors of the measurement errors.

I know that this is asking a lot, but I think it is essential. Now I am going to ask for something much more, something that will seem mind boggling, greedy, and even absurd: *We need standard errors. But we also need standard errors of the standard errors.* Standard errors of the measurement errors are enough to correct econometric estimates for the biases that are associated with the use of mismeasured data. But in order to compute standard errors of these econometric estimates we need also to have standard errors of the standard errors. Expressed differently, if there are measurement errors in the data then econometric estimates are subject to both sampling error and misspecification error. If we knew the error rates in our data exactly, then we could correct perfectly the estimates, and we would be left with only sampling error. But we cannot know the error rates exactly, and we cannot eliminate altogether the misspecification uncertainty. In order to compute the probable amount of misspecification uncertainty, we will need some measure of the uncertainty in the error rate. Thus we need standard errors of the standard errors.[2]

To summarize, I speak to both data analysts and data collectors.

2. For further amplification, see the paper that this conference has stimulated, Edward E. Leamer, "We Need Standard Errors of the Standard Errors of the Measurement Errors of Our Data" (typescript, 1989).

To the data analysts I say: You need to make explicit reference to measurement errors when you analyze a data-set. This has two benefits. First, it will allow you to learn something from the data. Otherwise, whatever are your estimates, you will probably dismiss them as entirely due to measurement errors. Secondly, it will make you acutely aware of the need for more accurate data, and you may then communicate that to the data collectors.

To the data collectors, I say: To understand how the economy behaves, I need:

(a) more data

(b) more accurate data

(c) more accurate estimates of the accuracy of the data.

You surely overemphasize (a). You recognize (b). But please don't neglect (c). It is the real limiting factor right now.