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1 Optimal Factor Allocations for Thirteen Countries

James M. Henderson

1.1 Introduction

Distortions in commodity and factor markets significantly affect commodity patterns of trade and, perhaps even more important, the factor proportions in individual industries. This is a major conclusion of most of the country studies for the project on alternative trade strategies and employment. This chapter is designed to determine what might happen if trade barriers and factor market distortions were relaxed so resources could be shifted toward sectors with comparative advantage and factor proportions could be adjusted in individual sectors. Many of the individual country studies made estimates of the magnitudes of commodity and factor market distortions, using the assumptions and techniques appropriate for each country. This study is complementary. A broad framework and model are used for the analysis of all countries, complementing the detailed data of the individual studies. The model is applied to determine some of the short- to medium-run effects of distortion relaxation for nine developing countries and, for comparison, four developed countries.

The basic model is constructed within a nonlinear programming format. Each country is assumed to face fixed international prices, and the model is implemented for one country at a time. The maximand is the international value added (IVA) of domestic production. Optimality thus is guided by international, rather than domestic, prices. Each country is assumed to have a fixed endowment of labor and capital. Intermediate

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good inputs are used in fixed proportions relative to the output of each industry. Input-output coefficients provide the requisite data. Labor and capital inputs are governed by Cobb-Douglas production functions, and thereby continuous substitution between these factors is allowed for each industry.

Upper and lower limits relative to historical levels are imposed for the outputs of traded goods. The limits prevent solutions with extreme specialization and allow consideration to the short- to medium-run directions of movements toward comparative advantage allocations from observed allocations. The limits reflect some relaxation rather than total elimination of distortions. Solutions of the model describe freer trade but do not go all the way to free trade. In addition, the limits reflect both the fixity of capital and unobserved constraints that in the real world would result in upward-sloping supply curves. The optimal solutions of the model thus provide indications of the directions of change. The shadow prices corresponding to the output constraints indicate the gains from such changes and also may suggest the severity of underlying distortions.

It must be recognized from the outset that the freer trade described by the model has not been observed, and that neither exact nor stochastic measures of its consequences are possible. However, it is possible to confront the solutions of the model with the individual country studies described in Krueger et al. (1981). That volume and this chapter have six countries in common—Chile, Indonesia, the Ivory Coast, South Korea, Tunisia, and Uruguay. These studies rely heavily upon census data rather than on the comprehensive input-output data used here. Comparisons of the two types of studies show general comparability and compatibility. The present study provides information that supplements and extends the country studies with regard to the implications of alternative trade strategies.

Section 1.2 contains a discussion of the structure of the model, that is, its underlying assumptions and definitions. The properties of optimal solutions are the subject of section 1.3. Kuhn-Tucker conditions are applied to determine equilibrium conditions, and optimal shadow prices are derived. A three-factor extension of the model is obtained by separating labor into unskilled and skilled components. The empirical implementation of the model is covered in section 1.4.

Optimal solutions are analyzed in section 1.5 in terms of (1) implied employment changes, (2) implied IVA and DVA (domestic value added) changes, (3) a measure of comparative advantage, (4) implications for trade, and (5) implied capital/labor ratio changes. A three-factor application for Chile is also described. Section 1.6 contains conclusions and suggestions for further research.

There are four appendixes. Appendix A contains a description of some of the model's mathematical properties. Data sources and rectification procedures are described in Appendix B. Appendix C contains some detailed sectoral data to supplement the more aggregative data presented in the text. Computational procedures to obtain optimum solutions are described in Appendix D.

1.2 Structure of the Model

1.2.1 Classification of Goods

Each of $(n + 1)$ sectors is assumed to have a single homogeneous good. The terms "good" and "sector" are used interchangeably, as are the terms international good and traded good. The outputs of the sectors numbered 1 through m are international goods that can be exported to and imported from other countries. A subset, the outputs of the sectors numbered 1 through $r<m$, are natural resource based (NRB). These require the existence of natural resources such as cropland, forests, or bodies of ore before production can take place. The remaining $(m-r)$ international goods do not directly require the existence of such natural resources. These are designated "HOS" (Heckscher-Ohlin-Samuelson) sectors in conformity with the nomenclature of the individual country studies (see Krueger et al. 1981). Sectors $(m + 1)$ through n cover home goods that are consumed in the country in which they are produced. The output of sector $(n + 1)$ is a noncompetitive import that is consumed but not produced within a given country. Consequently, there are $(m + 1)$ traded goods. The composition of noncompetitive imports, of course, differs from country to country.

1.2.2 The International Trade System

The country under consideration is free to import and export at the fixed international prices $(p_1, p_2, \ldots, p_m)$ and p_{n+1} measured in domestic currency units. These prices are unaffected by its trade levels.

Following input-output practice, physical units are defined so that the base-year domestic price for each good equals one. Each country is assumed to have a fixed exchange rate, and international prices are measured in terms of domestic currency units. Since the model treats real rather than monetary phenomena, nothing is lost by this assumption. International prices could be measured equivalently in terms of United States dollars or any other foreign currency unit for which there is a fixed exchange rate. Factor prices are also measured in domestic currency units. They reflect international prices in that they are used in the production of international goods as well as home goods. Home goods prices also reflect international values as transmitted through the price system in that inputs used in home goods production have opportunity costs in terms of international goods production.

1.2.3 Domestic Production

Produced intermediate inputs are assumed to be required in fixed proportions for the production of each good. The input-output coefficient a_{ij} gives the quantity of the ith good required to produce one unit of the jth. Accordingly, $a_{ij}X_j$ units of good i are required to produce X_j units of good j. The nonproduced factors, labor and capital, are also required for each good as specified by the Cobb-Douglas production functions:

$$(1) \qquad X_j = A_j L_j^{\alpha_j} K_j^{(1-\alpha_j)}, \ (j = 1, \ldots, n)$$

where $A_j > 0$ and $0 \leqq \alpha_j \leqq 1$ are given parameters. The respective inputs of labor and capital for the production of good j are denoted by L_j and K_j. In section 1.3 it is shown that the labor and capital shares of DVA are α_j and $(1 - \alpha_j)$ respectively under competitive assumptions. The marginal products of labor and capital, that is, the partial derivatives of (1) are denoted by

$$MPL_j = \frac{\partial X_j}{\partial L_j} = \alpha_j A_j L_j^{(\alpha_j - 1)} K_j^{(1-\alpha_j)}$$
$$MPK_j = \frac{\partial X_j}{\partial K_j} = (1 - \alpha_j) A_j L_j^{\alpha_j} K_j^{-\alpha_j} \qquad (j = 1, \ldots, n)$$

respectively.

The Cobb-Douglas functions become

$$(2) \qquad X_j = A_j U_j^{\alpha_j} S_j^{\beta_j} K_j^{(1-\alpha_j-\beta_j)} \qquad (j = 1, \ldots, n)$$

when labor is separated into skilled and unskilled components with the respective input levels U_j and S_j.[1] The coefficients again sum to one with $0 \leqq \alpha_j, \beta_j \leqq 1$. The exponent for each factor input again gives its competitive share of DVA.

The country under investigation has the fixed endowments L^0 units of labor and K^0 units of capital available for use in production. It may leave some of its endowments unused, but it cannot use more than its endowments. Specifically,

$$(3) \qquad \sum_{j=1}^{n} L_j \leqq L^0$$

$$(4) \qquad \sum_{j=1}^{n} K_j \leqq K^0.$$

Factors are completely immobile among countries but are mobile between sectors within a given country subject to the output limits described below.

For three factors the labor endowment consists of U^0 units of unskilled and S^0 units of skilled labor, and (3) becomes:

(5) $$\sum_{j=1}^{n} (U_j + S_j) \leqq U^0 + S^0$$

(6) $$\sum_{j=1}^{n} S_j \leqq S^0.$$

These constraints allow skilled laborers to work at unskilled tasks but do not allow unskilled laborers to work at skilled tasks. The sum of the U_j can exceed U^0 if the sum of the S_j falls short of S^0 by at least the amount of this difference.

It is assumed that the output level for each international good cannot be increased or decreased from its base value (X_j^0) by more than 100δ percent ($0 < \delta < 1$):

(7) $$(1 - \delta)X_j^0 \leqq X_j \leqq (1 + \delta)X_j^0. \qquad (J = 1, \ldots, m)$$

Individual sectoral values for δ and differential values for increases and decreases are easily introduced when circumstances warrant. Alternatively, limits could be placed upon factor service changes rather than output changes. The output constraints provide indirect short- to medium-run limits on labor and capital mobility. They serve as proxies for other institutional and real constraints to output flexibility that cannot be explicitly introduced into the model. They allow for a relaxation, rather than an elimination, of distortions. They permit consideration of movements within a neighborhood of an observed base-year solution and indicate the directions in which changes might take place. These limited changes are more useful for a consideration of alternative trade strategies than unconstrained long-run changes, because the latter would result in very high levels of specialization and fail to reflect the conditions that give rise to upward-sloping supply curves. Policy determination is often in terms of small and gradual changes with slow relaxation of institutional constraints. "Shadow prices" corresponding to (7) are derived in section 1.3.

1.2.4 Domestic Consumption and Home Goods Outputs

Home goods final consumption levels for a base year, denoted by C_i^0 ($i = m + 1, \ldots, n$), include all uses observed during the base year other than intermediate input uses. These cover net trade,[2] final purchases by consumers and governments, investment, and inventory change. Home goods final consumption levels are treated as constants. The optimization problem is to maximize IVA given these final consumption levels. Relaxation of the constant level assumption would substantially complicate the model with little alteration of major results.

The output level for each home good is determined by its fixed final consumption level and its use as an intermediate input:

$$X_i = C_i^0 + \sum_{j=1}^{n} a_{ij}X_j. \qquad (i = m + 1, \ldots, n)$$

Solving these $(n - m)$ linear equations for the $(n - m)$ home goods output levels,

$$X_i \geqq k_i + \sum_{j=1}^{m} \sigma_{ij} X_j, \qquad (i = m + 1, \ldots, n) \tag{8}$$

where $k_i = \sum_{j=m+1}^{n} \mu_{ij} C_j^0$ and $\sigma_{ij} = \sum_{h=m+1}^{n} \mu_{ih} a_{hj}$.

The coefficient μ_{ij} is the quantity of the ith home good required directly and indirectly to produce one unit of the jth home good. Here, k_i is a constant giving the gross output of the ith home good necessary to meet the direct and indirect requirements for the fixed home goods final demands.[3] The coefficient σ_{ij} is the quantity of the ith home good necessary directly and indirectly to support one unit of output of international good j. The μ and σ coefficients are derived from the input-output coefficients in Appendix A. The inequality in (8) facilitates the derivations of section 1.3. It specifies that the output of each home good be *at least as great* as final consumption and production requirements. It is shown that the exact equality holds in equilibrium.

The assumptions of the model allow a two-stage procedure for the optimization of a country's welfare or utility under free trade. First, let the country maximize IVA for its production of traded goods. Second, let it spend the maximum IVA to buy an optimal consumption bundle. This procedure corresponds very closely to the tradition in international trade theory of treating production choices as separate from consumption choices because of the availability of international markets. It has considerable value for empirical application. It means that optimal production specialization patterns can be determined without having to either model or forecast international goods final consumption patterns. Opportunities for errors thus are normally lessened. Of course it is necessary to forecast final consumption for international goods before optimal trading patterns can be determined.

1.3 Equilibrium Properties of the Model

1.3.1 The Objective Function

The IVA for a representative country's production is

$$V = \sum_{j=1}^{m} p_j X_j - \sum_{j=1}^{n} \sum_{i=1}^{m} p_i a_{ij} X_j - \sum_{j=1}^{n} p_{n+1} a_{n+1,j} X_j, \tag{9}$$

which is simply the international value of its traded outputs less the international value of its traded inputs. Let γ_j be the fixed value of the traded inputs necessary to produce one unit of good j:

$$\gamma_j = \sum_{i=1}^{m} p_i a_{ij} + p_{n+1} a_{n+1,j}, \qquad (j=1, \ldots, n)$$

and rewrite (9) as

(10) $$V = \sum_{j=1}^{m} p_j X_j - \sum_{j=1}^{n} \gamma_j X_j.$$

Now let

(11) $$\hat{z}_j = p_j - \gamma_j - b_j \qquad (j=1, \ldots, m)$$

for international goods where $\hat{z}_j$ is direct and indirect IVA per unit of j and b_j (see Appendix A) is the international value of the international goods used as inputs directly and indirectly to produce the home goods used as inputs in the production of j. Direct IVA per unit of j is simply $z_j = p_j - \gamma_j$. The IVA coefficients are constants because the underlying international prices and input-output coefficients are constants. A coefficient will be negative if the international value of its direct and indirect inputs exceed its international price. Equation (10) may be rewritten as

(12) $$V = \sum_{j=1}^{m} \hat{z}_j X_j - K,$$

where K (see Appendix A) is a constant giving the international value of the traded goods necessary to directly and indirectly support the fixed home goods final demands.

The constant K has no effect upon the determination of an optimum solution and may be omitted from (12) so that each country is assumed to maximize the direct and indirect IVA from its production of traded goods. Note that indirect IVA in this context is traded goods used to produce home goods used to produce traded goods. There are no indirect international good requirements, since inputs may be directly purchased in the international markets without transaction costs.

1.3.2 An Illustration

A simple system is pictured in figure 1.1 within a standard international trade format. There are two traded goods and no home goods. The output transformation curve for the fixed labor and capital endowments is given by DBACE. Point A represents base-year output levels. The maximum and minimum limits as defined by the broken lines allow outputs to increase or decrease by 40 percent. The feasible point set, that is, the output levels that satisfy all the constraints, is FBC. Both labor and capital are fully utilized for points on the transformation curve arc BC. One or both the primary factors are underutilized at all interior points in the feasible set. Good 1 is at its minimum limit at B, and good 2 is at its minimum limit at C. In this particular example the maximum limits lie

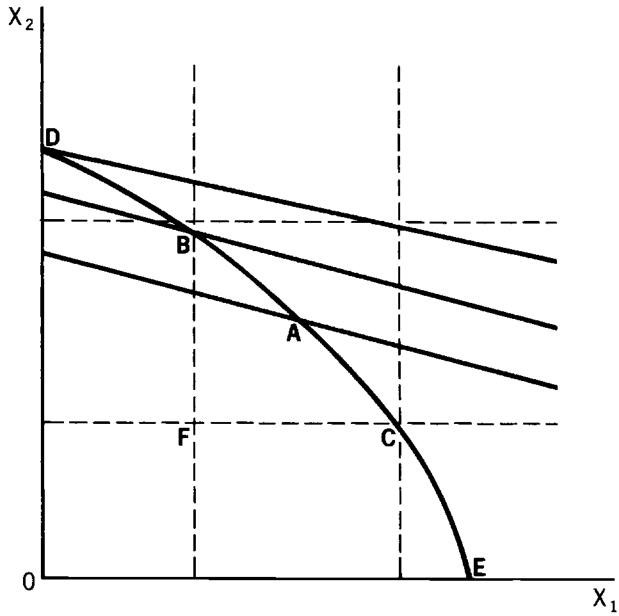

Fig. 1.1

above the transformation curve and therefore are not binding for any set of international prices.

An optimal point maximizes IVA within the feasible set. Let an isovalue line be the locus of all output combinations that yield a particular IVA for specified international prices. Its slope equals the negative of the IVA ratio: $-\hat{z}_2/\hat{z}_1$. The lines containing points A, B, and D give increasing IVAs for a particular IVA ratio. The base point A gives the lowest value of the three, and the tangent point D gives the highest.[4] However, D is not feasible because it violates the lower output limit for good 1. If this constraint did not exist, D would be optimal, and there would be almost complete specialization in good 2. Point B is optimal. It gives the highest IVA of any point in the feasible set. For B, both factors are fully utilized. Good 1's output is at its minimum limit, good 2's output is between its minimum and maximum limits.

Another example is pictured in figure 1.2. The transformation curve is the same as in figure 1.1, but the base output point and IVA ratio are different. The feasible point set is FBCE. The transformation curve segment BC is bounded by the upper and lower limits for good 1. The tangent point D is optimal for the unit IVA ratio corresponding to the line on which it lies. In this case none of the output limits is effective.

The positively sloped line containing B in figure 1.2 is an isovalue line for which IVA per unit of good 1 is negative. Total IVA increases as the

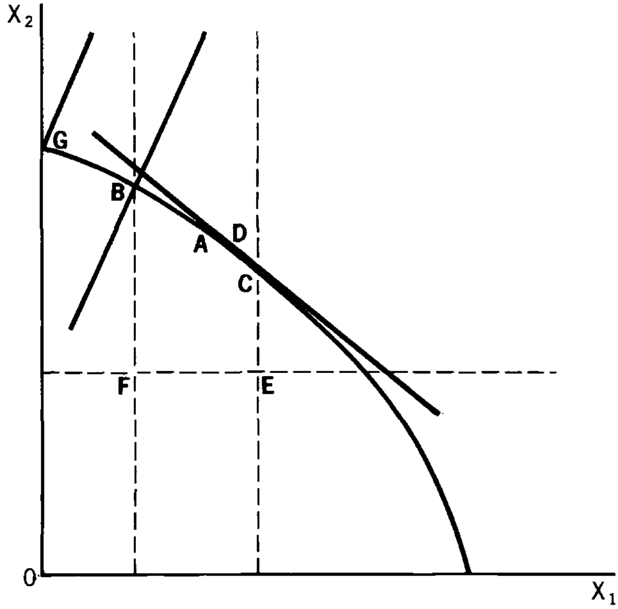

Fig. 1.2

line moves to the left with X_2 increasing relative to X_1. The complete specialization point G would be optimal if there were no lower limit for good 1. The optimal point in this case is B with the smallest possible output for good 1.

1.3.3 The Kuhn-Tucker Conditions

A representative country desires to select nonnegative values for its output and primary input levels that maximize its IVA subject to the constraints given by (1), (3), (4), (7), and (8). For the Lagrange function

$$\begin{aligned}(13)\qquad Z = &\sum_{i=1}^{m} p_j X_i - \sum_{i=1}^{n} \gamma_i X_i + w(L^0 - \sum_{i=1}^{n} L_i) + c(K^0 - \sum_{i=1}^{n} K_i) \\ &+ \sum_{i=1}^{n} q_i (A_i L_i^{\alpha_i} K_i^{1-\alpha_i} - X_i) + \sum_{i=1}^{m} u_i [(1+\delta)X_i^0 - X_i] \\ &+ \sum_{i=1}^{m} v_i [X_i - (1-\delta)X_i^0] + \sum_{i=m+1}^{n} \pi_i(X_i - k_i - \sum_{j=1}^{m} \sigma_{ij} X_j),\end{aligned}$$

where the parenthesized constraints have been rewritten so that each is in the form $\geqq 0$. It is more convenient to use (10) than (12) at this juncture. A Lagrange multiplier is introduced for each of the $(2n + m + 2)$ constraints. These increase the total number of variables to $(5n + m + 2)$.

Since the objective function and constraints of (13) are all concave and the Slater constraint qualification is met,[5] the Kuhn-Tucker conditions (see Hadley 1962) are necessary and sufficient for an optimum. Specifically,

(14.1) $$\frac{\partial Z}{\partial X_j} = p_j - \gamma_j - q_j - u_j + v_j - h_j \leqq 0, \frac{\partial Z}{\partial X_j} X_j = 0, X_j \geqq 0 \quad (j=1, \ldots, m)$$

(14.2) $$\frac{\partial Z}{\partial X_j} = \pi_j - \gamma_j - q_j - h_j \leqq 0, \frac{\partial Z}{\partial X_j} X_j = 0, X_j \geqq 0 \quad (j=m+1, \ldots, n)$$

(14.3) $$\frac{\partial Z}{\partial L_j} = q_j(MPL_j) - w \leqq 0, \frac{\partial Z}{\partial L_j} L_j = 0, L_j \geqq 0 \quad (j=1, \ldots, n)$$

(14.4) $$\frac{\partial Z}{\partial K_j} = q_j(MPK_j) - c \leqq 0, \frac{\partial Z}{\partial K_j} K_j = 0, K_j \geqq 0 \quad (j=1, \ldots, n)$$

(14.5) $$\frac{\partial Z}{\partial w} = L^0 - \sum_{i=1}^{n} L_i \geqq 0, \frac{\partial Z}{\partial w} w = 0, w \geqq 0$$

(14.6) $$\frac{\partial Z}{\partial c} = K^0 - \sum_{i=1}^{n} K_i \geqq 0, \frac{\partial Z}{\partial_c} c = 0, c \geqq 0$$

(14.7) $$\frac{\partial Z}{\partial q_i} = A_i L_i^{\alpha_i} K_i^{(1-\alpha_i)} - \mathrm{X_i} \geqq 0, \frac{\partial Z}{\partial q_i} q_i = 0, q_i \geqq 0 \quad (i=1, \ldots, n)$$

(14.8) $$\frac{\partial Z}{\partial u_i} = (1+\delta)X_i^0 - X_i \geqq 0, \frac{\partial Z}{\partial u_i} u_i = 0, u_i \geqq 0 \quad (1=1, \ldots, m)$$

(14.9) $$\frac{\partial Z}{\partial v_i} = X_i - (1+\delta)X_i^0 \geqq 0, \frac{\partial Z}{\partial v_i} v_i = 0, v_i \geqq 0 \quad (1=1, \ldots, m)$$

(14.10) $$\frac{\partial Z}{\partial \pi_i} = X_i - k_i - \sum_{j=1}^{n} \sigma_{ij} X_j \geqq 0, \frac{\partial Z}{\partial \pi_i} \pi_i = 0, \pi_i \geqq 0, \quad (i=m+1, \ldots, n)$$

where $h_j = \sum_{i=m+1}^{n} \pi_i a_{ij}$ is the direct unit cost in terms of the prices π_i $(i=m+1, \ldots, n)$ of the home goods inputs used for the production of a unit of good j.

Conditions (14) are necessary and sufficient for optimal solutions, but they do not guarantee that such solutions exist. Fortunately, existence is no problem for the present model. The parameters of the model are defined (see section 1.4) so that base-year outputs provide feasible solutions, and that points in neighborhoods—perhaps large neighborhoods—about these outputs are also feasible.

1.3.4 Shadow Prices and Equilibrium Conditions

In general, a Lagrange multiplier is a shadow price—sometimes called an efficiency price—that gives the rate at which the maximum value of the objective function would increase per unit increase in the quantity being constrained. For example, w is the increment of optimal IVA per marginal unit of labor, that is, the value of the marginal product of labor. It is interpreted as the optimal wage rate. Table 1.1 contains economic interpretations of the shadow prices corresponding to each group of constraints.

