1992

An assessment of the likely impact of the liberalization of the Soviet economy on Soviet patterns of trade

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Order Number 9234827

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Iowa State University, 1992

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An assessment of the likely impact of the liberalization of the Soviet economy on Soviet patterns of trade

by

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A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major: Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1992

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1. INTRODUCTION

1.1 Background

The development of the centrally planned economic system in the Soviet Union[1] dates back to the late 1920s with the inauguration of the first Five-Year plan (1928-32). In this economic system, Gosplan (the state planning committee) and Gossnab (the state committee for material and technical supply) were responsible for allocating resources and determining the amount of goods to be produced by each sector of the economy. In the beginning of this period the Soviet economy experienced high growth rates, especially in the industrial sector. But the problems of central planning soon began to surface. One inherent problem of central planning for an economy as large as the Soviet economy is the lack of an efficient flow of information. Technological progress has not matched that of the Industrial Market Economies (IMEs) of the West. During the last two decades the Soviet economic growth

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[1]The term *Soviet Union* is used throughout this study since the model's base year is 1989, before the dissolution of the country. The use of Soviet Union or USSR thus refers to the former Soviet Union, with all 15 republics. See Figure 1.1 for a map of the country before the break-up.

Figure 1.1. The Soviet Union as of 1989, including all 15 republics
(U.S. CIA Handbook of Economic Statistics, 1991, p. 10)

rate has slowed, according to official Soviet data, U.S. Central Intelligence Agency (CIA) estimates, and Khanin/Selyunin estimates (Table 1.1). As a result, there is a need to reform the Soviet economy.

1.2 Economic Reform

For more than two decades it was apparent that reform of the Soviet economy was necessary. But it was not until Mikhail Gorbachev was appointed General Secretary of the Soviet Communist Party in March 1985, that serious consideration was given to reform. President Gorbachev initiated a program of economic and social change termed *perestroika*. Originally, the Soviet leadership intended to combine central planning with some elements of a market economy, thus moving the economy to a "mixed economy" or "market socialism." However, because of increased pressure for more economic reform the Soviets are now planning to completely decentralize their economy and adopt a market-based, western-style economic system.

Several important questions need to be addressed as a result of this impending liberalization plan. One such question is how the reform plan should be implemented? In what order should these economic reforms be introduced to achieve maximum economic efficiency? And how rapidly should the reform

Table 1.1. Economic growth in the Soviet Union, 1961-85 (average annual percentages)

Period	**Net Material Product**	**Gross National Product**	**Net Material Product**
	Soviet official statistics	U.S. CIA estimates	Khanin/Selyunin estimates
1961-65	6.5	4.8	4.3
1966-70	7.8	5.0	4.0
1971-75	5.7	3.1	3.2
1976-80	4.3	2.2	1.0
1981-85	3.6	1.8	0.6
1986-87	3.2	1.9	-

Source: Feinberg et. al., *U.S. Foreign Policy and the USSR, China, and India: Economic reform in three Giants.* Transaction Books, New Brunswick, 1990 pp. 47.

process proceed? Another question concerns the conversion of the ruble to a hard currency. In view of the multiple exchange rate problem, what will the equilibrium value of the ruble be after economic liberalization, and how can this rate be determined? Another concern is how economic liberalization will affect the Soviet Union's participation in world trade. In other words, what will Soviet trade patterns be after economic reforms have been fully implemented? This last question is the one that is answered in this study.

1.3 Soviet Foreign Trade under Central Planning

Under central planning, foreign trade is administered by several interconnected bureaucracies. The leadership of the Soviet Communist Party, which sets broad outlines of foreign trade policy, is at the top of this hierarchy. The Ministry of Foreign Trade (MFT), is the agency that actually conducts trade through its many Foreign Trade Organizations (FTOs), who are each responsible for a wide range of commodities. Some Soviet enterprises and cooperatives are now able to engage directly in foreign trade. However, trading of certain products has remained under the auspices of the FTOs. The Soviet Union is a major world trader, particularly within

Eastern Europe. In 1988 their exports were valued at US$110.7 billion while their imports were valued at US$107.3 billion.[2] However, 67 percent of 1988 Soviet exports went to Council for Mutual Economic Assistance (CMEA) countries, while only 22 percent went to capitalist industrialized countries for the same year (Hill 1989).

1.4 Statement of Problem

After economic liberalization, Soviet foreign trade will undergo fundamental changes because of the way it has been administered. The transition of the Soviet and East European economies from central planning to market economies is bound to "have large effects on the volume and patterns of international trade, particularly within Europe."[3]

Thus, the main objective in this study is to predict the trade patterns for the Soviet Union after a market economy has

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[2]U.S. Central Intelligence Agency, *Handbook of Economic Statistics*, (Washington D. C., U.S. Government Printing Press, 1990). The numbers are official Soviet statistics using U.S. dollar exchange rates for the Soviet foreign exchange ruble as announced by the state bank of the USSR.

[3]Quoted from Center for Economic Policy Research, *Monitoring European Integration: The Impact of Eastern Europe*, Cambridge University Press, London, 1990. - An annual report of the Center for Economic Policy Research, which examines the impact of economic reform of Eastern Europe and the Soviet Union on international trade.

developed. The study also examines how economic liberalization will influence Soviet agricultural trade patterns. This study is important because changes in Soviet trade patterns could affect