Enough is known about the specifics of the present model to allow considerable specification of conditions (14). Since each international good is subject to a positive lower limit, and each home good has a positive final demand, is used in the production of other goods, or both, *all optimal output levels are positive.* Since $X_j > 0$, $\partial Z/\partial X_j = 0$ follows from the condition $(\partial Z/\partial X_j)X_j = 0$, and the first two sets of conditions in (14) are strict equalities in equilibrium. Rearranging terms,

(15) $$p_j = \gamma_j + h_j + q_j + r_j \qquad (j = 1, \ldots, m)$$

(16) $$\pi_j = \gamma_j + h_j + q_j, \qquad (j = m+1, \ldots, n)$$

where $r_j = (u_j - v_j)$. Following the interpretations given in table 1.1, the price of an international good equals the sum of the unit costs of its international inputs (γ_j), its home goods inputs (h_j), and its factor inputs (q_j) plus the net unit rent (r_j) arising from its output limits. A positive (negative) r_j is the unit profit (loss) arising from difference between unit international price and unit shadow costs for a good at its maximum (minimum) limit. Zero profits would prevail if the government imposed unit taxes equal to positive r_js and paid unit subsidies equal to the absolute value of negative r_js. The rents would all be zero if there were no

Table 1.1 **Shadow Prices**

Constraint	Shadow Price	Definition
1	q_j	Optimal DVA per unit of output
3	w	Wage per unit of labor
4	c	Price per unit of capital service
7	u_i	Rent for one more unit of capital output i
7	v_i	Rent for one less unit of output i
8	π_i	Price per unit of a home good

output limits. They are a consequence of relaxing rather than eliminating the causes of distortion.

The imputed price for a home good (π_j) equals the unit cost of its inputs given by (16). Home goods are not traded, but their prices reflect international prices because home and international goods are used in each other's production, and because labor and capital are used for the production of both.

The eighth set of conditions in (14) states that u_i can be positive only if X_i is at its upper limit, and the ninth set states that v_i can be positive only if X_i is at its lower limit. Consequently, u_i and v_i cannot both be positive for the same good, though both can be zero. In fact, normally there is at least one marginal good that is at neither its upper nor its lower limit with $r_i = 0$.[6] Such goods provide reference points for the calculation of unit rents. A positive rent corresponds to a good at its maximum limit. A positive IVA increment could be achieved if its output could be increased by drawing the requisite factor quantities from the marginal goods. IVA exceeds factor cost for such goods, and IVA equals factor costs for the marginal goods.

Similarly, a negative rent corresponds to a good at its minimum limit. A positive IVA increment could be achieved if its output could be decreased with the released factor quantities used for the production of the marginal good. IVA is less than factor costs for such goods.[7]

Since all primary factor production functions are Cobb-Douglas and all outputs are positive, positive amounts of labor and capital are used in the production of each good.[8] This means that the second and third sets of (14) are also satisfied as strict equalities with

(17) $$q_j(MPL_j) = w \qquad (j=1, \ldots, n)$$

(18) $$q_j(MPL_j) = c. \qquad (j=1, \ldots, n)$$

These state the well-known conditions for profit maximization that the value of the marginal product for each factor equals the factor's price.

The marginal products of each factor are always positive for Cobb-Douglas production functions. Consequently, an incremental quantity of either factor can be used to increment the output of the marginal good and thereby increment total IVA.[9] It follows that both factors are fully utilized for optimal solutions. This means that optimal solutions will be on the transformation surface. The shadow price w is the rate of increase of optimal IVA per unit increase of labor endowment. It is positive and is interpreted as the wage rate. Similarly, c is interpreted as the price of capital services. The partial derivatives of (14.5) and (14.6) equal zero in equilibrium. Since marginal products are positive for the Cobb-Douglas functions, it follows that the q_j are positive for positive w and c.

The strict equalities in (14.7) and (14.10) are satisfied in equilibrium, since a strict inequality would entail producing an output and throwing it away.

Utilizing (17) and (18), total factor payments for the production of good j are

$$wL_j + cK_j = q_j(\alpha_j \frac{X_j}{L_j})\, L_j + q_j\,[(1-\alpha_j)\,\frac{X_j}{K_j}]\, K_j = q_jX_j,$$

which equals optimal DVA. Thus (15) and (16) state that the whole of optimal DVA is absorbed by factor payments.

An equilibrium solution may be interpreted as the outcome of competitive behavior in which people optimize subject to the domestic prices $(p_j - r_j)$. The output limits prevent the equalization of the domestic and international prices and prevent the equalization of IVA and optimal DVA. Let the government impose a system of taxes and subsidies as given by the optimal r_js. Assume that the net tax revenue, $\sum_{j=1}^{n} r_jX_j$, which may be positive, negative, or zero, is redistributed.

1.3.5 Measures of IVA and DVA

IVA and DVA are each used in two different senses in this paper, and it is necessary to keep track of which concepts are being used in particular instances. In general, value added per unit for a good is simply the difference between unit price and unit costs on some set of inputs for that good. Different concepts result from the use of different price or cost concepts.

Direct and indirect unit IVA as defined by (11):

$$\hat{z}_j = p_j - \gamma_j - b_j$$

is international price less the unit costs of international inputs used directly and the international inputs used to produce direct and indirect home goods inputs. Since international prices and input-output coefficients are constant, this concept of IVA can be defined without reference to an optimal solution.

Direct unit IVA (z_j) is international price minus the cost of all international inputs:

(19) $$z_j = p_j - \gamma_j. \qquad (j = 1, \ldots, m)$$

Since b_j (see Appendix A) is assumed to be positive, it follows that $\hat{z}_i < z_j$.

Optimal direct unit DVA for an international good differs from unit IVA by the amount of its unit rent and home goods inputs:

(20) $$q_j = z_j - r_j - h_j, \qquad (j = 1, \ldots, m)$$

which follows from (15). The q_j are always positive even though a corresponding z_j may be negative. This concept of DVA is relevant only with reference to an optimal solution.

Base-year unit DVAs for international goods are

$$q_j^0 = 1 - \sum_{i=1}^{n} a_{ij}, \qquad (j = 1, \ldots, m) \tag{21}$$

since unit prices prevailed. These may deviate substantially from the other DVA and IVA measures. Negative q_j^0s are possible. However, it is more common to have a positive q_j^0 corresponding to a negative z_j.[10] Production of such outputs is made viable through domestic policies, such as high rates of protection, that make base-year DVAs positive.

1.3.6 The Cost of Distortions

Commodity and factor market distortions prevent a country from obtaining the maximum IVA that would be realized in the absence of such distortions. The difference between actual and maximum IVA is the cost of the distortions. This concept represents a generalization of the concept of the cost of protection.[11] The difference between observed IVA and the optimal IVA given by the present model provides an overall measure of the cost of distortions. Looked at from a more positive viewpoint, it provides a measure of the gains from relaxing distortions. Empirical measures of these costs (gains) are given in section 1.5.

Analysis of the relative magnitudes of distortion costs on a sectoral basis is useful in considering alternative trade strategies. The following measure of sectoral distortion costs is used in section 1.5:

$$g_j = \frac{\hat{z}_j}{w\hat{\ell}_j^* + c\hat{k}_j^*} - 1, \qquad (j = 1, \ldots, m) \tag{22}$$

where $\hat{\ell}_j^*$ and $\hat{k}_j^*$ respectively are the optimal direct and indirect labor and capital requirements per unit output.[12] This measure gives the number of currency units of IVA obtained per unit expenditure for domestic factors in the production of international good *j relative to the marginal good.*[13] The coefficient is zero for the marginal good, positive for a good with a positive rent and negative for a good with a negative rent. Sector distortion costs are indicated by the absolute values of the g_j coefficients.

The g_j coefficients are constructed to represent changes in factor allocations constrained by the upper and lower output limits. The total costs of distortions may be substantially understated if larger output variations are allowed.

1.3.7 A Three-Factor Extension

A three-factor version of the model has been constructed with two classes of labor—unskilled and skilled, allowing one-way mobility between labor classes. A skilled worker may take an unskilled job, but an unskilled worker may not take a skilled job. The three-factor programming format is very similar to the two-factor format: select nonnegative values for outputs, unskilled labor inputs, skilled labor inputs, and capital inputs that maximize IVA as represented by (11) subject to the production functions (2); the factor endowments (5), (6), and (3); the output limits (7); and the home goods requirements (8). The appropriate Lagrange function is

(23)
$$\begin{aligned} Z = & \sum_{i=1}^{m} p_i X_i - \sum_{i=1}^{n} \gamma_i X_i + w(U^0 + S^0 - \sum_{i=1}^{n} U_i \\ & - \sum_{i=1}^{n} S_j) + s(S^0 - \sum_{i=1}^{n} S_i) \\ & + c(K^0 - \sum_{i=1}^{n} K_i) + \sum_{i=1}^{n} q_i(A_i U_i^{\alpha_i} S_i^{\beta_i} K_i^{(1-\alpha_i-\beta_i)} - X_i) \\ & + \sum_{i=1}^{m} U_i[(1+\delta)X_i^0 - X_i] + \sum_{i=1}^{m} v_i[X_i - (1-\delta)X_i^0] \\ & + \sum_{i=m+1}^{n} \pi_i(X_i - k_i - \sum_{i=1}^{m} \sigma_{ij} X_j). \end{aligned}$$

Kuhn-Tucker conditions again are applicable. Conditions (14.1), (14.2), (14.4), (14.6), (14.8), (14.9), and (14.10) are applicable for three factors as well as two. The remaining conditions for the three-factor extension are

(24.3a)
$$\frac{\partial Z}{\partial U_j} = q_j(MPU_j) - w \leqq 0, \frac{\partial Z}{\partial U_j} U_j = 0, U_j \geqq 0 \qquad (j=1, \ldots, m)$$

(24.3b)
$$\frac{\partial Z}{\partial S_j} = q_j(MPS_j) - (w+s) \leqq 0, \frac{\partial Z}{\partial S_j} S_j = 0, S_j \geqq 0 \qquad (j=1, \ldots, n)$$

(24.5a)
$$\frac{\partial Z}{\partial w} = U^0 + S^0 - \sum_{i=1}^{n} U_i \geqq 0, \frac{\partial Z}{\partial w} w = 0, w \geqq 0$$

(24.5b)
$$\frac{\partial Z}{\partial s} = S^0 - \sum_{i=1}^{n} S_i \geqq 0, \frac{\partial Z}{\partial s} s = 0, s \geqq 0$$

(24.7)
$$\frac{\partial Z}{\partial q_i} = A_i U_i^{\alpha_i} S_i^{\beta_i} K_i^{(1-\alpha_i-\beta_i)} - X_i \geqq 0, \frac{\partial Z}{\partial q_i} q_i = 0, q_i \geqq 0. \qquad (i=m+1, \ldots, n)$$

For the reasons explained earlier, the equilibrium values for all the variables—other than the u_i, v_i, and s—are always positive, and the corresponding derivatives equal zero.

Equations (14), (15), and (16) hold for both two and three factors, but (17) is replaced by

(25a)
$$q_j(MPU_j) = w$$

(25b)
$$q_j(MPS_j) = w + s.$$

The wage rates for unskilled and skilled workers are w and $(w + s)$ respectively. The equilibrium skill premium, s, will be zero if skilled labor is not scarce; that is, the strict equality in (6) does not hold for an optimal solution. If some skilled workers are employed in unskilled jobs, all skilled workers will receive the unskilled wage, w.

It is easily verified that $wU_j + (w + s)S_j + cK_j = q_jX_j\,(j=1, \ldots, n)$ so that zero profits would prevail throughout the system with the appropriate unit taxes and subsidies.

1.4 Empirical Implementation

The model has been applied for nine developing countries: Chile, Indonesia, Ivory Coast, Kenya, South Korea, Taiwan, Tunisia, Turkey, and Uruguay; and for four developed countries: Belgium, France, Germany, and Italy. To a large degree the data are drawn from input-output studies. For the developing countries other than Kenya, Taiwan, and Turkey, the input-output studies are the same as used for NBER individual country studies. Some price and skill data were also drawn from these six country studies. Summaries for six of the studies are contained in Krueger et al. (1981). The country studies rely more heavily upon the census data than input-output data whereas the current study requires the comprehensive input-output data. Consequently, the data in this study and the country studies are not always strictly comparable. Nonetheless they are complementary, with a great deal of common ground.

This section begins with a general discussion of empirical implementation, followed by a discussion of the determination of the requisite data and parameters. The following are required: (1) input-output coefficients, the a_{ij}; (2) international prices, the p_j; (3) labor and capital data to provide the L^0 (or U^0 and S^0) and K^0; (4) Cobb-Douglas parameters, the A_j and α_j (also for the three-factor version β_j); and (5) base-year outputs and home goods final demands, the X_i^0 and C_i^0. The coefficient δ was arbitrarily set equal to 0.25 to restrict output changes to plus or minus 25 percent. Experimentation suggests that "reasonable" variation of δ will not trigger major changes in the solution results.

The use of base-year data to implement the model ensures that the base-year outputs provide a feasible solution. Consequently, optimal solutions in terms of IVA may be viewed as movements from the base-year observations. In interpreting the optimal solutions, it is assumed that the base-year observations describe optimal solutions giving maximum DVA subject to the constraints in force during the base year. Thus, base-year distortions are built in. Optimal solutions in terms of DVA differ from base solutions in two major regards. First, the optimal solutions are subject to fewer constraints. Second, they entail maximization of IVA rather than DVA. Base-year observations provide feasible, but not optimal, solutions for the IVA programs.

1.4.1 Base Years, Sector Classifications, and Adjustments

Some particulars for the applications are contained in table 1.2. More specific detail for the individual applications is given in Appendix B. There are sixteen applications in total for thirteen countries. There are separate applications for 1966, 1970, and 1973 for South Korea in order to investigate changes in comparative advantage over time. In addition, a three-factor extension of the model is applied for Chile.

The base years as listed in table 1.2 span the thirteen years from 1961 through 1973. The input-output tables differ markedly in procedures and span a wide range of reliability. The data for South Korea are perhaps the best. The sector classifications differ in a number of important regards. Value added for labor is used to represent physical labor inputs, and nonlabor value added is used to represent physical capital inputs. The definitions of nonlabor value added differ somewhat between countries. Consequently, comparison of capital labor ratios for pairs of countries must be made with great care.

The second column of table 1.2 indicates whether the input-output agricultural value added was adjusted. The adjustments consist of shifts to the labor component of value added from the nonlabor component. The labor component is understated in most cases because income to owner-operators is treated as profit rather than labor income. A common adjustment was to assume that two-thirds of value added for agriculture as a whole is labor income. Particulars are given in Appendix B.

The solutions as presented in section 1.5 normally have sectoral data aggregated into the following six major divisions: (1) agriculture, including forestry and fisheries; (2) other natural resource based (NRB) industries; (3) food production; (4) textiles including clothing, furs, and leather; (5) other manufacturing industries; and (6) home goods industries.

Table 1.2 Particulars for Applications of the Optimal Trade Model

Country	Base Year	Agricultural Adjustment
Chile	1962[a]	Yes
Indonesia	1971	Yes
Ivory Coast	1972	Yes
Kenya	1967	Yes
South Korea	1966–70–73	Yes
Taiwan	1971	No
Tunisia	1972	No
Turkey	1973[b]	No
Uruguay	1961	Yes
Europe	1963	No

[a]International prices for 1961 are used.
[b]International prices for 1968 are used.

Divisions 1 and 2 contain the NRB sectors, and 3, 4, and 5 contain the HOS sectors. The number of sectors contained in each major division for each country is listed in table 1.3.

The total number of sectors ranges from a low of 20 for Uruguay to a high of 168 for Indonesia. The number of HOS sectors is less than 20 for three of the nine developing countries. The classification of sectors into the traded and home goods categories differs somewhat from country to country. In some cases a good is classified as a home good because it does not appear desirable to consider an expansion of trade for that good. For example, the sector "undistributed" may have had a substantial volume of foreign trade, but it is difficult to imagine a country specializing in the production of its output. Tobacco products are treated as an international good for Turkey, which is a major exporter, and as home goods for the other twelve countries. Alcoholic beverages are treated as home goods for all thirteen countries. It is very difficult to determine international prices for these heavily taxed and highly protected sectors. Furthermore, few if any countries are likely to consider relaxing their controls for these sectors. Consequently, current consumption and trade levels were frozen.

In some cases nontradable services required for the production of a particular international good are included within the sector for that good. In other cases, separate service sectors are defined. Textile dyeing and finishing in Korea is an example. Such sectors are treated as home goods even though they are part of a sequence leading to a traded good. In some cases nonexportable agricultural produce is placed in an individual sector. Paddy rice and sugarcane in Taiwan are examples. These are inputs for the international goods rice and sugar and are treated as home goods. Diverse treatments mean that one country may have a higher proportion of its labor force in home goods sectors than another solely as a result of

Table 1.3 Numbers of Sectors in Each Major Division

Country	Agriculture	Other NRB	Food	Textiles	Other Manufacturing	Home Goods	Total
Chile	2	6	2	3	14	27	54
Indonesia	29	12	23	11	48	45	168
Ivory Coast	6	1	9	3	17	11	47
Kenya	1	1	2	4	8	10	26
South Korea	8	3	9	16	52	30	118
Taiwan	8	4	9	6	29	20	76
Tunisia	7	4	6	6	25	20	68
Turkey	4	6	8	5	24	16	63
Uruguay	2	1	2	3	9	3	20
Europe	2	5	9	7	31	8	62

classification differences. This problem is somewhat ameliorated by focusing upon direct plus indirect factor use.

The breakdown of traded goods into the NRB and HOS categories is particularly troublesome for Korea, Taiwan, and to some degree Tunisia for which the input-output data combine extraction and processing of nonmetallic minerals. The combined sectors are classed as HOS, which causes some noncomparability for major division results. Different levels of aggregation present major comparability problems. A typical optimal solution has every sector but one[14] at either its maximum or its minimum output limit. The Ivory Coast, Kenya, and Uruguay have only one sector in the other NRB division, and as a result they will normally realize output changes of plus or minus 25 percent for this division, while countries with more sectors in the division may have smaller absolute changes. Similarly, a country with an aggregative sector such as "machinery" normally realizes a 25 percent output change, whereas a country with fifteen machinery sectors normally has some at their output maxima and others at their minima. Consequently, the absolute value of the aggregate change in machinery output may be smaller in the second country even though the underlying conditions are the same for both. As more information is gained, it may prove desirable to let δ vary with the level of aggregation. These and other problems are considered in section 1.5.

1.4.2 Input-Output Coefficients

The a_{ij} were taken from base-year input-output tables and follow the input-output definition whereby the domestic price for each sector equals one (or sometimes, one million), with the corresponding physical output units being the quantities that could have been purchased for one (or one million) domestic currency unit(s) during a base year. The typical input-output coefficient gives the number of physical units of the output of sector i defined in this manner necessary to produce one physical unit of the output sector j defined in this manner. This definition is retained throughout.

1.4.3 International Prices

The domestic currency price of a traded good is denoted by ρ_j, and its international dollar price is denoted by p_j. The two are related as follows:

$$\rho_j = (1/R)p_j(1 + t_j), \qquad (j=1, \ldots, m) \tag{26}$$

where t_i is an implicit tariff rate with a negative value indicating an implicit subsidy and R is an exchange rate giving the number of units of domestic currency per dollar. Nothing essential is lost by letting $R = 1$ and thereby measuring international prices in domestic currency units. It is customary to define units so that $p_j = 1$ and $\rho_j = (1 + t_j)$. Here, however, the input-output convention $\rho_j = 1$ is retained so that

$$p_j = 1/(1 + t_j). \qquad (j=1, \ldots, m) \tag{27}$$

The essential results of the analysis are independent of the units in which goods are defined. The individual sectoral prices used for the model applications are listed in Appendix C.

The implicit tariff rate t_j provides a measure of the divergence between domestic and international prices. It reflects quantitative restrictions and a variety of other influences as well as tariffs. The ideal way to measure the rate is to compute it directly from measures of domestic and international prices. This procedure was used for Chile, the Ivory Coast, and Uruguay. Appropriate nominal tariff rates were used for some of the other countries, and the ratios of duty collections to imports were used for others. The use of such rates introduces an error insofar as they fail to reflect domestic/international price differences accurately. For countries such as South Korea and Taiwan, where nontariff barriers are relatively unimportant, the error is probably small. For some of the other countries it may be large for some sectors. International prices are the most difficult data to obtain.

1.4.4 Labor and Capital Data

The input-output tables also are the principal source of labor and capital information. Wage payments and employer contributions to Social Security are used to measure labor input, and all other value added except taxes and subsidies is used to measure capital input. Thus it is assumed that the productivities of individual laborers are directly proportional to their wage rates. The capital data were adjusted in cases where abnormally low profits were earned. There are occasional cases where a capital input as defined above is negative. This is a particular problem for sectors that are run as State Economic Enterprises in Turkey. Comparable data for other sectors are used to make the capital adjustments. Particulars are given in Appendix B. The L^0 and K^0 estimates were obtained by summing the individual sector quantities for the base year.

The Chile study in Krueger et al. (1981) provided supplementary information that allowed a breakdown of input-output labor data into skilled and unskilled categories. For Chile it is a white-collar/blue-collar distinction. There are no data for the agricultural sectors. It is assumed somewhat arbitrarily that 5 percent of agricultural labor is skilled. Values for U^0 and S^0 were obtained by summing individual sector data. By this criterion 18 percent of the Chilean labor force is skilled. The Tunisia study also has a skill breakdown, with unskilled workers, apprentices, and seasonal employees constituting the unskilled group. These data were used to provide a skill breakdown for the input-output labor coefficients. Again, 5 percent of agricultural labor is assumed to be skilled. The aggregates indicate that 43 percent of the Tunisian labor force is skilled by this criterion. The Tunisian and Chilean data are not comparable, since many Tunisian blue-collar workers are classed as skilled.

Labor and capital inputs can be measured in terms of either stocks or flows. The choice often depends upon data availability. The individual country studies sometimes use stock measures and sometimes use flow measures. Flows are used here with factor payments as proxies for the flow of factor services. The use of stocks and flows are equivalent if stock/flow ratios are constant over an economy as a whole, as is assumed here. Errors may be introduced if stock/fllow ratios differ between sectors within a given economy, or if a uniform overall ratio varies in response to factor price changes. The costs of distortion will be understated if factors, particularly unskilled labor, were underutilized in the base year. Corrections are straightforward wherever such variations in stock/flow ratios can be identified and measured.

The definition of uniform labor units always presents problems whether the unit is man-hours or wage payments. It is by no means clear which metric is preferable. The wage metric can introduce errors if intersectoral wage differentials reflect distortions rather than productivity differences. Again, corrections can be made wherever the requisite information is available.

1.4.5 Cobb-Douglas Coefficients

Let ℓ_j and k_j denote the respective base-year adjusted labor and capital inputs per unit of output. These provide the basis for the Cobb-Douglas coefficients on the assumption that α_j is labor's share of base-year of DVA in sector j:[15]

$$\alpha_j = \ell_j/(\ell_j + k_j). \qquad (j = 1, \ldots, n) \tag{28}$$

The sectoral alphas used for the applications are listed in Appendix C. The A_j are determined by dividing the production function (1) by X_j and solving for

$$A_j = 1/(\ell_j^{\alpha_j} k_j^{(1-\alpha_j)}). \qquad (j = 1, \ldots, n) \tag{29}$$

A similar procedure is used for the three-factor extension.

1.4.6 Base-Year Outputs and Home Goods Final Demands

The X_j^0 are simply the base-year gross output levels provided by the input-output tables. Base-year import and export data also were secured directly from the input-output tables for most of the countries. These are not necessary for implementing the model, but they are useful for interpreting its solutions as described in section 1.5.

The fixed home goods final demand levels were computed from the input-output data as follows:

$$C_i^0 = X_i^0 - \sum_{j=i}^{n} a_{ij} X_j^0. \qquad (i = m+1, \ldots, n) \tag{30}$$

These equal total final demands less imports as given by the input-output data.

1.5 The Optimal Solutions

1.5.1 Implied Labor Service Shifts

Table 1.4 shows labor changes, on a major-division basis implied by shifts from base-year observations to optimal solutions. Columns 1 and 3 contain percentage distributions by division of direct labor services, and column 2 contains the differences between the two distributions that sum to zero, since labor service totals are the same for corresponding base years and optimal solutions.

Labor services are measured in terms of factor payments. Consequently, for a relative low-wage sector such as agriculture the percentage of labor shown in table 1.4 is smaller than the percentage of the labor force working in agriculture. The converse normally is true for manufacturing. There are some differences in the definitions of the home goods sectors between countries. Some services that are included in the agricultural sectors for one country are included in separate home goods sectors for another. In Taiwan, for example, the home goods sector "paddy" supplies the international goods sector "rice." The two activities are combined in a single sector in other countries. The agriculture and home goods percentages for the Ivory Coast and Kenya are an example of different classification procedures that do not represent massive structural differences. Intercountry comparisons of labor distributions must be made with care.

For the base year, the three manufacturing divisions constitute from 10 to 12 percent of total labor services for Indonesia, the Ivory Coast, Kenya, and Tunisia and about 20 percent for South Korea, Taiwan, and Turkey. The figure is almost 27 percent for Uruguay, where meat-packing is a major activity. Also, some of Uruguay's NRB activities are included in other manufacturing as a result of a very aggregative sectoral classification. Manufacturing constitutes more than 40 percent of total labor services for Germany and about 30 percent for the other European countries.

The optimal solutions indicate agricultural expansions for all of the developing countries except South Korea 1973 and Tunisia. Table 1.4 shows a decline of 0.66 percent of the total labor services for agriculture

Table 1.4 Base-Year and Optimal Solution Labor/Service Distributions by Major Division (Percentages of Total Labor Services)

Country	Base Year (1)	Solution Shift (2)	Optimal: Direct (3)	Optimal: Indirect (4)	Optimal: Direct and Indirect (5)
Chile					
Agriculture	20.59	3.16	23.75	3.73	27.48
Other NRB	8.99	1.75	10.74	2.16	12.90
Food	3.90	−1.15	2.75	2.22	4.97
Textiles	4.55	−1.36	3.19	1.33	4.52
Other manufacturing	14.51	−3.94	10.57	5.13	15.70
Home goods	47.46	1.54	49.00	−14.57	34.43
Total	100.00	0.00	100.00	0.00	100.00
Indonesia					
Agriculture	42.75	2.11	44.86	0.43	45.29
Other NRB	1.56	−0.32	1.24	0.23	1.47
Food	6.10	0.02	6.12	0.64	6.76
Textiles	1.84	−0.40	1.44	0.19	1.63
Other manufacturing	4.71	−0.71	4.00	0.58	4.58
Home goods	43.04	−0.70	42.34	−2.07	40.27
Total	100.00	0.00	100.00	0.00	100.00
Ivory Coast					
Agriculture	48.01	−0.66	47.37	10.01	57.38
Other NRB	0.32	−0.08	0.24	0.06	0.30
Food	3.46	−0.06	3.40	1.38	4.78
Textiles	2.93	−0.70	2.23	0.50	2.73
Other manufacturing	4.21	0.21	4.40	3.94	8.34
Home goods	41.07	1.29	42.36	−15.89	26.47
Total	100.00	0.00	100.00	0.00	100.00
Kenya					
Agriculture	21.04	3.55	24.59	1.44	26.03
Other NRB	0.60	−0.15	0.45	0.10	0.55
Food	2.13	−0.54	1.59	0.87	2.46
Textiles	1.19	−0.01	1.18	0.27	1.45
Other manufacturing	8.24	−1.81	6.43	1.57	8.00
Home goods	66.80	−1.04	65.76	−4.25	61.51
Total	100.00	0.00	100.00	0.00	100.00
South Korea, 1966					
Agriculture	51.21	−0.50	50.71	0.55	51.26
Other NRB	2.29	−0.51	1.78	0.14	1.92
Food	2.41	0.46	2.87	0.66	3.53
Textiles	4.10	0.59	4.70	0.93	5.63
Other manufacturing	7.84	−0.39	7.45	2.82	10.27
Home goods	32.15	0.34	32.49	−5.10	27.39
Total	100.00	0.00	100.00	0.00	100.00

Table 1.4 (continued)

Country	Base Year (1)	Solution Shift (2)	Optimal: Direct (3)	Optimal: Indirect (4)	Optimal: Direct and Indirect (5)
South Korea, 1970					
Agriculture	36.98	1.29	38.27	1.02	39.29
Other NRB	1.90	−0.33	1.57	0.27	1.84
Food	2.58	0.28	2.86	0.90	3.76
Textiles	4.76	0.01	4.77	1.33	6.10
Other manufacturing	9.43	−0.49	8.94	3.57	12.51
Home goods	44.35	−0.76	43.59	−7.09	36.50
Total	100.00	0.00	100.00	0.00	100.00
South Korea, 1973					
Agriculture	35.79	−1.54	34.25	0.89	35.14
Other NRB	1.77	−0.35	1.42	0.65	2.07
Food	2.62	−0.14	2.48	0.84	3.32
Textiles	5.42	1.31	6.73	1.86	8.59
Other manufacturing	11.86	0.14	12.00	3.15	15.15
Home goods	42.54	0.58	43.12	−7.39	35.73
Total	100.00	0.00	100.00	0.00	100.00
Taiwan					
Agriculture	11.08	0.04	11.12	7.74	18.86
Other NRB	1.21	0.33	1.54	0.12	1.66
Food	1.49	0.40	1.89	1.98	3.87
Textiles	3.13	1.05	4.18	1.26	5.44
Other manufacturing	18.36	−4.52	13.84	4.55	18.39
Home goods	64.73	2.70	67.43	−15.65	51.78
Total	100.00	0.00	100.00	0.00	100.00
Tunisia					
Agriculture	47.50	−2.04	45.46	1.54	45.49
Other NRB	3.27	−0.67	2.60	0.70	3.30
Food	2.24	−0.31	1.93	0.78	4.22
Textiles	2.14	0.46	2.60	0.53	3.13
Other manufacturing	6.02	1.30	7.32	1.99	9.31
Home goods	38.83	1.26	40.09	−5.54	34.55
Total	100.00	0.00	100.00	0.00	100.00
Turkey					
Agriculture	50.49	3.87	54.36	1.51	55.87
Other NRB	3.17	−0.74	2.43	0.37	2.80
Food	3.68	0.36	4.04	0.90	4.94
Textiles	4.69	0.43	5.12	0.87	5.99
Other manufacturing	12.14	−2.74	9.40	2.05	11.45
Home goods	25.83	−1.18	24.65	−5.70	18.95
Total	100.00	0.00	100.00	0.00	100.00

Table 1.4 (continued)

Country	Base Year (1)	Solution Shift (2)	Optimal: Direct (3)	Optimal: Indirect (4)	Optimal: Direct and Indirect (5)
Uruguay					
Agriculture	23.49	4.14	27.63	4.60	32.23
Other NRB	1.75	−0.45	1.30	0.13	1.43
Food	7.53	1.14	8.67	5.94	14.61
Textiles	4.55	−0.67	3.88	0.63	4.51
Other manufacturing	14.60	−3.76	10.84	3.19	14.03
Home goods	48.08	−0.40	47.68	−14.49	33.19
Total	100.00	0.00	100.00	0.00	100.00
Belgium					
Agriculture	6.71	−1.62	5.09	0.37	5.46
Other NRB	4.98	−0.54	4.44	0.60	5.04
Food	2.42	0.09	2.51	0.87	3.38
Textiles	5.45	−0.24	5.21	0.75	5.96
Other manufacturing	22.21	2.00	24.21	4.81	29.02
Home goods	58.23	0.31	58.54	−7.40	51.14
Total	100.00	0.00	100.00	0.00	100.00
France					
Agriculture	9.17	2.35	11.52	1.22	12.74
Other NRB	2.38	−0.01	2.37	0.47	2.84
Food	2.48	−0.08	2.40	0.75	3.15
Textiles	3.74	0.04	3.78	0.64	4.42
Other manufacturing	24.35	−2.24	22.11	4.79	26.90
Home goods	57.88	−0.06	57.82	−7.87	49.95
Total	100.00	0.00	100.00	0.00	100.00
Germany					
Agriculture	5.79	−1.43	4.36	0.43	4.79
Other NRB	2.75	0.69	3.44	0.80	4.24
Food	2.62	0.26	2.88	0.76	3.64
Textiles	4.64	0.11	4.75	0.49	5.24
Other manufacturing	36.97	−0.02	36.95	6.12	43.07
Home goods	47.23	0.39	47.62	−8.60	39.02
Total	100.00	0.00	100.00	0.00	100.00
Italy					
Agriculture	14.16	−3.47	10.69	0.40	11.09
Other NRB	1.42	0.35	1.77	0.34	2.11
Food	2.53	0.29	2.82	0.74	3.56
Textiles	4.49	−0.32	4.17	0.65	4.82
Other manufacturing	19.99	2.86	22.85	4.43	27.28
Home goods	57.41	0.29	57.70	−6.56	51.14
Total	100.00	0.00	100.00	0.00	100.00

in the Ivory Coast. However, this is more than offset by an expansion of home goods labor services that involve the processing of agricultural produce. Similarly, the slight increase of 0.04 percent for Taiwan is much larger when paddy is included. The South Korea 1973 solution suggests a move from agriculture to textiles. A similar shift is indicated for South Korea 1966, but 1970 indicates a shift to agriculture. A shift away from agriculture is suggested for each of the European countries except France.

The labor service shifts from manufacturing to agriculture suggested by the optimal solutions must be interpreted with care. Such shifts are not likely to be realized. The significant thing is that agriculture has comparative advantage over manufacturing and should be expanded relative to manufacturing. The shifts are large for Chile, Kenya, and Turkey, countries with trade strategies heavily oriented toward import substitution. The shifts to agriculture may reflect the lack of comparative advantage for import substitution manufacturing endeavors more than strong comparative advantage for agriculture. It is possible that other manufacturing industries with some competitive advantage that are currently small or nonexistent could absorb labor released from import substitution sectors.

A substantial increase for other NRB sectors is indicated for Chile with its rich mines, and there is a small increase for Taiwan. Declines are indicated for other developing countries. Labor service declines for all the manufacturing divisions are in order for Chile and Kenya. Indonesia has a small increase for food and shows declines for the other two. The Ivory Coast has declines for food and textiles and a modest increase for other manufacturing. Taiwan shows a sizable reduction for other manufacturing. Turkey has expansion for food and textiles and contraction for other manufacturing. Uruguay has expansion for food and contraction for the other two sectors. South Korea 1973 shows a large expansion for textiles and a modest expansion of other manufacturing. South Korea 1966 also shows a sizable textile expansion. It is significant that textiles did expand substantially in the late 1960s when Korean producers were confronted with international prices.

Belgium, Germany, and Italy all show reductions in agriculture. Belgium and Italy show corresponding increases for other manufacturing. The major thing that comes through for Germany is that its comparative advantage does not lie in agriculture. This has been confirmed by the decline of German agriculture since 1963 and the need for EEC protection of agriculture. The solutions suggest that France is the exception. An increase for agriculture and a decline for other manufacturing is indicated.

Two major uses have been indicated for home goods: the direct and indirect support of home goods final demands, and inputs for the production of international goods. For example, column 3 of table 1.4 shows that

49.00 percent of Chile's labor is used in the home goods division. Some 34.43 percent is attributable to home goods final demands, and 14.57 percent to inputs for the production of international goods. These indirect uses are allocated to the appropriate international goods sectors in column 4. Some 3.73 percent constitutes the home goods labor services that support agricultural output, and so on. Column 4 sums to zero, since total labor services are being reallocated but not changed in total. Column 5 is the sum of columns 3 and 4. For the five international goods divisions it gives total direct plus home goods indirect labor services. For home goods it gives the total home goods labor services that support home goods final demands.

Home goods indirect labor services for traded goods differ a great deal from country to country, indicating differing input-output accounting schemes. It is about 15 percent of total employment for Chile, the Ivory Coast, Taiwan, and Uruguay but is less than 6 percent for the other developing countries except South Korea. It is only 2 percent for Indonesia. The direct plus home goods indirect distributions are somewhat more comparable among countries than the direct, since differences attributable to classification differences are reduced.

Direct plus home goods indirect measures are used for the remaining evaluations of the optimal solutions, since these more closely represent the total impact of output and trade changes.

1.5.2 Implied IVA and DVA Changes

Since the model is designed to maximize IVA and since base-year solutions are feasible, it is not surprising that optimal IVAs are greater than base-year IVAs. It is of interest to ask, How much greater? Can substantial income increments be achieved by moving to a regime of freer trade? IVA increases by major divisions as percentages of base-year values are listed for each of the solutions in the top half of table 1.5. These are calculated by multiplying the base and optimal outputs by the corresponding direct and home goods indirect IVA coefficients, that is, the $\hat{z}_j$s as given by (11). A coefficient is negative if the international value of its traded inputs exceeds its international price. For the present applications there are ten negative $\hat{z}_j$s for the 847 individual sectors in the fifteen applications. Indonesia has six, Taiwan has three, and Turkey has one. The particular sectors can be found by finding g_j values smaller than -1 in Appendix C.

The maximum possible change for total IVA is substantially less than 25 percent. The output constraints limit the IVA increment for each individual sector to 25 percent, but the labor and capital constraints limit the number of sectors that can achieve their maxima. These restrictions suggest that the model may provide underestimates of the gains from free trade. Under these conditions IVA increments of 5 percent or more are

Table 1.5 Optimum Solution Changes of IVA and DVA (Percentages of Base-Year Values)

Country	Agri-culture	Other NRB	Food	Tex-tiles	Other Manu-facturing	All Traded
			IVA			
Chile	25.0	25.0	−25.0	−25.0	−3.1	3.6
Indonesia	8.2	−0.4	6.2	−6.3	−16.2	3.3
Ivory Coast	8.3	−25.0	1.8	−25.0	10.2	6.7
Kenya	17.7	−25.0	−25.0	−14.0	−11.7	10.8
South Korea, 1966	1.9	−25.0	18.7	18.0	2.2	3.9
South Korea, 1970	7.2	−8.5	13.5	7.7	−1.0	4.2
South Korea, 1973	−5.1	0.5	−6.8	23.5	5.7	2.8
Taiwan	15.2	25.0	10.7	−0.6	3.6	8.4
Tunisia	−4.2	12.6	−2.2	19.8	17.7	2.8
Turkey	10.7	−23.5	15.9	8.3	−14.2	5.3
Uruguay	19.3	−25.0	22.1	−25.0	−25.0	8.9
Belgium	−24.1	−13.3	8.6	2.7	10.2	3.0
France	25.0	3.5	1.4	4.8	−6.2	2.7
Germany	−17.7	24.1	10.6	3.5	5.8	6.8
Italy	−24.0	25.0	17.4	−6.1	15.8	2.8
			DVA			
Chile	25.0	25.0	−25.0	−25.0	−7.9	−4.9
Indonesia	3.2	−0.3	−1.6	−20.8	−4.2	0.1
Ivory Coast	1.2	−25.0	−2.9	−25.0	7.7	−1.0
Kenya	17.7	−25.0	−25.0	−16.2	−10.5	−8.1
South Korea, 1966	−1.1	−25.0	17.9	15.3	0.5	0.7
South Korea, 1970	2.6	−9.8	13.6	1.9	−5.3	1.0
South Korea, 1973	−5.8	−12.8	−7.6	23.0	3.6	0.4
Taiwan	15.0	25.0	−21.0	−14.9	−0.8	1.6
Tunisia	−4.1	13.9	−20.0	18.0	18.8	−1.4
Turkey	10.2	−24.2	11.1	5.1	−13.4	1.8
Uruguay	18.5	−25.0	19.8	−25.0	−25.0	−4.8
Belgium	−24.3	−12.8	6.6	−0.7	10.0	1.7
France	25.0	5.0	−3.2	1.9	−7.2	0.7
Germany	−24.4	24.3	13.9	2.6	7.6	5.2
Italy	−24.0	−25.0	13.1	−8.8	14.8	0.4

substantial. Five of the nine developing countries show increments of 5 percent or more. The gains for Kenya and Turkey are the result of the lessening importance of import substitution sectors. The large gain for Taiwan is to a large degree the consequence of reductions in the outputs of food sectors with negative IVAs, and it should be interpreted with care.

The sizable IVA gain for Germany is largely the result of the reduction of its inefficient agricultural sector. The European countries and South Korea 1973 show gains of about 3 percent. South Korea is much closer to a free-trade regime than the other eight developing countries, and as a result it has less to gain from a move toward freer trade. South Korea 1966 and 1970 show greater opportunities for gain during the earlier years of rapid growth. Perhaps some of that rapid growth can be interpreted in terms of movement away from an earlier heavily distorted situation.

The relatively small gains for Chile, Indonesia, and Tunisia, which are a long way from free trade, must be explained in other terms. A possible explanation is that the few sectors in which these countries compete effectively in international trade are already operating at prices very close to international prices and consequently offer small unit gains.

The breakdown of IVA changes again confirms the strong agricultural advantage for most of the developing countries. Only South Korea 1973 and Taiwan show declines of agricultural IVA. Turkey and Uruguay show substantial food IVA gains for processing their agricultural produce. The Ivory Coast and Tunisia are the only countries that show substantial gains for other manufacturing.

The DVA figures in the bottom half of table 1.5 are obtained by multiplying the base and optimal outputs by the base DVA coefficients as defined by (21). Here the optimal solution changes are evaulated in terms of prevailing domestic prices. The relevant question is, Are there incentives to shift to the optimal outputs, given prevailing, distorted prices? Generally the answer is no. The overall DVA increments are much smaller than overall IVA increments. In fact, the overall DVA increments are negative for five of the nine developing countries. The largest increment is 1.8 percent for Turkey. The explanation is straightforward. The developing countries have domestic relative prices that are far removed from international relative prices. The domestic prices serve to protect existing industrial structures and give little or no incentive for further movement toward comparative advantage as defined by international prices.

The differences between IVA and DVA rates of change are smaller for the European countries than for the developing countries. This reflects the smaller gap between domestic and international prices for the European countries.

1.5.3 The Costs of Distortions

The g_j coefficients as defined by (22) provide an opportunity cost measure of the costs of commodity and factor market distortions upon the jth sector. It gives the profit rate in terms of net IVA of allocating a dollar's (or other currency units) worth of factors to sector j where factor prices and proportions are defined in terms of the optimal solutions. Absolute as well as algebraic values are of significance in interpreting the g_j. A positive (negative) g_j gives the increase of IVA that would be achieved if one more (less) dollar's worth of factor was allocated to its production.

From another viewpoint the g_js rank sectors in terms of comparative advantage, or lack thereof, relative to the base-year observations. The magnitudes of the coefficients also provide indicators of the magnitudes of potential gains for alternative trade strategies. In general, countries with domestic prices close to international prices and few factor market distortions will have relatively small g_j coefficients. However, some problems of comparability between countries exist because of difference in levels of aggregation and differences in the accuracy with which international prices can be measured. Coefficients for individual sectors are given in Appendix C.

The major division coefficients given in table 1.6 were calculated by dividing the aggregate optimal direct and home goods indirect IVA for each division by its aggregate value of the factors used directly and indirectly. The coefficients in the last column for all traded sectors are the quotients of the aggregate of IVA and factor values over the five major divisions. The agricultural coefficient is at or close to zero for each of developing countries except South Korea and Tunisia, reflecting comparative advantage in agriculture. The South Korean coefficient is low, with a substantial advantage elsewhere, particularly in textiles. The Tunisian case is more complicated. One possible explanation is that comparative advantage lies in manufacturing because of relative inefficiency of Tunisian agriculture. France is the only one of the European countries with an advantage in agriculture. German agriculture is particularly inefficient.

Table 1.6 Distortion-Cost Coefficients by Major Division

Country	Agri-culture	Other NRB	Food	Tex-tiles	Other Manu-facturing	All Traded
Chile	0.320	0.657	−0.291	−0.557	0.042	0.089
Indonesia	0.024	−0.009	−0.092	−0.626	0.083	−0.038
Ivory Coast	0.169	−0.115	−0.055	−0.340	0.285	0.142
Kenya						
South Korea, 1966	−0.080	−0.073	0.854	0.114	−0.017	−0.033
South Korea, 1970	−0.104	−0.001	0.851	0.042	−0.044	−0.049
South Korea, 1973	−0.022	−0.406	−0.070	0.078	−0.041	0.007
Taiwan	0.072	0.132	−0.299	−0.307	−0.016	−0.033
Tunisia	−0.071	−0.060	−0.036	0.150	0.169	−0.016
Turkey	−0.004	−0.404	0.086	−0.020	−0.725	−0.299
Uruguay	0.033	−0.627	0.177	−0.517	−0.496	−0.451
Belgium	−0.107	−0.176	0.151	0.035	0.046	0.023
France	0.068	0.051	0.199	0.026	0.059	0.069
Germany	−0.165	0.195	0.122	0.018	0.050	0.059
Italy	−0.035	0.140	0.241	0.051	0.207	0.134

Chile shows a strong comparative advantage in other resources—copper, nitrate, and iron-ore mining.

Each European country shows comparative advantage for each of the three manufacturing divisions, with all twelve manufacturing coefficients positive. Manufacturing advantage for the developing countries is much spottier. Turkey and Uruguay show advantage for food sectors. Turkey has clear advantages for canned fruits and vegetables, other food products, and tobacco, as indicated in Appendix C. The Uruguayan advantage is in processing its own beef. South Korea has an advantage in a wide range of textile sectors.

The developing countries show a variety of expansion advantages for other manufacturing. The aggregate other manufactures coefficient is positive for five of the ten developing country applications. The top-ranked individual sectors for Chile are petroleum and coal products; wood products; pulp, paper, and products; and fabricated metal products. On the whole these sectors are close to natural resources. Only wood and paper have realized sizable exports thus far. The Indonesian coefficient is dominated by petroleum refining. Its exclusion would reduce the other manufacturing coefficient to -0.138. The Ivory Coast coefficient is dominated by petroleum products, which includes both production and refining. Its exclusion would reduce the other manufacturing coefficient to -0.088.

South Korea has a number of other manufacturing sectors with advantage and has far and away the broadest manufacturing export base of the developing countries. Taiwan, despite an overall coefficient of -0.016, also has a broad range of manufacturing sectors with advantage. Tunisia also shows many manufacturing sectors with advantage.

Turkey and Uruguay show little if any advantage for other manufacturing. Much of the poor showing for Turkey may result from the poor performance of State Economic Enterprises and an extensive import substitution policy. The poor showing for Uruguay is partially comparative disadvantage because agriculture, livestock, and food have such strong advantage.

The aggregate coefficients for all traded goods have the same signs as the aggregate rents, that is, the $\sum_{j=1}^{m} r_j X_j$. These weighted averages provide some information of interest but must be interpreted with care. The European coefficients are all positive. These countries do not subsidize inefficient industries to the same degree as the developing countries, for which seven of ten coefficients are negative. South Korea 1973 has a small but positive coefficient, indicating broad expansion potentials. The Chilean coefficient reflects its efficient mining sectors, and the Ivory Coast coefficient reflects advantages in coffee, cocoa, and timber. Turkey's inefficient State Economic Enterprises and its import substitution are reflected in its strongly negative coefficient.

1.5.4 Implications for Trade

Optimal net trade levels might be determined by subtracting optimal consumption levels from optimal output levels where consumption levels are determined on the basis of country preference functions subject to balance-of-payments constraints, but the determination of optimal consumption levels is beyond the scope of this chapter. Consequently, trade implications of the optimal solutions must be investigated by more indirect procedures.

Table 1.7 contains major division IVA growth rates with export and import weights. The export figures are calculated using the formula

$$\gamma_J = \frac{\sum_{j \varepsilon J} \rho_j \hat{z}_j E_j^0}{\sum_{j \varepsilon J} \hat{z}_j E_j^0}, \qquad (J = 1, \ldots, 5)$$

where j refers to individual sectors, J refers to major divisions, and the ρ_j are the individual sector growth rates, usually plus or minus 25 percent. The last column of table 1.7 contains the growth rates for total IVA as taken from table 1.5.

An overall export expansion advantage would be reflected in an export rate higher than the corresponding import rate, and an overall import substitution advantage would be reflected in an import rate higher than the corresponding export rate. By these criteria, overall export expansion advantages are indicated for seven of the eleven applications for the developing countries. The overall import substitution advantages for South Korea 1966 and 1970 apparently were realized through its rapid industrialization and had been converted to an overall export expansion by 1973 as growth took place and exports expanded. The overall import substitution advantage for Taiwan may indicate that export expansion had been pushed too far by 1971 and that some retrenchment was desirable. Nonetheless, export expansion appears desirable for some of Taiwan's individual sectors. Again, the Tunisian result suggests contraction of agriculture and expansion of manufacturing. The low export and import growth rates suggest near optimality for the highly industrialized European countries.

Comparing the Chilean and Indonesian figures shows that much richer results may be achieved for more disaggregate sectoral classifications. Little of interest is found by examining the major division growth rates for the highly aggregate Chilean classification. Four of the five major division rates are at extremes. The rates for all traded goods are meaningful, however, because of the differential distributions of exports and imports among divisions. The major division rates for the much more disaggregate Indonesia data are of interest. The export growth rate exceeds the import growth rate for every major division except agriculture.

Table 1.7 **Implied IVA Growth Rates with Export and Import Weights (Percentages of Base-Year Values)**

Country	Agri-culture	Other NRB	Food	Tex-tiles	Other Manu-facturing	All Traded	Total IVA
Chile							
Exports	25.0	25.0	−25.0	−25.0	−6.7	23.7	3.6
Imports	25.0	25.0	−25.0	−25.0	−9.9	−4.4	
Indonesia							
Exports	−9.6	2.4	14.1	−17.3	23.2	2.8	3.3
Imports	−4.5	−8.8	8.7	−24.6	−22.4	−18.9	
Ivory Coast							
Exports	19.7	−25.0	10.4	−25.0	9.6	16.5	6.7
Imports	−24.8	—[a]	5.4	−25.0	−11.3	−13.9	
Kenya							
Exports	17.7	−25.0	−25.0	−9.9	−0.1	4.9	10.8
Imports	17.7	−25.0	−25.0	−18.1	−18.2	−16.0	
South Korea, 1966							
Exports	7.6	−25.0	−20.8	15.6	−6.8	−3.7	3.9
Imports	7.2	−25.0	24.7	23.8	13.7	13.3	
South Korea, 1970							
Exports	−24.5	19.1	11.2	2.7	1.8	0.5	4.2
Imports	17.4	6.1	3.5	19.3	7.8	11.5	
South Korea, 1973							
Exports	−19.2	23.7	2.5	22.8	4.8	8.0	2.8
Imports	−5.7	11.4	−15.9	24.4	−0.7	−1.0	
Taiwan							
Exports	−4.2	25.0	−17.2	−21.1	−3.3	−7.5	8.4
Imports	22.7	25.0	−13.7	7.0	−7.1	8.7	
Tunisia							
Exports	−19.4	15.7	−22.0	24.1	13.6	9.4	2.8
Imports	7.4	24.9	24.1	4.3	20.1	17.8	
Turkey							
Exports	11.6	−25.0	15.8	−6.1	−8.1	5.3	5.3
Imports	10.3	−22.8	15.0	4.6	−23.8	−20.8	
Uruguay							
Exports	16.6	−25.0	24.8	−25.0	−25.0	11.3	8.9
Imports	25.0	−25.0	24.2	−25.0	−25.0	−15.5	
Belgium							
Exports	−22.7	−8.9	−8.5	−14.4	11.5	3.7	3.0
Imports	−14.7	−12.1	2.6	−13.1	−1.7	3.0	
France							
Exports	25.0	16.0	4.9	−5.2	−13.8	−7.1	2.7
Imports	25.0	14.0	16.4	−10.7	−14.5	−0.8	
Germany							
Exports	−18.9	23.2	11.9	7.6	−2.5	−1.6	6.8
Imports	−23.3	25.0	13.1	−10.4	16.8	−1.7	
Italy							
Exports	−24.8	25.0	−8.6	−13.0	11.0	1.8	2.8
Imports	−23.3	25.0	13.1	−10.4	16.8	3.5	

[a]Less than 0.05 in absolute value.

At first glance Indonesia might appear to have a general export expansion advantage for other manufacturing, since this division has a 23.2 percent export growth rate. This is not the case, however. Indonesia's other manufacturing exports are dominated by petroleum refining and reprocessed rubber, for which it has major export advantages. The optimal solutions suggest increased imports, with few minor exceptions, for the remainder of other manufacturing.

In summary, the optimal solutions suggest that within the relevant range export expansion is superior to import substitution for most developing countries. To be sure, large policy shifts might lead to opposite results, but for countries and policies covered by the model applications, moves away from import substitution are clearly indicated.

1.5.5 Maximum and Minimum Output Distributions

The optimal solution for each country, except South Korea 1973, has only one sector with an output that is at neither its maximum or its minimum limit. South Korea 1973 has two. The numbers of sectors at each limit for each country is given by major division in table 1.8. A marginal sector is included with the maxima if its output increases and with the minima if it decreases. The reader may determine the status of individual sectors by consulting the g_j values in Appendix C. The value $g_j = 0$ designates a marginal sector, $g_j > 0$ designates a maximum, and $g_j < 0$ designates a minimum.

The relative numbers of other manufacturing sectors in the two categories indicate the status of the various countries in terms of world trade potential. Those with a relatively high number of maxima have broadly based comparative advantage. This is the case for the European countries, South Korea, Taiwan, and Tunisia. Chile has some maxima, but its minima reflect its import substitution policies. Indonesia, Kenya, Turkey, and Uruguay are at the opposite extreme with little general advantage in manufacturing. South Korea 1966 and 1970 and Turkey show advantages for a majority of their food-processing sectors. South Korea for all three years and Tunisia show substantial advantages for textiles.

1.5.6 Implied Capital/Labor Service Ratio Changes

The value-added measures of labor and capital services, and the resultant capital/labor ratios, are not strictly comparable between countries. Differences result from different rates of remuneration for labor and capital, and from differences in accounting procedures. Column 1 of table 1.9 contains overall capital/labor ratios. These are K^0/L^0 in the notation of the model. The ratios range from a low of 0.63 for capital-poor Kenya to a high of 1.68 for Chile, which has high mining investments. The European ratios are lower than those for most of the developing countries. It appears that, when labor services are measured by payments, the

Table 1.8 **Number of Traded-Good Sectors at Maximum and Minimum Limits by Major Division**

Country	Agriculture		Other NRB		Food		Textiles		Other Manufacturing		All Traded	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Chile	2	0	6	0	0	2	0	3	5	9	13	14
Indonesia	14	15	2	10	6	17	2	9	5	43	29	94
Ivory Coast	3	3	0	1	3	6	0	3	5	12	11	25
Kenya	1	0	0	1	0	2	1	3	1	7	3	13
South Korea, 1966	3	5	0	3	8	1	13	3	25	27	49	39
South Korea, 1970	2	6	1	2	6	3	12	4	20	32	41	47
South Korea, 1973	2	6	1	2	4	5	13	3	22	30	42	46
Taiwan	6	2	4	0	2	7	1	5	14	15	27	29
Tunisia	3	4	1	3	3	3	5	1	20	5	32	16
Turkey	3	1	1	5	5	3	1	4	3	21	13	34
Uruguay	2	0	0	1	1	1	0	3	0	9	3	14
Belgium	1	1	1	1	6	3	2	5	20	11	30	21
France	2	0	1	4	6	3	3	4	16	15	28	26
Germany	1	1	3	2	5	4	4	3	25	6	38	16
Italy	1	1	5	0	5	4	3	4	23	8	37	17

Table 1.9 **Average and Marginal Capital/Labor Service Ratios**

	Capital/Labor Service Ratios					Rates of Substitution		Percentage Shifts to Traded	
		Base		Optimal					
Country	All Goods (1)	Traded (2)	Home (3)	Traded (4)	Home (5)	Optimal MRS (6)	Average Shift (7)	Labor (8)	Capital (9)
Chile	1.68	1.73	1.59	1.69	1.67	1.076	0.974	1.0	−0.6
Indonesia	1.53	1.37	1.75	1.32	1.84	1.071	1.034	1.3	−0.9
Ivory Coast	0.78	0.68	1.08	0.68	1.06	0.973	0.864	−0.3	0.3
Kenya	0.63	0.67	0.61	0.66	0.62	1.014	1.015	0.2	−0.4
South Korea, 1966	1.01	0.79	1.58	0.81	1.54	0.997	49.584	—[a]	1.2
South Korea, 1970	1.07	0.91	1.35	0.90	1.38	1.076	0.916	0.4	−0.4
South Korea, 1973	1.29	1.11	1.61	1.12	1.59	0.982	0.403	−0.4	0.1
Taiwan	0.67	0.83	0.52	0.84	0.52	0.985	0.994	−0.2	0.3
Tunisia	1.43	0.95	2.41	0.98	2.28	0.938	0.965	−1.3	0.9
Turkey	1.66	1.19	2.85	0.94	4.77	1.058	0.902	9.7	−5.3
Uruguay	1.25	1.09	1.56	1.08	1.60	1.023	1.001	0.5	−0.4
Belgium	0.83	0.60	1.05	0.60	1.05	1.001	0.103	—[a]	—[a]
France	0.73	0.58	0.87	0.59	0.86	0.988	1.076	−0.3	0.4
Germany	0.66	0.64	0.70	0.64	0.69	0.996	0.696	−0.1	0.1
Italy	0.84	0.68	0.99	0.68	0.99	0.996	0.519	−0.1	0.1

[a]Less than 0.005 in absolute value.

developed countries have more labor per unit of capital than the developing, and when labor is measured in man-years they have less.

Base-year capital/labor service ratios are computed separately for traded and home goods in columns 2 and 3 of table 1.9. The variance for home goods is much greater than that for traded goods. This reflects some major differences in the treatment of home goods among the countries. For six of the developing countries home goods are more capital-intensive than traded goods, for Kenya intensities are about the same, and for two countries traded goods are more intensive than home goods. The high capital-intensity of traded goods for Chile follows from specialization in mining. The very high home goods capital/labor service ratios for Tunisia and Turkey are the result of accounting rather than real differentials vis-à-vis the other developing countries.

The model is defined so that the marginal rate of substitution (MRS) between capital and labor, $-dL_j/dK_j = MPK_j/MPL_j$, for a base year equals one for each sector. The optimal rates given in column 6 of table 1.9 differ from one but are the same for all sectors for any given country solution. An optimal rate greater than one means that the wage rate increases more than the price of capital services, which suggests that existing factor market distortions favor use of capital relative to labor. This is the result for five of the nine developing countries and for South Korea for 1970. The optimal solutions sometimes dictate movements away from highly protected capital-intensive import substitution sectors to less capital-intensive resource and resource-processing sectors. The Ivory Coast, South Korea 1966 and 1973, Taiwan, and Tunisia have optimal MRSs less than one, suggesting that distortions favor labor more than capital.

By assumption, the total quantities of labor and capital services are unaffected by movements from base to optimal solutions. Consequently, the overall capital/labor service ratio is unaltered. However, the ratios for the traded and home goods sectors do change as shown in columns 4 and 5 of table 1.9. The decreases of the capital/labor service ratios for traded goods coincident with increases for home goods for Chile, Indonesia, Kenya, Turkey, and Uruguay provide additional labor for the production of goods for export. In these cases labor services are shifted from home to traded goods and capital services are shifted from traded to home. The rates of substitution for the shifts are given in column 7 of table 1.9. These rates are less than one for Chile and Turkey, indicating that these shifts yield substantially more labor services per unit of capital services than do shifts on the margin. The very large rate for Korea 1966 corresponds to a very small quantity of labor services. The magnitudes of these factor shifts are expressed as percentages of the base-year labor and capital service quantities devoted to traded goods in the last two columns of table 1.9. The shift for Turkey is particularly large as a consequence of a shift away from capital-intensive import substitutes. The most dramatic aspect of table 1.9 is the fall of Turkey's traded goods capital/labor service ratio from 1.19 to 0.94. The Ivory Coast, South Korea, Taiwan, and Tunisia shift capital from the home to the traded goods sectors. The relative shifts for the European countries are quite small.

1.5.7 A Three-Factor Extension

The three-factor version of the model described in sections 1.2 and 1.3 was applied for Chile, with blue-collar and white-collar workers representing unskilled and skilled labor as described in Appendix B. Skill breakdowns also were made for Tunisia and Turkey, but three-factor applications were not made.

Base-year and optimal-solution labor service summaries for Chile are given in table 1.10. Almost 18 percent of the base-year labor services are classified as skilled. The HOS divisions are considerably more skill-intensive than the NRB divisions and home goods. The optimal solution shows a surfeit of skilled labor services, with 1.64 percent of total labor services—9.2 percent of the skilled labor services—shifted from skilled to unskilled employment. This shift follows the shift from skill-intensive import substituting HOS sectors to NRB export sectors. Chile simply has

Table 1.10 Base-Year and Optimal Solution Chilean Unskilled and Skilled Labor Service Distributions by Major Division (Percentages of Total Labor Services)

Sector	Base Year	Solution Shift	Optimal Direct	Optimal Indirect	Direct and Indirect
Unskilled labor services					
Agriculture	19.56	3.00	22.56	3.33	25.89
Other NRB	8.08	1.59	9.67	1.94	11.61
Food	1.98	−0.59	1.39	2.00	3.39
Textiles	2.52	−0.72	1.80	1.41	3.21
Other manufacturing	8.14	−2.37	5.77	4.49	10.26
Home goods	41.94	0.73	42.67	−13.17	29.50
Unskilled services	82.22	1.64	83.86	0.00	83.86
Skilled labor services					
Agriculture	1.03	0.16	1.19	0.37	1.56
Other NRB	0.91	0.16	1.07	0.74	1.81
Food	1.91	−0.55	1.36	0.22	1.58
Textiles	2.03	−0.64	1.39	0.15	1.54
Other manufacturing	6.37	−1.57	4.80	0.43	5.23
Home goods	5.53	0.80	6.33	−1.91	4.42
Skilled services	17.78	−1.64	16.14	0.00	16.14
Total	100.00	0.00	100.00	0.00	100.00

more skilled labor than is required if it seeks its comparative advantage. This result is very strong. However, one must not conclude that skilled labor would actually move from the factories to the farms and the mines. A more likely result would be increased skill intensity in all sectors including agriculture and mining. There might also be some narrowing of the unskilled/skilled wage differential.

The three-factor optimal solution for Chile is very similar to the two-factor optimal solution. Output levels, g-coefficients, home goods prices, and most other variables have the same values for both. The optimal MRS between skilled and unskilled labor is one. The optimal skilled and unskilled wage rates are the same, with an optimal skill premium of zero. The sum of the unskilled and skilled optimal direct employment distributions in table 1.10 is the same as the aggregate optimal direct distribution in table 1.5. The direct and indirect distributions sum to the table 1.5 distribution in the aggregate, but not for each individual division. In general, two-factor and three-factor solutions are not much different unless skilled labor is scarce.

A simple test to determine whether skilled labor is scarce can be performed if a two-factor optimal solution and unskilled and skilled base coefficients are available. Assume that skilled labor is not scarce, that equilibrium conditions are

$$\frac{MPU_j}{MPK_j} = \frac{\alpha_j}{(1-\alpha_j-\beta_j)} \frac{X_j^*/U_j^*}{X_j^*/K_j^*} = \frac{w^*}{c^*} \qquad (j=1, \ldots, n)$$

$$\frac{MPS_j}{MPK_j} = \frac{\beta_j}{(1-\alpha_j-\beta_j)} \frac{X_j^*/S_j^*}{X_j^*/K_j^*} = \frac{w^*}{c^*},$$

where * denotes equilibrium values with c^*, w^*, K_j^*, and X_j^* given by the two-factor solution. Now solve for U_j^* and S_j^*:

$$U_j^* = \frac{\alpha_j}{(1-\alpha_j-\beta_j)} \frac{c^*}{w^*} K_j^* \qquad (j=1, \ldots, n)$$

$$S_j^* = \frac{\beta_j}{(1-\alpha_j-\beta_j)} \frac{c^*}{w^*} K_j^*.$$

Finally, sum the S_j^* for all sectors. If this sum is greater than the skill endowment, skilled labor is scarce.

This test was performed for some preliminary skill data for Turkey and Tunisia. The Turkish results are similar to the Chilean. Turkey would have a surfeit of skilled labor if a movement were made toward its comparative advantage in agriculture and food-processing. The test for Tunisia suggests that skilled labor is scarce. This is not surprising, since the optimal solution indicates movement from NRB to HOS sectors with higher skill intensity.

A simple generalization appears to be in order: Skilled labor is not scarce for countries moving from HOS import substitutes to NRB and HOS exportable sectors, but it would be scarce for countries moving in the opposite direction. This result parallels the findings of the individual country studies in which import substituting industries are shown to be skill-intensive.

1.6 Conclusions

The research described here was designed to ask what might happen if the causes of trade and factor market distortions were relaxed *and* economic activities were guided by prices closer to international prices in some nine developing countries. For comparison, the same questions were asked for four developed European countries. On the whole, the results are encouraging and are consistent with detailed individual country studies.

The empirical results show export expansion to be superior to import substitution for the developing countries except Taiwan and Tunisia. The South Korea solutions for 1966 and 1970 suggest import substitution, but many of the former import substitutes had become exports by 1973. The solution for that year suggests manufacturing export promotion. For most of the developing countries, advantage appears to lie in NRB sectors and HOS sectors that process NRB outputs *given existing production patterns*. Since movement of labor back to agriculture is unlikely, and probably undesirable, the developing countries might well look for currently small or nonexistent sectors with export advantage. The Korean successes might be duplicated to some degree in other countries.

Some of the developing countries with advantage in the NRB sectors have developed labor force skills in connection with import substitution. The optimal solutions suggest a surplus of skilled labor for those countries should trade policies alter. This suggests that some reported "shortages" of skilled workers may have been a consequence, at least in part, of choice of trade strategy.

The empirical applications proved a number of results beyond the primary question of where advantage lies. The use of home goods as indirect inputs was measured, and vast differences in treatment of home goods among countries were noted. The short-run opportunity costs of not relaxing current distortions were measured. The average for the developing countries is a bit over 5 percent, which, given the structure of the model, is sizable. Estimated gains are bounded by existing production structures and factor quantities.

The empirical applications indicate that there is little if any incentive for producers in the developing countries to move toward the optimal solutions. Their citizens appear to be optimizing given current domestic prices, which are often far removed from corresponding international prices. South Korea is an exception in that its domestic prices are close to their international counterparts. Factor distortions appear to favor capital more than labor in five of nine cases and to favor labor more than capital in the remaining four.

Fortunately, the results for most of the countries are very robust. In most cases, international price estimates could be subject to substantial error without altering the principal findings about where comparative advantage lies. Some parametric analysis was done by asking how optimal solutions might change if some key prices were to change by 10 to 20 percent. There were some individual changes, but on the whole not much change of significance. A solution for Chile was calculated with 1967 prices substituted for the 1961 prices. The same broad NRB advantage again emerged.

A conclusion of all empirical studies is that better data would be a great help. That is true here. International prices, in particular, are both very important and very difficult to estimate. Ideally, they should be derived from implicit tariff rate studies, as was done for Chile, the Ivory Coast, and Uruguay. Implicit tariff rates measure proportionate difference between domestic and international prices. Average tariff collections rates may be far removed from the desired implicit rates, and nominal tariff rates may be even further removed. But each had to be used for some countries in the absence of implicit rates.

This is the first study for which the current model has been applied. Use of the model for the study of countries other than those covered here provides an obvious line for future research. There are also many possibilities for further study of the properties of the model's optimal solutions and for extensions of the model. Three of them are mentioned here: (1) an investigation to determine the relation of the g_j coefficients to domestic resource cost and effective protection rates; (2) applications in which several distinct labor skill classes are incorporated; and (3) extensions in which alternative trade strategies are more explicitly introduced into the model.

Appendix A: Some Mathematical Properties of the Model

Some of the coefficients of the model are explicitly derived here in terms of the underlying input-output matrixes. The input-output balance equation is

$$X = AX + C, \tag{A1}$$

where X and C are n-component row vectors of output and final consumption levels respectively, and A is an $(n \times n)$ matrix of input-output coefficients with typical element a_{ij} that gives the quantity of good i necessary to produce a unit of good j. Partitioning (A1) into international and home good blocks,

$$\text{(A2)} \qquad \begin{pmatrix} X_T \\ X_H \end{pmatrix} = \begin{bmatrix} A_{TT} A_{TH} \\ A_{HT} A_{HH} \end{bmatrix} \begin{pmatrix} X_T \\ X_H \end{pmatrix} + \begin{pmatrix} C_T \\ C_H \end{pmatrix},$$

where the subscript T designates the m international goods and the subscript H designates the $(n - m)$ home goods. For example, the submatrix A_{HT} $[(n - m) \times m]$ gives the home goods input requirements for the production of international goods. By block multiplication of (A2),

$$\text{(A3)} \qquad \begin{aligned} X_T &= A_{TT}X_T + A_{TH}X_H + C_T \\ X_H &= A_{HT}X_T + A_{HH}X_H + C_H. \end{aligned}$$

Solving (A3) for home goods outputs,

$$\text{(A4)} \qquad X_H = (I - A_{HH})^{-1}A_{HT}X_T + (I - A_{HH})^{-1}C_H,$$

which is the same as equation (8) in the text. The coefficient k_i is the ith element of the matrix product $(I - A_{HH})^{-1}C_H$, and σ_{ij} is an element of the $[(m - n) \times m]$ matrix product $(I - A_{HH})^{-1}A_{HT}$. The coefficient μ_{ij} is an element of the home goods inverse matrix $(I - A_{HH})^{-1}$.

Rewriting (10) in matrix terms,

$$\text{(A5)} \qquad V = P_TX_T - \Gamma_TX_T - \Gamma_HX_H,$$

where P_T is an m-component row vector of international prices, and Γ_T and Γ_H are row vectors containing the γ_j coefficients for international and home goods respectively. Substituting for X_H from (A4),

$$\text{(A6)} \qquad \begin{aligned} V = {} & [P_T - \Gamma_T - \Gamma_H(I - A_{HH})^{-1}A_{HT}]X_T \\ & - \Gamma_H(I - A_{HH})^{-1}C_H, \end{aligned}$$

which is the same as (12). The square bracketed term on the right is an m-component vector of the $\hat{z}_j$ coefficients, and K equals the second term on the right. The b_j of (11) are given by the vector $\Gamma_H(I - A_{HH})^{-1}A_{HT}$.

Let L_T^* and L_H^* be vectors of labor services per unit output coefficients that correspond to an optimal solution. Let W denote total labor service use so that

$$W = L_T^*X_T + L_H^*X_H.$$

Substituting from (A4),

$$\text{(A7)} \qquad \begin{aligned} W = {} & [L_T^* + L_H^*(I - A_{HH})^{-1}A_{HT}]X_T \\ & + L_H^*(I - A_{HH})^{-1}C_H. \end{aligned}$$

The square bracketed term on the right is a vector of the $\hat{\ell}^*_j$ used in (22). The second term on the right is the quantity of labor services used to support the home goods final demands. A similar derivation is applicable for capital service coefficients.

Appendix B: Data Sources and Rectification Procedures

Data sources and data adjustments for each country are described here under four headings: (1) Input-output data: sources for the base-year data are given. (2) Value-added adjustments: adjustments to make the input-output value-added data more adequately represent labor and capital service inputs are described. (3) International prices: sources are described. (4) Skill breakdown: the procedures for separating the input-output value-added labor input data into skilled and nonskilled service components are described for Chile, Tunisia, and Turkey.

For some countries the labor value added for agriculture covers only hired employees. Family labor income is treated as profit and thus included in nonlabor value added. Adjustment is necessary to make the labor components reflect labor service inputs. Lacking specific information, it was assumed that labor services constitute two-thirds of agriculture value added and capital services constitute one-third. The adjustment for a country with one agricultural sector is very easy.

For a country with N agricultural sectors it is assumed that the two-thirds rule holds for the aggregate:

$$\text{(B1)} \qquad \sum_{j=1}^{N} L_j = \frac{2}{3} \sum_{j=1}^{N} (\bar{L}_j + \bar{K}_j),$$

where $\bar{L}_j$ and $\bar{K}_j$ denote respective labor and capital value added before adjustment and L_j and K_j denote them after adjustment. Aggregate value added is assumed to remain unchanged in each sector:

$$\text{(B2)} \qquad L_j + K_j = \bar{L}_j + \bar{K}_j, \qquad (j=1, \ldots, N)$$

and the adjusted capital/labor service ratios are assumed to be proportional to the unadjusted:

$$\text{(B3)} \qquad \frac{L_j}{K_j} = \gamma \frac{\bar{L}_j}{\bar{K}_j}. \qquad (j=1, \ldots, N)$$

The system (B1), (B2), and (B3) has $(2N + 1)$ equations that can be solved for the $(2N + 1)$ variables, γ, L_j, K_j $(j=1, \ldots, N)$.

For a few sectors the nonlabor value-added coefficients are negative or very small and do not reasonably represent capital service inputs. Capital service data for similar sectors were used to construct capital service coefficients for such sectors. After adjustment these sectors normally show a loss at base-year prices. Such losses are often partially offset by government subsidy.

International prices often are constructed from tariff collection and import data according to the formula

$$p_j = \frac{1}{(1 + T_j/M_j)},$$

where T_j and M_j are tariff collections and import levels c.i.f. for sector j.

Chile

Input-output data. Source was the Chilean input-output table for 1962 prepared by the Oficina de Planificación Nacional, Departamento de Cuentas Sociales.

Value-added adjustments. The two-thirds adjustment was made for one agricultural sector. The banking and other financial services sectors have negative nonlabor value-added coefficients. Capital service coefficients were constructed from the value-added data for other Chilean service sectors.

International prices. Prices were constructed from implicit tariff rates, which reflect international/domestic price ratios, given by Jere R. Behrman, *Foreign Trade Regimes and Economic Development: Chile* (New York: Columbia University Press, 1976), tables 5.3 and A.3.

Skill breakdown. The census data used for the Chile study gave a white-collar/blue-collar labor breakdown for four-digit ISIC manufacturing industries. These data were used to disaggregate the value-added labor service coefficients into skilled and unskilled components. Agriculture, forestry, and fisheries were assumed to have 5 percent skilled labor. Individual service sectors were assumed to have either 5, 10, 15, or 20 percent skilled labor depending upon their characteristics.

Indonesia

Input-output data. Source was the Indonesia study with data derived from government sources.

Value-added adjustments. The two-thirds adjustment was made for twenty-four agricultural sectors. Output and value-added adjustments were made for a number of sectors as a part of the Indonesia study.

International prices. Prices were constructed from nominal tariff rates used for the Indonesia study.

Ivory Coast

Input-output data. Source was the Ivory Coast country study with data derived from governmental sources.

Value-added adjustments. None. The Ivory Coast study provided appropriate data.

International prices. Prices were constructed as a part of the country study to reflect the ratio of domestic to world prices.

Kenya

Input-output data. Source was *Input-Output Table for Kenya 1967* (Central Bureau of Statistics, Ministry of Finance and Planning, December 1972).

Value-added adjustments. The two-thirds adjustment was made for one agricultural sector.

International prices. Prices were constructed from tariff and import data given in the input-output table.

South Korea

Input-output data. Sources were data tapes prepared by the Korean Development Institute (KDI) for all three years.

Value-added adjustments. The two-thirds adjustment was made for six agricultural sectors.

International prices. Prices for 1970 and 1973 were constructed from tariff and import data on the KDI data tapes. Prices for 1966 were constructed from tariff and import data given in Wontack Hong, *Statistical Data on Trade and Subsidy Policy in Korea* (KDI, August 1976), tables B.35 and B.36.

Taiwan

Input-output data. Source was the official publication *Taiwan Input-Output Tables, Republic of China, 1971*, compiled by Overall Planning Department, Economic Planning Council (Executive Yuan, June 1974).

Value-added adjustments. Two sectors, edible vegetable oils and tea, have negative nonlabor value added. The input-output study gives physical capital data for the sectors. Value-added capital service coefficients were constructed by assuming that the ratio of value added to physical capital is the same for these sectors as the aggregate for the other food sectors.

International prices. Prices were constructed from tariff and import data given in the input-output study.

Tunisia

Input-output data. Source was the Tunisia study with data from governmental sources.

Value-added adjustments. The two-thirds adjustment was made for four agricultural sectors. Four sectors had negative nonlabor value added: other livestock, sugar, lumber, and pulp and paper. Capital service coefficients were constructed by assuming that these sectors have the same capital/labor service ratios as similar Tunisian sectors.

International prices. Prices were constructed from nominal tariff rates for the 150-sector classification used in the Tunisia study. Some adjustments were made on the basis of that study.

Skill breakdown. The census data used for the Tunisian study contain a labor breakdown by seven skill classes. Four are considered skilled: management and engineers, white-collar employees, supervisory personnel, and skilled and semiskilled workers. Three are considered unskilled: unskilled workers, apprentices, and seasonal workers. The value-added labor service coefficients were distributed in proportion to the distributions for corresponding census sectors. It was assumed that 5 percent of agricultural labor is skilled.

Turkey

Input-output data. Source was the 1973 input-output table constructed by the State Institute of Statistics.

Value-added adjustments. Six sectors—coal mining, nonferrous ore mining, nonmetallic mineral mining, nonferrous metal basic industries, railroad equipment, and railway transport—have negative nonlabor value added. These sectors are mainly State Economic Enterprises that are run at losses. Capital service coefficients were constructed using data for similar Turkish sectors.

International prices. Prices were constructed from nominal tariff rates for 1968 given by Tercan Baysan, *Economic Implications of Turkey's Entry into the Common Market*, (Ph.D. diss., University of Minnesota, 1974), table 3.

Skill breakdown. Skilled data for 1968 developed in Baysan, *Economic Implications*, were used.

Uruguay

Input-output data. Source is 1961 tables prepared and published by government agencies.

Value-added adjustments. The two-thirds adjustment was made individually for two agricultural sectors.

International prices. Prices were constructed from the implicit tariff rates, reflecting international/domestic price ratios, used for the Uruguay study.

European Countries

Input-output data. Source is the European Economic Community tables for 1965 published in 1970.

Value-added adjustments. It is assumed that three-fifths of value added for the single agricultural sector for each country is attributable to labor services.

International prices. Prices were constructed from the tariff collection and import data given in the input-output tables.

Appendix C: Sectoral Data

Table 1.A.1 contains selected data for the NRB and HOS sectors for each of the fifteen two-factor applications of the model. A descriptive name is given for each sector. Commas are used in place of the word *and*. For example, "other beans, nuts" means other beans and nuts. Sector type codes are: A (agriculture, forestry, and fisheries), R (other natural

resource based sectors), F (food), T (textiles, textile products, leather, leather products, and furs), and M (other manufacturing sectors). The p_j are international prices that are defined relative to unit base-year prices. The α_j are the labor-share exponents for the Cobb-Douglas production functions; these are derived from the base-year input-output tables with adjustments as described in Appendix B. The X_j^* are outputs drawn from the optimal solutions and are measured in appropriate value units.

The g_j coefficients are defined by equation (22). A positive coefficient for a sector means that the sector is at its maximum output limit in the optimum solution with a positive u_j and zero v_j. A negative coefficient means that the sector is at its minimum limit with a positive v_j and zero u_j. A zero value indicates a marginal sector for which both u_j and v_j are zero. The $\hat{\ell}_j^*$ and $\hat{k}_j^*$ are the respective optimal direct plus indirect labor and capital service coefficients per unit of output. Indirect means the labor and capital services required to produce the home goods outputs that are required for the production of a unit of an international good.

Table 1.A.1 Selected Sectoral Data

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Chile							
Agriculture, forestry	A	0.70	0.67	1,133	0.20	0.43	0.34
Fisheries	A	0.83	0.12	55	0.59	0.13	0.64
Coal mining	R	0.73	0.78	57	0.20	0.54	0.25
Iron mining	R	0.98	0.30	90	0.74	0.25	0.52
Copper mining	R	1.00	0.30	510	0.82	0.23	0.55
Nitrate mining	R	0.99	0.58	62	0.94	0.36	0.26
Stone, clay, glass	R	0.60	0.36	47	0.05	0.25	0.57
Other nonmetallic mining	R	0.68	0.45	72	0.12	0.40	0.49
Food	F	0.55	0.35	722	−0.31	0.09	0.20
Beverages	F	0.45	0.21	255	−0.26	0.11	0.38
Textiles	T	0.35	0.31	232	−0.59	0.14	0.34
Apparel, shoes	T	0.28	0.21	433	−0.54	0.11	0.43
Leather, products	T	0.38	0.25	42	−0.54	0.10	0.31
Wood	M	0.74	0.46	171	0.25	0.22	0.27
Furniture, accessories	M	0.43	0.33	116	−0.32	0.16	0.39
Pulp, paper, products	M	0.65	0.28	99	0.21	0.14	0.35
Printing, publishing	M	0.58	0.42	50	−0.05	0.25	0.42
Rubber products	M	0.50	0.17	32	−0.15	0.09	0.42
Chemicals	M	0.52	0.30	169	−0.04	0.15	0.37
Petroleum, coal products	M	0.67	0.09	240	0.55	0.10	0.40
Nonmetallic mineral products	M	0.42	0.27	111	−0.42	0.17	0.44
Basic metals	M	0.60	0.44	125	−0.11	0.21	0.29
Fabricated metal products	M	0.63	0.39	187	0.21	0.19	0.37
Machinery	M	0.54	0.38	136	0.00	0.18	0.36
Electrical machinery	M	0.49	0.23	84	−0.10	0.14	0.46
Transport equipment	M	0.54	0.33	128	−0.02	0.18	0.39
Miscellaneous manufactures	M	0.44	0.15	68	−0.25	0.11	0.50

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Indonesia							
Paddy	A	1.15	0.69	580.0	0.02	0.62	0.31
Maize	A	1.18	0.77	46.5	0.05	0.70	0.23
Cassava	A	1.11	0.77	46.8	−0.01	0.71	0.23
Other root crops	A	1.11	0.68	11.9	−0.01	0.61	0.31
Vegetables	A	1.11	0.65	53.2	−0.01	0.57	0.33
Fruits	A	1.00	0.65	70.1	−0.11	0.49	0.29
Peanuts	A	1.11	0.53	11.8	−0.01	0.44	0.42
Soybeans	A	1.11	0.41	28.4	0.01	0.35	0.53
Other beans, nuts	A	1.00	0.41	2.5	−0.09	0.35	0.53
Rubber	A	1.15	0.77	66.8	0.05	0.65	0.23
Sugarcane	A	0.80	0.85	16.1	−0.32	0.63	0.17
Coconut	A	1.33	0.68	74.8	0.19	0.64	0.32
Palm	A	1.11	0.64	25.4	0.04	0.47	0.30
Other crops	A	1.54	0.73	5.5	0.41	0.65	0.27
Tobacco	A	0.95	0.77	12.5	−0.15	0.64	0.23
Coffee	A	1.18	0.74	25.4	0.06	0.66	0.26
Tea	A	1.11	0.83	11.3	0.03	0.61	0.16
Cloves	A	0.86	0.47	12.1	−0.23	0.43	0.52
Nutmeg	A	1.11	0.67	3.2	0.01	0.55	0.29
Spices	A	1.14	0.77	14.6	0.02	0.70	0.23
Other agricultural products	A	1.06	0.78	2.4	−0.06	0.68	0.20
Cattle	A	1.11	0.64	26.3	0.02	0.57	0.34
Milk-cow raising	A	1.00	0.54	1.0	−0.14	0.21	0.20
Other livestock	A	1.11	0.80	1.0	0.01	0.72	0.19
Poultry	A	1.00	0.06	34.4	−0.05	0.05	0.80

Forest products	A	1.00	0.21	71.4	−0.06	0.18	0.67
Bamboo	A	1.00	0.17	14.7	−0.09	0.16	0.82
Other forest products	A	1.05	0.22	2.8	0.01	0.18	0.64
Marine fishing	A	1.00	0.09	71.0	−0.06	0.08	0.83
Inland fishing	A	1.00	0.14	36.6	−0.07	0.13	0.81
Coal mining	R	1.00	0.15	0.5	−0.11	0.14	0.41
Crude petroleum, natural gas	R	1.00	0.03	291.0	0.00	0.03	0.85
Iron ore	R	1.00	0.26	0.4	−0.07	0.23	0.68
Tin ore	R	1.00	0.33	15.5	−0.08	0.23	0.49
Nickel ore	R	1.00	0.03	3.4	−0.06	0.04	0.85
Bauxite	R	1.00	0.23	2.0	−0.09	0.19	0.65
Other nonferrous ore	R	1.00	0.72	0.6	0.10	0.41	0.22
Stone, clay	R	1.00	0.52	18.6	−0.06	0.41	0.42
Chemicals for fertilizer	R	0.97	0.48	0.1	−0.01	0.39	0.45
Salt	R	1.00	0.51	4.4	−0.10	0.45	0.47
Asphalt mining	R	1.00	0.17	0.3	−0.08	0.15	0.78
Other nonmetal mining	R	0.87	0.54	*	−0.19	0.45	0.41
Poultry products	F	1.00	0.01	12.5	−0.05	0.01	0.94
Meat products	F	0.95	0.07	48.4	−0.36	0.02	0.32
Dairy products	F	0.58	0.19	3.9	−0.71	0.04	0.17
Canned fruit	F	0.56	0.39	0.3	−0.88	0.18	0.31
Canned fish	F	1.00	0.19	62.2	−0.08	0.05	0.19
Coconut oil	F	1.11	0.18	58.8	−0.41	0.05	0.23
Other vegetable, animal oil	F	1.11	0.13	47.9	0.06	0.04	0.26
Rice milling, cleaning	F	1.15	0.44	741.0	0.07	0.08	0.11
Grain milling	F	1.22	0.29	6.6	0.51	0.06	0.15
Tapioca flour	F	1.11	0.39	36.8	0.12	0.08	0.13
Bakery products	F	0.53	0.73	6.1	−1.92	0.16	0.09
Noodles, macaroni	F	1.00	0.25	3.3	−0.31	0.10	0.32
Sugar refining	F	0.79	0.23	62.0	−0.31	0.12	0.40
Cocoa, chocolate	F	0.77	0.36	1.8	−0.52	0.12	0.23

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Coffee	F	1.18	0.24	61.2	0.14	0.10	0.31
Tea	F	1.00	0.67	21.2	−0.21	0.28	0.16
Soybean products	F	1.00	0.31	24.7	−0.25	0.08	0.19
Other food products	F	0.90	0.37	10.7	−0.28	0.13	0.23
Alcoholic beverages	F	0.72	0.28	3.6	−0.33	0.13	0.32
Nonalcoholic beverages	F	0.60	0.45	10.6	−0.76	0.13	0.19
Tobacco processing	F	1.11	0.54	59.5	0.22	0.16	0.16
Cigarettes	T	0.55	0.25	64.0	−1.12	0.06	0.16
Spinning	T	1.08	0.37	19.5	−0.49	0.13	0.23
Weaving	T	0.69	0.37	65.8	−1.06	0.11	0.20
Textile bleaching, printing	T	0.91	0.26	4.5	−0.23	0.17	0.45
Batik	T	1.00	0.45	30.8	0.38	0.13	0.18
Knitting	T	0.57	0.37	2.5	−1.30	0.13	0.22
Textiles	T	0.56	0.26	9.1	−1.34	0.07	0.20
Clothing	T	0.64	0.46	57.9	−0.67	0.15	0.19
Carpets, ropes	T	0.74	0.74	1.7	−1.18	0.28	0.14
Tanneries	T	1.00	0.27	3.2	−0.03	0.13	0.36
Leather products	T	1.00	0.33	0.9	0.01	0.14	0.30
Leather shoes	T	0.61	0.26	12.5	−0.63	0.13	0.40
Sawmills	M	1.00	0.18	45.6	−0.04	0.09	0.37
Wood, cork products	M	1.00	0.25	10.0	−0.04	0.08	0.22
Furniture, fixtures	M	0.76	0.51	10.9	−0.73	0.17	0.18
Pulp, paper	M	0.77	0.25	3.9	−0.40	0.12	0.35
Paper products	M	0.69	0.22	2.3	−0.39	0.12	0.43
Printing, publishing	M	0.80	0.39	24.0	−0.26	0.22	0.36
Basic industrial chemicals	M	0.93	0.32	1.5	−0.19	0.16	0.35
Fertilizer, pesticides	M	1.00	0.52	2.4	−0.04	0.18	0.21
Paints, lacquers	M	0.61	0.43	5.0	−0.70	0.20	0.29

Drugs, medicines	M	0.73	0.37	6.1	−0.45	0.16	0.30
Soap, cleaners	M	0.71	0.24	21.8	−0.88	0.09	0.29
Cosmetics	M	1.72	0.28	11.7	1.86	0.10	0.27
Matches	M	0.57	0.31	0.9	−0.85	0.14	0.32
Other chemical products	M	0.78	0.64	1.5	−0.90	0.11	0.09
Petroleum refining	M	1.14	0.11	238.5	0.25	0.06	0.46
Other petroleum products	M	1.06	0.23	1.5	−0.21	0.05	0.18
Tires, tubes	M	0.64	0.40	7.6	−0.87	0.10	0.17
Reprocessed rubber	M	1.12	0.52	112.9	0.05	0.10	0.11
Other rubber products	M	0.76	0.30	1.5	−0.64	0.12	0.30
Plastic products	M	0.75	0.34	3.6	−0.53	0.13	0.27
Ceramics, earthenware	M	0.61	0.20	0.5	−0.64	0.12	0.49
Glass products	M	0.71	0.25	1.7	−0.51	0.14	0.43
Structural clay products	M	0.68	0.28	17.2	−0.49	0.17	0.45
Cement	M	0.82	0.32	12.6	−0.37	0.12	0.26
Other nonmetallic products	M	0.83	0.46	4.8	−0.48	0.19	0.25
Iron steel	M	0.96	0.45	3.9	−0.03	0.13	0.18
Nonferrous metals	M	1.00	0.07	22.2	0.02	0.03	0.32
Cutlery, general hardware	M	0.78	0.46	4.9	−0.45	0.19	0.25
Metal furniture, fixtures	M	0.83	0.43	9.4	−0.35	0.12	0.18
Structural metal products	M	0.89	0.39	10.5	−0.26	0.14	0.23
Other fabricated metal products	M	0.84	0.32	16.7	−0.33	0.12	0.26
Machinery	M	0.96	0.80	1.0	−0.07	0.21	0.24
Electrical machinery	M	0.89	0.70	13.9	−0.20	0.33	0.17
Radio, television equipment	M	0.68	0.31	1.3	−0.43	0.13	0.28
Household electrical appliances	M	0.69	0.40	0.6	−0.42	0.12	0.19
Batteries	M	0.68	0.26	3.0	−0.61	0.13	0.36
Other electrical equipment	M	0.89	0.36	1.1	−0.14	0.16	0.29
Shipbuilding	M	0.96	0.25	7.6	−0.10	0.13	0.40
Railroad equipment	M	1.00	0.33	3.0	−0.06	0.16	0.33
Motor vehicles	M	0.48	0.26	46.1	−0.67	0.13	0.36

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Motorcycles	M	0.64	0.19	10.7	−0.57	0.06	0.29
Aircraft	M	0.91	0.46	2.4	−0.09	0.15	0.18
Instruments	M	0.92	0.42	0.1	−0.15	0.18	0.28
Photographic equipment	M	0.88	0.38	*	−0.21	0.18	0.31
Jewelry	M	0.82	0.48	4.5	−0.69	0.17	0.20
Musical instruments	M	0.71	0.34	*	−0.78	0.18	0.37
Sporting goods	M	0.67	0.41	0.2	−0.58	0.17	0.27
Other manufactures	M	1.00	0.41	10.5	0.08	0.17	0.26
Ivory Coast							
Traditional agriculture	A	0.99	0.76	44,771	−0.17	0.65	0.22
Coffee	A	1.47	0.70	60,808	0.35	0.54	0.29
Cocoa	A	1.59	0.50	31,245	0.27	0.49	0.47
Other export agriculture	A	1.10	0.74	13,907	−0.06	0.53	0.23
Timber	A	1.20	0.55	48,281	0.33	0.33	0.27
Fisheries	A	0.78	0.65	3,563	−0.33	0.45	0.28
Minerals	R	0.87	0.51	1,867	−0.11	0.28	0.27
Flour	F	0.78	0.21	2,504	−0.71	0.08	0.19
Other milled products	F	0.99	0.49	4,105	−0.13	0.22	0.22
Bakery products	F	0.98	0.46	8,393	0.00	0.20	0.23
Canned fruit	F	1.00	0.47	3,793	−0.11	0.15	0.16
Processed coffee	F	0.78	0.20	1,529	−0.68	0.12	0.33
Processed cocoa	F	1.16	0.10	4,361	−0.21	0.04	0.26
Other processed foods	F	0.96	0.83	19,560	0.06	0.14	0.07
Edible oils	F	0.85	0.41	7,040	−0.43	0.20	0.26
Miscellaneous foods, tobacco	F	0.82	0.25	8,320	0.82	0.09	0.16
Textiles	T	0.79	0.40	16,531	−0.29	0.19	0.24
Clothing	T	0.66	0.63	3,406	−0.47	0.29	0.21

Shoes	T	0.65	0.82	2,131	−0.47	0.32	0.14
Lumber mills	M	1.04	0.67	7,100	−0.08	0.27	0.15
Wood products	M	0.78	0.77	1,470	−0.42	0.34	0.12
Petroleum products	M	0.89	0.25	35,819	1.39	0.09	0.12
Fertilizers	M	0.94	0.41	2,015	−0.19	0.13	0.17
Paint	M	0.69	0.42	1,156	−0.68	0.16	0.19
Soap, detergents	M	0.71	0.23	3,371	−0.38	0.14	0.27
Basic chemicals	M	0.92	0.50	372	−0.32	0.17	0.17
Plastics	M	0.76	0.52	2,075	−0.34	0.21	0.20
Other chemicals	M	0.74	0.39	897	−0.39	0.28	0.38
Rubber	M	0.94	0.42	1,207	−0.27	0.11	0.14
Cement, building products	M	0.98	0.39	8,223	0.15	0.15	0.19
Auto manufacture	M	0.87	0.35	3,748	−0.13	0.10	0.15
Other vehicles	M	1.00	0.62	2,450	0.06	0.24	0.18
Metalwork	M	0.98	0.57	11,768	0.03	0.21	0.17
Machinery	M	0.85	0.66	2,234	−0.26	0.26	0.17
Paper	M	0.77	0.45	1,586	−0.33	0.12	0.14
Printing, other manufacturing	M	1.05	0.59	5,259	0.01	0.38	0.28
Kenya							
Agriculture, fishing, forestry	A	0.98	0.67	85,658	0.00	0.57	0.30
Mining, quarrying	R	0.66	0.52	3,113	−0.40	0.34	0.31
Other food	F	0.84	0.59	37,001	−0.45	0.11	0.10
Bakery, cocoa, chocolate	F	0.82	0.58	2,749	−0.19	0.18	0.16
Textile, raw materials	T	0.97	0.63	3,239	0.01	0.23	0.16
Finishing textiles	T	0.71	0.66	2,393	−0.42	0.24	0.16
Knitting garments	T	0.75	0.57	4,876	−0.22	0.21	0.18
Shoes, leather	T	0.85	0.47	2,402	−0.16	0.16	0.19
Sawmills	M	0.89	0.60	2,204	−0.14	0.30	0.25
Wood, printing, publishing	M	0.93	0.59	9,171	−0.03	0.29	0.22
Rubber products	M	0.80	0.42	728	−0.30	0.19	0.26

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Paint, varnish, soap	M	0.85	0.49	3,769	−0.01	0.19	0.20
Petroleum, chemicals	M	0.93	0.27	34,101	0.98	0.06	0.14
Nonmetallic products	M	0.89	0.33	4,489	−0.06	0.28	0.41
Metal products, machinery, miscellaneous	M	0.94	0.57	11,390	−0.02	0.27	0.22
Transport equipment	M	0.86	0.69	11,302	−0.11	0.40	0.20
South Korea, 1966							
Rice, barley, wheat	A	0.96	0.66	279.0	0.00	0.55	0.29
Pulses, cereals	A	0.97	0.81	17.4	0.01	0.68	0.17
Vegetables	A	0.57	0.76	63.8	−0.48	0.58	0.19
Fruits	A	0.66	0.49	7.1	−0.41	0.34	0.38
Industrial crops	A	0.75	0.82	14.7	−0.27	0.63	0.15
Livestock, poultry	A	0.87	0.46	42.3	−0.13	0.25	0.32
Forest products	A	0.95	0.42	20.6	−0.01	0.35	0.50
Fishing	A	1.00	0.39	30.6	0.07	0.28	0.47
Coal mining	R	0.90	0.76	11.6	−0.05	0.54	0.22
Metal ores	R	0.83	0.37	5.5	−0.13	0.29	0.51
Raw salt	R	0.93	0.72	0.6	−0.02	0.52	0.28
Meat, dairy foods	F	0.93	0.43	26.6	0.29	0.08	0.14
Processed fruits, vegetables	F	0.93	0.33	0.6	0.29	0.14	0.29
Processed seafoods	F	0.93	0.35	10.3	−0.09	0.14	0.27
Grain milling	F	0.93	0.47	25.1	0.01	0.23	0.30
Bakery, confectionery	F	0.93	0.58	9.0	0.02	0.14	0.14
Refined sugar	F	0.93	0.18	7.9	1.00	0.06	0.23
Seasonings, oils	F	0.93	0.45	21.0	0.22	0.15	0.22
Other foods	F	0.93	0.42	16.6	0.07	0.13	0.20
Soft drinks	F	0.96	0.55	2.3	0.32	0.17	0.24
Cotton yarn	T	0.96	0.50	26.6	0.37	0.10	0.12

Silk yarn	T	0.96	0.40	5.4	0.32	0.12	0.18
Worsted, woolen yarns	T	0.70	0.52	6.8	−0.71	0.15	0.17
Hemp, flax yarns	T	0.96	0.67	0.8	0.52	0.21	0.13
Other yarns	T	0.96	0.42	6.7	0.70	0.11	0.19
Cotton fabrics	T	0.96	0.47	20.9	0.09	0.10	0.12
Silk fabrics	T	0.97	0.41	1.9	0.06	0.17	0.26
Worsted, woolen fabrics	T	0.97	0.40	12.1	0.49	0.14	0.23
Hemp fabrics	T	0.97	0.43	1.3	0.04	0.23	0.32
Other fabrics	T	0.97	0.55	14.2	0.11	0.18	0.20
Knit products	T	0.86	0.48	9.4	−0.02	0.17	0.22
Rope, fishnets	T	0.86	0.53	3.5	0.09	0.15	0.16
Apparel, accessories	T	0.86	0.49	47.9	0.04	0.17	0.23
Miscellaneous textile products	T	0.86	0.51	10.0	0.02	0.23	0.26
Leather, fur	T	0.96	0.38	3.0	0.14	0.13	0.23
Leather products	T	0.84	0.61	4.6	−0.14	0.23	0.20
Lumber, plywood	M	0.83	0.42	17.0	−0.13	0.12	0.23
Wood products	M	0.97	0.55	3.7	0.14	0.22	0.26
Furniture	M	0.97	0.52	4.8	0.18	0.19	0.24
Pulp	M	0.96	0.79	*	0.06	0.42	0.22
Paper, paperboard	M	0.90	0.39	9.1	−0.04	0.15	0.30
Other paper products	M	0.74	0.48	5.0	−0.41	0.19	0.26
Printing, publishing	M	0.99	0.72	19.1	0.01	0.29	0.17
Rubber products	M	0.87	0.51	18.4	0.01	0.17	0.23
Basic inorganic chemicals	M	0.73	0.08	2.0	−0.17	0.23	0.33
Basic organic chemicals	M	0.73	0.39	3.3	−0.42	0.13	0.23
Explosives	M	0.77	0.35	1.0	−0.24	0.13	0.27
Paint, printing ink	M	0.74	0.30	2.0	−0.36	0.12	0.29
Drugs	M	0.77	0.33	6.8	−0.19	0.16	0.32
Soap surfactants	M	0.67	0.39	2.7	−0.76	0.11	0.19
Cosmetics	M	0.95	0.35	2.1	0.23	0.18	0.32
Pesticides	M	0.79	0.32	1.2	−0.15	0.21	0.45

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Miscellaneous chemical products	M	0.89	0.34	6.0	0.19	0.14	0.29
Fertilizers	M	0.99	0.39	6.1	0.17	0.21	0.37
Petroleum products	M	0.95	0.12	23.1	0.59	0.04	0.21
Coal products	M	1.00	0.42	13.4	−0.06	0.15	0.20
Cement	M	0.96	0.22	11.1	0.15	0.18	0.46
Clay, concrete products	M	0.83	0.57	7.1	0.03	0.32	0.30
Glass products	M	0.76	0.52	2.5	−0.06	0.25	0.33
Pottery	M	0.83	0.69	2.0	0.03	0.37	0.26
Other nonmetallic products	M	0.68	0.63	2.3	−0.23	0.35	0.32
Pig iron	M	0.92	0.68	0.5	0.08	0.19	0.19
Steel ingots	M	0.92	0.48	5.5	−0.01	0.09	0.39
Steel sheet, bars	M	0.91	0.47	6.3	−0.02	0.10	0.16
Pipes, galvanized, plated steel	M	0.91	0.41	3.5	−0.07	0.11	0.19
Cast, forged steel	M	0.91	0.45	2.1	−0.02	0.18	0.43
Nonferrous metals	M	0.93	0.45	4.2	0.08	0.13	0.38
Nonferrous primary products	M	0.85	0.60	1.6	−0.15	0.18	0.43
Structural metal products	M	0.93	0.57	6.7	0.01	0.18	0.21
Miscellaneous metal products	M	0.93	0.63	8.4	0.01	0.21	0.22
Prime movers, boilers	M	0.96	0.58	3.2	0.08	0.25	0.27
Machine tools	M	0.96	0.59	1.0	0.08	0.24	0.28
Special industrial machinery	M	0.96	0.57	5.4	0.08	0.24	0.27
General industrial machinery	M	0.96	0.56	1.1	0.07	0.25	0.30
Office service machinery	M	0.76	0.60	0.3	−0.33	0.26	0.23
Sewing machines	M	0.96	0.44	1.1	0.11	0.20	0.32
Machinery components	M	0.88	0.47	1.0	−0.11	0.22	0.30
Electrical equipment	M	0.95	0.48	4.6	0.06	0.20	0.29
Electronics	M	0.92	0.42	6.7	0.04	0.17	0.28
Electrical products	M	0.85	0.50	1.8	−0.05	0.21	0.26

Miscellaneous electrical equipment	M	0.84	0.36	2.8	−0.20	0.11	0.27
Shipbuilding	M	0.98	0.61	5.5	0.12	0.25	0.20
Railroad equipment	M	1.00	0.89	6.5	0.43	0.12	0.09
Motor vehicles	M	0.69	0.56	9.6	−0.37	0.22	0.24
Bicycles, carts	M	0.83	0.55	1.9	−0.22	0.20	0.23
Instruments	M	0.73	0.62	2.6	−0.37	0.24	0.23
Synthetic resin products	M	0.91	0.93	4.2	−0.08	0.16	0.26
Miscellaneous manufactures	M	0.90	0.93	8.8	−0.59	0.21	0.31
South Korea, 1970							
Rice, barley, wheat	A	1.00	0.67	546.5	0.01	0.54	0.29
Pulses, cereals	A	0.91	0.82	31.5	0.00	0.69	0.19
Vegetables	A	0.59	0.76	111.4	−0.49	0.58	0.20
Fruits	A	0.68	0.32	17.2	−0.36	0.25	0.54
Industrial crops	A	0.77	0.81	28.2	−0.26	0.59	0.17
Livestock, poultry	A	0.89	0.46	95.4	−0.18	0.18	0.23
Forest products	A	0.92	0.27	49.1	−0.06	0.24	0.65
Fishing	A	0.59	0.59	49.3	−0.52	0.39	0.30
Coal mining	R	0.92	0.76	18.8	−0.05	0.58	0.23
Metallic ores	R	0.99	0.38	16.4	0.06	0.31	0.51
Raw salt	R	0.97	0.52	2.9	−0.01	0.44	0.42
Meat, dairy products	F	0.89	0.43	57.7	−0.05	0.09	0.17
Processed fruits, vegetables	F	0.74	0.32	3.1	−0.27	0.19	0.25
Processed seafoods	F	0.83	0.51	27.0	0.07	0.19	0.27
Grain milling	F	1.00	0.08	71.9	0.07	0.18	0.23
Bakery, confectionery	F	0.87	0.47	15.0	−0.16	0.15	0.20
Refined sugar	F	0.89	0.24	27.9	1.07	0.06	0.18
Seasonings, oils	F	0.92	0.40	43.6	0.22	0.14	0.24
Other foods	F	0.97	0.39	69.6	0.13	0.12	0.21
Soft drinks	F	0.96	0.40	8.7	0.59	0.13	0.25
Cotton yarn	F	1.00	0.69	40.3	0.37	0.14	0.13

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Silk yarn	T	1.00	0.47	21.1	0.22	0.15	0.19
Worsted, woolen yarns	T	0.70	0.55	8.6	−0.60	0.15	0.17
Hemp, flax yarns	T	1.00	0.65	1.3	0.46	0.17	0.15
Other yarns	T	0.99	0.49	32.2	0.54	0.13	0.18
Cotton fabrics	T	0.99	0.64	29.6	0.04	0.14	0.10
Silk fabrics	T	1.00	0.18	5.4	0.09	0.25	0.17
Worsted, woolen fabrics	T	0.99	0.38	23.9	0.58	0.17	0.17
Hemp fabrics	T	0.98	0.56	2.6	0.04	0.24	0.23
Other fabrics	T	0.99	0.56	40.3	0.14	0.19	0.21
Knit products	T	0.96	0.55	69.1	0.02	0.20	0.19
Rope, fishnets	T	0.96	0.49	8.4	0.04	0.15	0.19
Apparel, accessories	T	0.86	0.59	93.6	−0.30	0.18	0.20
Miscellaneous textile goods	T	0.89	0.59	18.8	−0.10	0.19	0.29
Leather, fur	T	0.97	0.63	4.6	0.44	0.13	0.14
Leather products	T	0.85	0.58	7.2	−0.20	0.24	0.24
Lumber, plywood	M	0.83	0.47	48.7	−0.42	0.12	0.16
Wood products	M	0.91	0.45	5.3	−0.01	0.23	0.32
Furniture	M	0.91	0.61	9.2	0.10	0.21	0.21
Pulp	M	0.96	0.48	3.2	0.10	0.16	0.23
Paper, paperboard	M	0.90	0.51	20.5	−0.04	0.15	0.26
Other paper products	M	0.74	0.51	11.8	−0.42	0.19	0.23
Printing, publishing	M	0.97	0.69	42.2	0.09	0.31	0.21
Rubber products	M	0.80	0.59	20.2	−0.34	0.19	0.22
Basic inorganic chemicals	M	0.78	0.46	6.7	−0.21	0.24	0.33
Basic organic chemicals	M	0.77	0.38	8.7	−0.36	0.14	0.25
Explosives	M	0.80	0.38	1.8	−0.22	0.17	0.30
Paint, printing ink	M	0.76	0.34	4.6	−0.36	0.13	0.26
Drugs	M	0.80	0.39	25.2	−0.19	0.19	0.32

Soap, surfactants	M	0.69	0.40	6.6	−0.68	0.13	0.23
Cosmetics	M	0.99	0.35	7.5	0.15	0.20	0.37
Pesticides	M	0.82	0.34	5.1	−0.24	0.15	0.31
Miscellaneous chemical products	M	0.92	0.44	41.9	0.14	0.16	0.25
Fertilizers	M	1.00	0.24	40.6	0.15	0.15	0.42
Petroleum products	M	0.73	0.22	70.5	−0.02	0.06	0.18
Coal products	M	0.95	0.48	43.6	0.11	0.15	0.20
Cement	M	0.96	0.26	44.1	0.16	0.20	0.43
Clay, concrete products	M	0.85	0.51	14.0	−0.13	0.29	0.33
Glass products	M	0.75	0.47	8.4	−0.21	0.26	0.36
Pottery	M	0.86	0.53	1.8	−0.09	0.32	0.36
Other nonmetallic products	M	0.67	0.48	6.1	−0.38	0.32	0.38
Pig iron	M	0.95	0.64	0.6	0.13	0.15	0.17
Steel ingots	M	0.90	0.53	17.1	−0.04	0.12	0.46
Steel sheet, bars	M	0.87	0.52	37.7	−0.16	0.12	0.25
Pipes, galvanized plated steel	M	0.83	0.48	10.5	−0.25	0.11	0.16
Cast, forged steel	M	0.83	0.42	5.1	−0.16	0.17	0.41
Nonferrous metals	M	0.86	0.49	7.6	−0.26	0.16	0.21
Nonferrous primary products	M	0.79	0.57	3.2	−0.17	0.12	0.22
Structural metal products	M	0.83	0.61	11.3	−0.14	0.17	0.18
Miscellaneous metal products	M	0.86	0.60	11.0	−0.07	0.20	0.22
Prime movers, boilers	M	0.91	0.60	5.8	0.01	0.25	0.23
Machine tools	M	0.95	0.63	2.7	0.10	0.26	0.22
Special industrial machinery	M	0.96	0.63	12.0	0.19	0.23	0.21
General industrial machinery	M	0.91	0.67	4.7	0.01	0.27	0.21
Office, service machinery	M	0.70	0.75	0.4	−0.42	0.29	0.16
Sewing machines	M	0.89	0.62	1.3	0.09	0.22	0.21
Machine components	M	0.81	0.61	1.9	−0.20	0.27	0.25
Electrical equipment	M	0.91	0.49	13.2	0.07	0.17	0.23
Electronics	M	0.88	0.53	39.9	0.15	0.17	0.20
Electrical products	M	0.82	0.51	11.4	0.02	0.19	0.23

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Miscellaneous electrical equipment	M	0.81	0.38	10.4	−0.22	0.13	0.25
Shipbuilding	M	0.98	0.57	9.0	0.16	0.22	0.21
Railroad equipment	M	1.00	0.59	11.7	0.26	0.16	0.17
Motor vehicles	M	0.69	0.48	47.6	−0.37	0.15	0.20
Bicycles, carts	M	0.83	0.48	8.3	−0.14	0.16	0.23
Instruments	M	0.75	0.55	6.3	−0.52	0.19	0.20
Synthetic resin products	M	0.94	0.45	17.6	−0.03	0.18	0.28
Miscellaneous manufactures	M	0.92	0.41	66.8	0.01	0.19	0.34
South Korea, 1973							
Rice, barley, wheat	A	0.98	0.66	748.0	0.00	0.57	0.30
Pulses, cereals	A	0.98	0.81	31.5	−0.01	0.71	0.19
Vegetables	A	0.83	0.76	139.1	−0.18	0.58	0.17
Fruits	A	0.85	0.49	36.8	−0.05	0.37	0.47
Industrial crops	A	0.93	0.82	90.2	0.00	0.59	0.18
Livestock, poultry	A	0.97	0.46	298.1	1.05	0.22	0.23
Forest products	A	0.95	0.42	64.0	−0.03	0.26	0.64
Fishing	A	0.91	0.39	129.4	−0.07	0.26	0.45
Coal mining	R	0.37	0.76	30.3	−0.80	0.56	0.18
Metal ores	R	0.98	0.37	20.2	0.05	0.40	0.47
Raw salt	R	0.92	0.72	6.1	−0.07	0.43	0.44
Meat, dairy products	F	0.95	0.43	109.7	−0.01	0.09	0.17
Processed fruits, vegetables	F	0.88	0.33	14.0	−0.06	0.16	0.27
Processed seafoods	F	0.97	0.35	52.8	0.11	0.18	0.23
Grain milling	F	1.00	0.47	108.9	−0.23	0.12	0.23
Bakery, confectionery	F	0.96	0.58	77.0	0.07	0.12	0.16
Refined sugar	F	0.81	0.18	37.9	−0.12	0.04	0.23
Seasonings, oils	F	0.92	0.45	80.1	0.05	0.13	0.22

Other foods	F	0.86	0.42	86.0	−0.33	0.09	0.19
Soft drinks	F	0.70	0.55	18.6	0.04	0.13	0.21
Cotton yarn	T	0.95	0.50	98.9	0.03	0.10	0.21
Silk yarn	T	0.99	0.40	50.2	0.07	0.10	0.19
Worsted, woolen yarns	T	1.01	0.52	34.3	0.14	0.11	0.21
Hemp, flax yarns	T	1.00	0.67	2.2	0.18	0.17	0.14
Other yarns	T	0.99	0.42	99.2	0.25	0.11	0.27
Cotton fabrics	T	0.99	0.47	84.2	0.12	0.09	0.19
Silk fabrics	T	1.00	0.41	19.8	0.11	0.20	0.25
Worsted, woolen fabrics	T	1.00	0.40	43.1	0.10	0.16	0.29
Hemp fabrics	T	0.89	0.43	2.5	−0.14	0.22	0.34
Other fabrics	T	1.00	0.55	99.2	0.14	0.14	0.14
Knit products	T	1.00	0.48	165.3	0.18	0.16	0.27
Rope, fishnets	T	0.93	0.53	11.5	−0.17	0.12	0.21
Apparel, accessories	T	0.99	0.49	450.0	0.10	0.15	0.28
Miscellaneous textile products	T	0.97	0.51	55.3	−0.09	0.15	0.29
Leather, fur	T	0.99	0.38	21.7	0.04	0.13	0.23
Leather products	T	0.91	0.61	16.4	0.01	0.19	0.19
Lumber, plywood	M	0.99	0.42	211.4	0.08	0.09	0.17
Wood products	M	0.86	0.55	10.8	−0.21	0.21	0.24
Furniture	M	0.92	0.52	20.4	0.01	0.18	0.23
Pulp	M	0.94	0.79	2.8	−0.04	0.13	0.26
Paper, paperboard	M	0.92	0.39	52.0	−0.04	0.11	0.27
Other paper products	M	0.90	0.48	31.7	−0.05	0.17	0.19
Printing, publishing	M	0.96	0.72	91.1	0.05	0.28	0.20
Rubber products	M	0.84	0.51	60.8	−0.38	0.14	0.16
Basic inorganic chemicals	M	0.87	0.46	17.9	−0.07	0.19	0.36
Basic organic chemicals	M	0.90	0.39	34.7	−0.05	0.10	0.26
Explosives	M	0.77	0.35	2.1	−0.47	0.20	0.16
Paint, printing ink	M	0.83	0.30	7.5	−0.27	0.11	0.18
Drugs	M	0.75	0.33	52.1	−0.34	0.16	0.38

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Soap, surfactants	M	0.85	0.39	15.4	−0.30	0.10	0.24
Cosmetics	M	0.49	0.35	11.5	−0.89	0.17	0.31
Pesticides	M	0.87	0.32	10.4	−0.17	0.11	0.22
Miscellaneous chemical products	M	0.93	0.34	180.2	0.01	0.10	0.30
Fertilizers	M	1.00	0.39	52.8	0.10	0.19	0.38
Petroleum products	M	0.88	0.12	291.6	0.26	0.05	0.21
Coal products	M	0.93	0.42	87.2	0.73	0.14	0.24
Cement	M	0.85	0.22	42.9	−0.08	0.19	0.48
Clay, concrete products	M	0.90	0.57	26.9	−0.05	0.28	0.35
Glass products	M	0.83	0.52	13.2	−0.10	0.26	0.29
Pottery	M	0.93	0.69	4.3	−0.02	0.30	0.35
Other nonmetallic products	M	0.77	0.63	16.6	−0.24	0.28	0.42
Pig iron	M	0.98	0.68	1.3	0.07	0.15	0.18
Steel ingots	M	0.98	0.48	83.8	0.04	0.06	0.33
Steel sheet, bars	M	0.95	0.47	111.4	−0.05	0.06	0.18
Pipes, galvanized plated steel	M	0.88	0.41	28.9	−0.39	0.08	0.10
Cast, forged steel	M	0.92	0.45	17.3	−0.06	0.15	0.27
Nonferrous metals	M	0.94	0.45	13.4	−0.03	0.14	0.22
Nonferrous primary products	M	0.89	0.60	7.3	−0.07	0.10	0.14
Structural metal products	M	0.92	0.57	25.8	−0.09	0.16	0.15
Miscellaneous metal products	M	0.89	0.63	27.7	−0.10	0.15	0.26
Prime movers, boilers	M	0.96	0.58	7.3	0.08	0.23	0.12
Machine tools	M	0.97	0.59	6.8	0.10	0.19	0.16
Special industrial machinery	M	0.98	0.57	34.1	0.10	0.19	0.16
General industrial machinery	M	0.97	0.56	10.7	0.05	0.23	0.18
Office, service machinery	M	0.96	0.60	14.6	0.07	0.19	0.09
Sewing machines	M	0.91	0.44	2.1	−0.01	0.15	0.30
Machine components	M	0.81	0.47	4.6	−0.37	0.20	0.16

Electrical equipment	M	0.91	0.48	18.2	−0.09	0.16	0.17
Electronics	M	0.98	0.42	240.4	0.14	0.13	0.19
Electrical products	M	0.92	0.50	31.3	0.27	0.17	0.17
Miscellaneous electrical equipment	M	0.96	0.36	52.1	0.05	0.10	0.20
Shipbuilding	M	0.98	0.61	32.8	0.08	0.27	0.12
Railroad equipment	M	1.00	0.89	17.4	0.13	0.14	0.17
Motor vehicles	M	0.83	0.56	62.2	−0.07	0.17	0.13
Bicycles, carts	M	0.93	0.55	25.2	0.02	0.11	0.24
Instruments	M	0.87	0.62	18.6	−0.14	0.13	0.18
Synthetic resin products	M	0.96	0.44	55.9	0.09	0.17	0.15
Miscellaneous manufactures	M	0.97	0.52	132.7	0.06	0.19	0.26
Taiwan							
Other common crops	A	0.86	0.54	5,848	0.02	0.38	0.32
Crops for processing	A	0.91	0.71	6,083	0.10	0.52	0.22
Horticultural crops	A	0.55	0.60	5,644	−0.44	0.43	0.30
Hogs	A	0.83	0.54	14,936	0.10	0.15	0.11
Other livestock	A	0.90	0.63	7,482	0.23	0.25	0.14
Forestry	A	0.89	0.58	5,974	0.37	0.41	0.29
Fisheries	A	0.73	0.50	6,321	−0.18	0.33	0.32
Rice	A	0.94	0.48	1,790	0.18	0.47	0.29
Coal, products	R	0.92	0.81	3,009	0.18	0.58	0.18
Metallic minerals	R	0.92	0.64	244	0.11	0.35	0.23
Petroleum, natural gas	R	0.89	0.12	1,111	0.16	0.10	0.59
Salt	R	0.61	0.63	682	0.12	6.33	0.19
Sugar	F	0.55	0.46	3,831	−0.82	0.32	0.20
Canned foods	F	0.48	0.58	3,884	−4.02	0.17	0.11
Slaughtered meat	F	0.81	0.34	18,829	0.43	0.06	0.06
Monosodium glutamate	F	1.00	0.19	1,474	0.90	0.10	0.32
Wheat flour	F	0.87	0.34	1,663	−0.50	0.07	0.09
Vegetable oil	F	0.66	0.46	3,003	−1.42	0.06	0.05

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Nonalcoholic beverages	F	0.48	0.34	741	−0.30	0.18	0.25
Tea	F	0.40	0.52	543	−1.49	0.11	0.10
Miscellaneous food products	F	0.72	0.58	3,152	−0.46	0.15	0.11
Artificial fibers	T	0.91	0.20	10,322	0.14	0.08	0.24
Artificial fabrics	T	0.79	0.53	2,935	−0.18	0.12	0.11
Cotton fabrics	T	0.65	0.54	1,385	−0.67	0.13	0.11
Woolen, worsted fabrics	T	0.66	0.41	2,746	−0.45	0.12	0.15
Miscellaneous fabrics, apparel	T	0.52	0.78	1,621	−0.64	0.20	0.08
Leather, products	T	0.66	0.75	1,173	−0.66	0.19	0.08
Lumber	M	0.64	0.63	1,263	−0.91	0.16	0.11
Plywood	M	0.66	0.61	10,880	−0.93	0.17	0.12
Wood, bamboo, rattan products	M	0.79	0.60	10,275	0.00	0.24	0.17
Pulp, paper, products	M	0.83	0.52	12,020	0.11	0.15	0.14
Printing, publishing	M	0.94	0.69	14,287	0.21	0.34	0.17
Rubber, products	M	0.84	0.60	4,079	0.10	0.17	0.12
Chemical fertilizer	M	0.89	0.41	25,737	0.28	0.08	0.11
Medicines	M	0.75	0.61	3,077	−0.13	0.30	0.19
Plastics, products	M	0.87	0.49	6,314	0.12	0.16	0.16
Petroleum products	M	0.75	0.13	14,082	0.20	0.04	0.24
Nonedible oils	M	0.77	0.40	1,330	−0.52	0.11	0.16
Industrial chemicals	M	0.84	0.29	88,867	0.05	0.13	0.27
Miscellaneous chemical products	M	0.83	0.48	3,451	−0.05	0.15	0.15
Cement	M	0.66	0.28	4,804	0.01	0.15	0.27
Cement products	M	0.65	0.63	542	−0.31	0.28	0.15
Glass	M	0.70	0.49	962	−0.18	0.24	0.24
Miscellaneous nonmetallic minerals	M	0.73	0.66	1,986	−0.17	0.42	0.21
Steel, iron	M	0.87	0.67	6,191	−0.02	0.10	0.08
Steel, iron products	M	0.72	0.47	5,352	−0.41	0.16	0.17

Aluminum	M	0.81	0.48	1,064	−0.06	0.14	0.19
Aluminum products	M	0.92	0.54	1,363	0.29	0.18	0.17
Miscellaneous metals, products	M	0.88	0.63	2,892	0.06	0.19	0.13
Machinery	M	0.80	0.61	6,594	−0.21	0.24	0.17
Household electrical equipment	M	0.61	0.60	40,507	−0.37	0.31	0.21
Communications equipment	M	0.81	0.51	10,809	−0.23	0.15	0.14
Other electrical equipment	M	0.79	0.60	4,738	−0.12	0.24	0.17
Shipbuilding	M	0.93	0.68	2,852	0.21	0.25	0.13
Motor vehicles	M	0.68	0.53	4,838	−0.33	0.16	0.14
Other transport equipment	M	0.89	0.49	2,228	0.04	0.21	0.21
Tunisia							
Cereals, feed	A	0.87	0.69	119,486	0.00	0.54	0.25
Vegetables	A	0.76	0.78	27,545	−0.19	0.54	0.25
Horticultural crops	A	0.81	0.75	69,730	−0.04	0.57	0.25
Olive oil	A	0.60	0.40	56,760	−0.76	0.11	0.18
Forestry	A	0.96	0.83	5,070	0.19	0.72	0.14
Livestock	A	0.84	0.45	114,968	0.01	0.25	0.32
Fisheries	A	0.75	0.67	6,859	−0.14	0.80	0.27
Phosphate mining	R	0.78	0.88	9,062	−0.39	0.65	0.34
Metal mining	R	0.79	0.88	5,423	−0.18	0.54	0.21
Salt	R	0.56	0.93	972	−0.32	0.44	0.12
Crude petroleum, natural gas	R	0.99	0.02	45,395	0.02	0.04	0.91
Canned foods	F	0.69	0.38	7,623	−0.23	0.13	0.24
Cereal foods	F	0.78	0.78	42,778	−0.34	0.11	0.07
Sugar products	F	0.77	0.23	17,928	0.10	0.05	0.16
Milk, products	F	0.90	0.12	4,269	0.32	0.05	0.28
Coffee	F	0.65	0.12	1,669	−0.53	0.05	0.29
Other vegetable oils	F	0.95	0.55	15,303	0.90	0.07	0.08
Spinning (except jute)	T	0.69	0.54	5,868	−0.25	0.15	0.20
Weaving (except jute)	T	0.75	0.63	22,900	0.13	0.20	0.20

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Jute spinning, weaving	T	0.77	0.57	1,633	0.01	0.13	0.14
Hosiery	T	0.76	0.92	9,113	0.83	0.15	0.08
Clothing	T	0.74	0.66	10,161	0.16	0.20	0.17
Leather products	T	0.72	0.65	7,574	0.04	0.20	0.20
Oil refining	M	0.79	0.21	30,723	1.12	0.04	0.12
Cement, lime, plaster	M	0.88	0.74	8,534	0.33	0.25	0.25
Cement products	M	0.86	0.47	7,696	0.09	0.23	0.33
Ceramics	M	0.71	0.57	11,916	−0.18	0.39	0.37
Tiles, sanitary fixtures	M	0.75	0.61	2,135	0.09	0.26	0.30
Glass, products	M	0.86	0.43	2,134	0.17	0.22	0.35
Iron, steel	M	0.87	0.28	31,613	0.10	0.10	0.22
Nonferrous metals	M	1.00	0.82	5,193	1.10	0.14	0.06
Foundries, etc.	M	0.87	0.48	6,585	0.11	0.25	0.29
Iron, metal products	M	0.84	0.41	12,416	0.11	0.17	0.25
Nonferrous products	M	0.92	0.66	3,000	0.25	0.19	0.16
Electrical products	M	0.87	0.91	6,780	0.57	0.15	0.12
Motor vehicle assembly	M	0.72	0.37	5,931	−0.01	0.09	0.20
Phosphoric acid, flour products	M	0.88	0.45	2,563	−0.04	0.21	0.23
Basic chemicals	M	0.94	0.38	80	0.21	0.22	0.36
Fertilizers	M	0.87	0.57	21,658	0.13	0.15	0.14
Industrial gas, explosives, pyrotechnics	M	0.81	0.78	1,761	0.03	0.31	0.17
Paint, varnish, ink	M	0.89	0.38	4,346	0.21	0.15	0.25
Toilet products, perfumes	M	0.80	0.48	6,517	−0.24	0.21	0.41
Pharmaceuticals	M	0.97	0.38	2,220	0.04	0.24	0.43
Rubber products	M	0.75	0.32	3,842	−0.14	0.15	0.31
Plastics	M	0.82	0.49	4,863	0.22	0.15	0.17
Cork, wood	M	0.86	0.42	8,985	0.06	0.23	0.34
Paper, printing, publishing	M	0.90	0.44	15,260	0.10	0.25	0.35
Miscellaneous manufactures	M	0.81	0.24	9,129	0.04	0.15	0.44

Turkey							
Agriculture	A	0.95	0.67	82,107	0.00	0.50	0.28
Animal husbandry	A	0.95	0.67	24,998	−0.04	0.43	0.25
Forestry	A	0.87	0.31	4,143	0.10	0.21	0.57
Fishing	A	0.95	0.50	856	0.06	0.39	0.44
Coal mining	R	0.88	0.81	1,688	−0.36	0.90	0.29
Crude petroleum, natural gas	R	0.19	0.06	1,038	−0.80	0.07	0.82
Iron ore mining	R	0.88	0.81	159	0.06	0.48	0.25
Nonferrous mining	R	0.83	0.81	378	−0.38	0.87	0.29
Nonmetallic mining	R	0.83	0.81	227	−0.28	0.71	0.28
Quarrying	R	0.83	0.40	606	−0.04	0.29	0.49
Meat, products	F	0.95	0.32	9,664	0.05	0.03	0.13
Canned fruits, vegetables	F	0.98	0.36	2,294	0.26	0.10	0.31
Oils, fats	F	0.87	0.37	4,486	−0.06	0.08	0.20
Grain mill products	F	0.93	0.28	3,597	−0.02	0.05	0.15
Sugar	F	0.41	0.91	2,579	−2.20	0.17	0.10
Other food products	F	0.93	0.72	14,106	0.18	0.14	0.17
Nonalcoholic beverages	F	0.93	0.57	750	0.49	0.18	0.22
Tobacco	F	0.80	0.32	9,015	0.28	0.13	0.29
Ginning	T	0.87	0.15	5,113	−0.42	0.02	0.15
Textiles	T	0.78	0.77	22,369	0.12	0.21	0.16
Apparel	T	0.67	0.31	3,362	−0.45	0.15	0.37
Leather, fur products	T	0.87	0.32	1,532	−0.08	0.11	0.34
Footwear	T	0.67	0.24	1,687	−0.37	0.15	0.53
Wood, products	M	0.74	0.39	4,406	−0.30	0.14	0.29
Wood furniture, fixtures	M	0.74	0.61	533	−0.19	0.19	0.21
Paper, products	M	0.47	0.66	1,723	−0.47	0.21	0.23
Printing, publishing	M	0.47	0.42	1,731	−0.52	0.23	0.43
Fertilizers	M	0.80	0.25	571	−0.82	0.31	0.97
Pharmaceuticals	M	0.48	0.46	1,871	−0.48	0.20	0.34
Other chemical products	M	0.46	0.44	5,636	−0.09	0.13	0.23

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Petroleum refining	M	0.27	0.05	16,443	0.07	0.02	0.17
Petroleum, coal products	M	0.27	0.27	1,106	−0.79	0.10	0.36
Rubber products	M	0.30	0.17	1,753	−0.90	0.09	0.43
Plastic products	M	0.30	0.58	1,264	−0.83	0.15	0.24
Glass, products	M	0.83	0.61	1,669	0.19	0.26	0.25
Cement	M	0.44	0.63	1,848	−0.48	0.23	0.25
Nonmetallic mineral products	M	0.83	0.61	3,495	0.02	0.32	0.32
Iron, steel	M	0.41	0.33	8,618	−0.68	0.16	0.33
Nonferrous metals	M	0.56	0.33	2,714	−0.62	0.20	0.47
Fabricated metal products	M	0.45	0.42	5,138	−0.51	0.16	0.28
Machinery	M	0.49	0.42	4,993	−0.10	0.14	0.24
Agricultural machinery	M	0.49	0.33	2,455	−0.23	0.07	0.20
Electrical machinery	M	0.48	0.36	3,578	−0.51	0.17	0.36
Shipbuilding	M	0.45	0.87	361	−0.55	0.55	0.16
Railroad equipment	M	0.45	0.87	624	−0.64	0.45	0.11
Motor vehicles	M	0.45	0.40	7,569	−0.36	0.13	0.28
Other transport equipment	M	0.45	0.22	479	−0.52	0.15	0.55
Uruguay							
Agriculture	A	1.00	0.67	1,847	0.09	0.40	0.33
Livestock	A	1.00	0.67	2,953	0.00	0.52	0.33
Mining	R	0.40	0.49	319	−0.63	0.31	0.36
Food, beverages	F	1.05	0.43	5,633	0.20	0.18	0.27
Tobacco	F	0.84	0.11	202	−0.19	0.12	0.57
Textiles	T	0.58	0.39	1,666	−0.67	0.12	0.20
Shoes, clothing	T	0.68	0.45	504	−0.27	0.23	0.34
Leather, products	T	0.79	0.22	101	−0.31	0.13	0.39
Wood products	M	0.61	0.53	194	−0.40	0.27	0.25
Paper, printing, publishing	M	0.73	0.51	364	−0.24	0.26	0.30

Rubber	M	0.42	0.31	190	−0.66	0.19	0.41
Chemicals	M	0.89	0.46	640	−0.05	0.21	0.30
Energy	M	0.19	0.51	868	−0.85	0.26	0.31
Metal products, machinery	M	0.73	0.48	473	−0.25	0.27	0.34
Electrical machinery	M	0.63	0.36	451	−0.40	0.18	0.33
Transport equipment	M	0.30	0.69	399	−0.74	0.37	0.18
Other industries	M	0.59	0.51	231	−0.47	0.30	0.40
Belgium							
Agriculture, forestry	A	0.85	0.60	1,248	−0.21	0.35	0.25
Fisheries	A	0.91	0.53	27	0.02	0.37	0.34
Coal mining	R	0.99	0.72	256	−0.27	0.79	0.35
Nonmetallic minerals	R	0.94	0.55	135	0.11	0.40	0.34
Animal, vegetable oils	F	0.93	0.63	160	0.02	0.16	0.11
Meat, products	F	0.90	0.20	815	0.27	0.06	0.18
Dairy products	F	0.95	0.63	356	0.26	0.11	0.09
Canned fruits, vegetables	F	0.91	0.75	31	−0.09	0.26	0.13
Grain mill products	F	0.89	0.45	352	−0.04	0.17	0.20
Sugar	F	0.94	0.72	129	0.54	0.21	0.11
Chocolate, confectionery	F	0.89	0.57	124	0.03	0.21	0.18
Animal feeds	F	0.91	0.68	357	0.14	0.09	0.07
Other food products	F	0.91	0.63	84	−0.09	0.20	0.15
Yarn, cloth	T	0.96	0.78	783	0.14	0.22	0.10
Textile products	T	0.87	0.72	400	−0.08	0.26	0.13
Knitted products	T	0.84	0.74	115	−0.09	0.29	0.13
Leather	T	0.89	0.76	33	−0.01	0.22	0.11
Leather products	T	0.79	0.66	22	−0.11	0.29	0.18
Shoes	T	0.85	0.84	58	−0.03	0.40	0.10
Clothing	T	0.86	0.82	484	0.03	0.31	0.09
Coke, coal products	M	0.99	0.76	281	0.03	0.22	0.15
Petroleum refining	M	0.68	0.34	720	2.19	0.02	0.04
Iron, steel	M	0.91	0.62	292	−0.29	0.17	0.13

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Iron, steel products	M	0.92	0.74	2,175	0.04	0.17	0.09
Nonferrous metal products	M	0.95	0.71	783	0.05	0.17	0.10
Nonmetallic mineral products	M	0.85	0.80	85	−0.01	0.54	0.18
Cement	M	0.88	0.60	336	0.05	0.34	0.26
Glass, products	M	0.88	0.83	123	−0.01	0.52	0.16
Petrochemicals	M	0.93	0.66	73	0.09	0.30	0.19
Industrial chemical products	M	0.93	0.63	513	0.11	0.30	0.21
Synthetics	M	0.93	0.74	143	0.06	0.29	0.14
Household, government chemical products	M	0.85	0.69	211	−0.08	0.31	0.18
Foundry products	M	0.86	0.76	74	−0.04	0.47	0.21
Other metal products	M	0.88	0.71	460	−0.01	0.36	0.18
Agricultural industrial machinery	M	0.90	0.72	961	0.02	0.35	0.17
Business machines	M	0.91	0.74	18	0.01	0.34	0.15
Electrical equipment	M	0.88	0.70	773	0.00	0.38	0.18
Motor vehicles	M	0.95	0.65	86	0.12	0.16	0.10
Shipbuilding	M	0.97	0.89	114	0.11	0.56	0.10
Railroad equipment	M	0.92	0.70	78	0.04	0.36	0.18
Motrocycles, bicycles	M	0.86	0.88	12	−0.02	0.41	0.11
Aircraft	M	0.95	0.86	53	0.04	0.57	0.11
Instruments	M	0.89	0.88	37	0.02	0.54	0.13
Lumber, plywood	M	0.92	0.53	300	0.08	0.24	0.23
Wood products	M	0.86	0.49	190	−0.02	0.26	0.28
Pulp, paper	M	0.91	0.64	121	−0.13	0.28	0.20
Paper products	M	0.87	0.70	135	−0.03	0.25	0.13
Printing, publishing	M	0.91	0.68	342	0.04	0.40	0.22
Rubber products	M	0.88	0.79	53	−0.11	0.42	0.15
Plastic products	M	0.89	0.55	145	0.01	0.26	0.22
Miscellaneous manufactures	M	0.95	0.86	214	0.13	0.21	0.05

France							
Agriculture, forestry	A	0.91	0.60	14,170	0.07	0.44	0.30
Fisheries	A	0.89	0.54	313	0.14	0.30	0.26
Coal mining	R	0.96	0.73	713	−0.10	0.67	0.27
Petroleum, natural gas	R	1.00	0.19	254	0.21	0.17	0.68
Iron ore mining	R	0.91	0.65	267	0.20	0.42	0.23
Other metal mining	R	0.80	0.62	39	0.03	0.27	0.18
Nonmetallic minerals	R	0.83	0.54	1,084	0.11	0.39	0.33
Animal, vegetable oils	F	0.95	0.61	593	0.33	0.18	0.12
Meat, products	F	0.91	0.64	4,997	0.82	0.06	0.05
Dairy products	F	0.88	0.55	1,908	−0.17	0.13	0.10
Canned fruits, vegetables	F	0.86	0.53	592	0.21	0.18	0.17
Grain mill products	F	0.79	0.35	2,191	−0.09	0.16	0.27
Sugar	F	0.95	0.52	910	0.49	0.16	0.15
Chocolate, confectionery	F	0.83	0.50	531	0.08	0.29	0.28
Animal feeds	F	0.98	0.63	1,010	0.70	0.08	0.05
Other food products	F	0.79	0.59	392	−0.18	0.18	0.13
Yarn, cloth	T	0.85	0.82	2,632	0.21	0.24	0.08
Textile products	T	0.74	0.64	1,657	−0.19	0.24	0.14
Knitted products	T	0.72	0.85	643	−0.12	0.31	0.08
Leather	T	0.86	0.51	665	0.25	0.17	0.15
Leather products	T	0.74	0.81	211	−0.09	0.30	0.10
Shoes	T	0.73	0.89	424	−0.09	0.30	0.08
Clothing	T	0.74	0.67	2,485	0.02	0.27	0.15
Coke, coal products	M	0.96	0.34	528	0.20	0.08	0.13
Petroleum refining	M	0.99	0.61	2,426	0.47	0.13	0.19
Iron, steel	M	0.79	0.74	362	−0.03	0.31	0.16
Iron, steel products	M	0.79	0.74	2,289	−0.03	0.31	0.16
Nonferrous metals, products	M	0.89	0.45	2,149	0.27	0.19	0.21
Nonmetallic mineral products	M	0.79	0.59	748	0.05	0.33	0.24
Cement	M	0.80	0.56	1,217	0.08	0.32	0.26

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Glass, products	M	0.75	0.68	386	−0.03	0.45	0.23
Petrochemicals	M	0.78	0.58	290	−0.04	0.33	0.24
Industrial chemical products	M	0.78	0.58	1,992	−0.09	0.33	0.25
Synthetics	M	0.76	0.52	705	−0.05	0.27	0.24
Household, government chemical products	M	0.77	0.73	2,594	0.05	0.28	0.13
Foundry products	M	0.73	0.79	832	−0.03	0.36	0.13
Other metal products	M	0.75	0.73	3,000	−0.02	0.34	0.15
Agricultural, industrial machinery	M	0.76	0.74	5,306	−0.01	0.33	0.14
Business machines	M	0.74	0.75	252	−0.07	0.30	0.14
Electrical equipment	M	0.74	0.79	3,426	−0.01	0.32	0.12
Motor vehicles	M	0.73	0.81	2,948	−0.05	0.28	0.09
Shipbuilding	M	1.00	0.83	280	0.00	0.58	0.15
Railroad equipment	M	0.78	0.75	480	0.03	0.26	0.11
Motorcycles, bicycles	M	0.87	0.80	289	0.28	0.27	0.08
Aircraft	M	0.91	0.77	1,206	0.33	0.35	0.12
Instruments	M	0.75	0.69	543	−0.02	0.42	0.20
Lumber, plywood	M	0.85	0.60	1,951	0.26	0.23	0.17
Wood products	M	0.75	0.84	1,189	0.03	0.31	0.11
Pulp, paper	M	0.83	0.64	1,449	0.20	0.27	0.17
Paper products	M	0.77	0.64	799	−0.12	0.20	0.13
Printing, publishing	M	0.90	0.72	2,907	0.18	0.38	0.17
Rubber products	M	0.77	0.75	1,249	0.03	0.34	0.13
Plastic products	M	0.71	0.70	692	−0.06	0.29	0.16
Miscellaneous manufactures	M	0.77	0.76	1,055	0.12	0.31	0.13
Germany							
Agriculture, forestry	A	0.85	0.60	8,749	−0.22	0.30	0.21
Fisheries	A	0.94	0.34	189	0.10	0.18	0.29
Coal mining	R	0.98	0.97	3,373	0.09	0.44	0.07

Petroleum, natural gas	R	0.76	0.35	1,381	1.21	0.08	0.11
Iron ore mining	R	1.00	0.77	40	−0.10	0.42	0.18
Other metal mining	R	1.00	0.77	33	−0.10	0.42	0.18
Nonmetallic minerals	R	0.98	0.44	1,575	0.13	0.30	0.37
Animal, vegetable oils	F	0.97	0.44	1,153	0.34	0.09	0.11
Meat, products	F	0.92	0.57	5,366	0.32	0.12	0.10
Dairy products	F	0.89	0.50	2,810	0.16	0.08	0.08
Canned fruits, vegetables	F	0.83	0.51	420	−0.12	0.18	0.17
Grain mill products	F	0.86	0.50	3,109	0.00	0.17	0.18
Sugar	F	0.78	0.35	434	−0.13	0.12	0.21
Chocolate, confectionery	F	0.85	0.59	683	−0.01	0.19	0.15
Animal feeds	F	0.95	0.57	1,042	0.28	0.11	0.10
Other food products	F	0.81	0.27	1,012	−0.20	0.10	0.23
Yarn, cloth	T	0.91	0.60	2,751	0.03	0.25	0.18
Textile products	T	0.91	0.60	3,305	0.03	0.25	0.18
Knitted products	T	0.91	0.60	1,198	0.04	0.25	0.18
Leather	T	0.93	0.86	525	0.18	0.18	0.05
Leather products	T	0.90	0.61	329	−0.02	0.30	0.20
Shoes	T	0.90	0.69	672	−0.01	0.34	0.17
Clothing	T	0.89	0.60	2,394	−0.02	0.26	0.18
Coke, coal products	M	0.98	0.97	1,382	0.09	0.44	0.07
Petroleum refining	M	0.76	0.35	3,263	1.21	0.08	0.11
Iron, steel	M	0.93	0.88	1,999	0.04	0.15	0.06
Iron, steel products	M	0.93	0.88	12,622	0.04	0.15	0.06
Nonferrous metals, products	M	0.98	0.53	3,219	0.13	0.17	0.16
Nonmetallic mineral products	M	0.92	0.68	746	−0.01	0.42	0.23
Cement	M	0.97	0.56	2,110	0.12	0.30	0.26
Glass, products	M	0.91	0.63	1,062	0.02	0.35	0.24
Petrochemicals	M	0.92	0.58	1,059	0.04	0.24	0.20
Industrial chemical products	M	0.92	0.58	3,217	0.04	0.24	0.20
Synthetics	M	0.92	0.58	1,283	0.04	0.24	0.20

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Household, government chemical products	M	0.92	0.58	3,539	0.04	0.24	0.20
Foundry products	M	0.93	0.69	2,633	0.02	0.36	0.21
Other metal products	M	0.90	0.66	5,601	−0.03	0.34	0.19
Agricultural industrial machinery	M	0.95	0.74	7,538	−0.04	0.35	0.15
Business machines	M	0.94	0.50	566	0.01	0.34	0.34
Electrical equipment	M	0.90	0.69	5,719	−0.02	0.34	0.18
Motor vehicles	M	0.92	0.60	8,826	0.04	0.24	0.17
Shipbuilding	M	0.96	0.87	792	0.06	0.37	0.09
Railroad equipment	M	0.94	0.93	240	0.07	0.40	0.07
Motorcycles, bicycles	M	0.92	0.68	214	0.01	0.33	0.17
Aircraft	M	0.94	0.93	514	0.07	0.40	0.07
Instruments	M	0.90	0.70	1,242	−0.03	0.39	0.19
Lumber, plywood	M	0.94	0.62	5,801	0.10	0.28	0.19
Wood products	M	0.94	0.62	3,760	0.10	0.28	0.19
Pulp, paper	M	0.90	0.62	2,013	0.02	0.25	0.18
Paper products	M	0.89	0.62	1,462	0.01	0.25	0.18
Printing, publishing	M	0.96	0.61	3,769	0.10	0.34	0.24
Rubber products	M	0.91	0.64	1,544	0.01	0.32	0.19
Plastic products	M	0.90	0.80	996	−0.01	0.25	0.25
Miscellaneous manufactures	M	0.92	0.57	1,234	0.02	0.30	0.23
Italy							
Agriculture, forestry	A	0.83	0.60	8.009	−0.04	0.40	0.27
Fisheries	A	0.87	0.36	232	0.01	0.28	0.48
Coal mining	R	0.94	0.76	19	0.11	0.63	0.23
Petroleum, natural gas	R	0.95	0.27	150	0.13	0.26	0.58
Iron ore mining	R	0.95	0.87	9	0.12	0.69	0.16
Other metal mining	R	0.95	0.82	61	0.13	0.68	0.19
Nonmetallic minerals	R	0.87	0.69	666	0.14	0.52	0.26

Animal, vegetable oils	F	0.87	0.52	593	0.38	0.09	0.10
Meat, products	F	0.84	0.39	2,768	0.34	0.07	0.11
Dairy products	F	0.86	0.50	1,485	0.18	0.11	0.11
Canned fruits, vegetables	F	0.80	0.61	232	−0.13	0.24	0.18
Grain mill products	F	0.93	0.48	3,735	0.35	0.10	0.11
Sugar	F	0.52	0.48	358	−0.53	0.14	0.14
Chocolate, confectionery	F	0.76	0.63	294	−0.16	0.24	0.17
Animal feeds	F	0.81	0.32	199	−0.02	0.07	0.14
Other food products	F	0.91	0.32	699	0.48	0.08	0.16
Yarn and cloth	T	0.93	0.74	1,801	0.15	0.26	0.13
Textile products	T	0.87	0.68	1,114	−0.01	0.29	0.15
Knitted products	T	0.89	0.64	445	−0.01	0.27	0.19
Leather	T	0.87	0.66	320	0.09	0.20	0.12
Leather products	T	0.81	0.56	114	−0.14	0.25	0.20
Shoes	T	0.96	0.66	740	0.24	0.32	0.19
Clothing	T	0.82	0.46	1,350	−0.10	0.18	0.22
Coke, coal products	M	0.95	0.58	258	0.40	0.18	0.14
Petroleum refineries	M	0.78	0.38	3,808	3.50	0.05	0.06
Iron, steel	M	0.94	0.65	565	0.03	0.14	0.10
Iron, steel products	M	0.94	0.71	3,894	0.18	0.20	0.12
Nonferrous metals, products	M	0.94	0.65	956	0.18	0.26	0.18
Nonmetallic mineral products	M	0.79	0.71	406	−0.09	0.46	0.22
Cement	M	0.88	0.56	820	0.06	0.32	0.26
Glass, products	M	0.87	0.67	433	0.07	0.34	0.19
Petrochemicals	M	0.91	0.50	517	0.14	0.20	0.19
Industrial chemical products	M	0.91	0.50	2,616	0.15	0.20	0.19
Synthetics	M	0.91	0.60	982	0.14	0.31	0.22
Household, government chemical products	M	0.90	0.58	1,525	0.16	0.27	0.21
Foundry products	M	0.80	0.80	305	−0.16	0.36	0.13
Other metal products	M	0.91	0.68	1,481	0.03	0.36	0.21
Agricultural industrial machinery	M	0.87	0.73	2,618	0.05	0.36	0.16

Table 1.A.1 (continued)

Sector	Type	p_j	α_j	X_j^*	g_j	$\hat{\ell}_j^*$	$\hat{k}_j^*$
Business machinery	M	0.89	0.76	284	0.05	0.46	0.17
Electrical equipment	M	0.87	0.74	1,810	0.00	0.35	0.15
Motor vehicles	M	0.83	0.72	1,506	−0.15	0.28	0.13
Shipbuilding	M	0.97	0.90	228	−0.01	0.47	0.10
Railroad equipment	M	0.93	0.92	267	0.08	0.63	0.08
Motorcycles, bicycles	M	0.88	0.82	128	−0.02	0.35	0.12
Aircraft	M	0.88	0.64	130	−0.01	0.28	0.17
Instruments	M	0.91	0.72	327	0.08	0.37	0.16
Lumber, plywood	M	0.90	0.47	1,210	0.14	0.23	0.26
Wood products	M	0.88	0.42	797	0.11	0.24	0.32
Pulp, paper	M	0.89	0.62	702	0.09	0.25	0.17
Printing, publishing	M	0.75	0.67	264	−0.13	0.26	0.14
Rubber products	M	0.96	0.72	1,261	0.23	0.38	0.17
Plastic products	M	0.89	0.67	659	0.05	0.34	0.19
Miscellaneous manufactures	M	0.95	0.70	489	0.26	0.26	0.12
	M	0.82	0.61	332	−0.08	0.33	0.23

*Less than 0.05.

Appendix D: Computational Procedure

A two-factor application of the model for South Korea has 326 constraints and 680 variables including the shadow prices. At first glance solution appears formidable. However, an iterative procedure was developed that greatly simplifies solution. South Korea solutions, for example, required less than twenty seconds of central processor time on the University of Minnesota CDC Cyber 74 computer. The procedure is described here in terms of computational steps. The matrix notation is defined in Appendix A.

Initial Steps

Step 1. The following data are read into the computer: A (input-output coefficients), ℓ^0 and k^0 (vectors of value-added labor and capital coefficients), p_T and p_{n+1} (international prices), X_T^0 (base-year output levels), C_H^0(home goods final consumption levels), L^0 and K^0 (labor and capital endowments), and δ (output change coefficient).

Step 2. The home goods inverse matrix $(I - A_{HH})^{-1}$ is computed.

Step 3. Equations (28) and (29) are used to compute Cobb-Douglas coefficients.

Step 4. Equations (7) and (A1) are used to compute the direct and indirect IVA coefficients (the $\hat{z}_j$).

Step 5. A vector, $\hat{C}_H$, of the direct and indirect home goods output requirements to meet the home goods final demands is computed:

$$\hat{C}_H = (I - A_{HH})^{-1} C_H^0.$$

Step 6. A vector $X_{T(\min)}$ of minimum output levels for international goods is computed as $X_{T(\min)} = (1 - \delta) X_T^0$, and a vector, D_T of differences between maximum and minimum levels as $D_T = 2\delta X_T^0$.

Step 7. An initial value for the wage/capital price ratio, $R = w/c$, is set. A convenient, but not necessary, initial value is $R = 1$, which corresponds to the base-year solution.[16]

Iterative Steps

Step 8. The equilibrium condition

$$-\frac{dK_j}{dL_j} = \frac{\alpha_j}{(1 - \alpha_j)} \frac{k_j}{\ell_j} = R \qquad (j=1, \ldots, n)$$

is invoked. Dividing (1) by X_j,

$$A\ell_j^{\alpha_j} k_j^{1-\alpha_j} = 1. \qquad (j=1, \ldots, n)$$

These equations are solved for

$$\ell_j = \left(\frac{\alpha_j}{(1-\alpha_j)}\right)^{1-\alpha_j} R^{\alpha_j - 1}/A \text{ and } k_j = \frac{(1-\alpha_j)}{\alpha_j}\ell_j R.$$

these labor and capital service per unit output coefficients are constants that correspond to cost minimization as long as R is constant.

Step 9. Equation (A7) is used to construct the vectors, $\hat{\ell}_T$ and $\hat{k}_T$, of direct and indirect labor and capital coefficients for international goods.

Step 10. The factor endowments are redefined as $\bar{L}^0$ and $\bar{K}^0$, which are net of the requirements for the minimum output levels for international goods, and the home goods output levels to meet the home goods final demands:

$$\bar{L}^0 = L^0 - \ell_T X_{T(\min)} - \ell_H \hat{C}_H^0$$
$$\bar{K}^0 = K^0 - \hat{k}_T X_{T(\min)} - k_H \hat{C}_H^0.$$

Step 11. The g_j coefficients as given by (22) are computed for each of the international goods with $w = R$ and $c = 1$ and are ranked from highest to lowest. Note that the ranking is invariant with respect to the choice of $w > 0$ as long as $w/c = R$.

Step 12. The vector D_T gives the maximum amounts by which the international goods outputs can be increased going from minimum to maximum levels. The output of the good with the highest g_j is increased until one factor service quantity becomes zero or until it reaches its maximum limit, whichever happens first. The factor service requirements are deducted from $\bar{L}^0$ and $\bar{K}^0$, and the process is repeated for the second highest g_j, the third highest, and so on until the residual quantity of one of the factor services becomes zero.

Step 13. If both residual factor service quantities become zero at the same time, the iterations are complete and computations shift to the final step. If the residual quantity of one is positive, another iteration is made beginning at step 8 for a new value of R. If capital is left over, R is increased to increase the capital/labor service ratio in every industry. If labor services are left over, R is decreased to decrease the capital/labor service ratios. For the present applications, the absolute value of the changes of R was $(0.1)\ (0.9)^I$, where I is the sequential number of the iteration.

Final Step

Step 14. An optimal solution has been obtained when the residual quantities of both factor services become zero. The reader may verify that constraints (14.5) through (14.10) are satisfied. Determination of optimal values for shadow prices and home goods output levels that satisfy (14.1) through (14.4) is straightforward.

Convergence

In fifteen of sixteen two-factor applications, convergence took place and was rapid. Some thirty-five iterations were required for South Korea 1970, with 118 sectors. Factor quantities less than 0.000001 were treated as zero. South Korea 1973 did not converge. The computations shifted back and forth between excess labor and excess capital services. Examination revealed that two sectors alternated being marginal, one corresponding to excess labor services and the other to excess capital services. An optimal solution was obtained by letting both sectors be marginal and adjusting their outputs so that both residual factor quantities became zero.

Notes

1. An alternative approach is provided by Vittorio Corbo and Patricio Meller, "The Substitution of Labor, Skill, and Capital: Its Implications for Trade and Employment," chapter 5 of this volume.

2. Input-output data often show international trade for service sectors that are treated as home goods. Such observed trade is included in the C_i^0, but no expansion or contraction of international trade in home goods is allowed.

3. These do not include home goods input requirements for the traded goods inputs necessary to produce the home goods final demands. Since international prices and input-output coefficients are both constants, these inputs have a fixed international value (see Appendix A) that is assumed to be deducted from maximal IVA before final consumption levels are determined for international goods.

4. Point D is near, but not on, the X_2 axis. For Cobb-Douglas transformation curves $-dX_2/dX_1 \rightarrow 0$ as $X_1 \rightarrow 0$, and $-dX_2/dX_1 \rightarrow -\infty$ as $X_2 \rightarrow 0$. Consequently, complete specialization would not occur in the absence of output constraints if $\hat{z}_1$ and $\hat{z}_2$ were both positive.

5. This follows from the existence of the nonoptimal interior solutions given by base-year observations.

6. This is not strictly true. In an unusual case all goods might be at limits. No such cases were encountered in the empirical applications. Consequently, the tedious explanation of how to handle such cases is omitted.

7. These are properties of optimal solutions for the model. Observed profits are often positive as a consequence of existing distortions for sectors for which the model indicates negative rents.

8. The applications include a few home goods sectors that use only one of the two factors. These are easily accommodated by omitting either (17) or (18).

9. It is assumed that $\hat{z}_j = 0$ for all marginal goods. This is the case for all of the applications described in section 1.5. If this assumption is not satisfied, a country can increase its total IVA by leaving some of both factors unemployed, and optimal factor prices are both zero.

10. A necessary condition for z_j to be negative is that r_j is positive, that is, the lower limit constraint on output j is binding.

11. See Johnson (1960).

12. Indirect covers the factor service quantities necessary to produce the home goods to support a unit of international good j. See Appendix A.

13. This measure is similar to DRC (domestic resource cost). See Krueger (1966).

14. There are two for South Korea for 1973.

15. Equation (28) follows because input-output data have base-year labor and capital prices equal to one. Consequently, ℓ_j (k_j) equals both the labor (capital) services used per unit of output and the expenditure upon labor (capital) per unit of output.

16. The Cobb-Douglas factor production functions are the only nonlinear element of the model. Once R is set, labor and capital service coefficients per unit output are determined, then the problem becomes one of solving a linear program. The iterative steps below exploit the particular properties of the present model to obtain linear programming solutions.

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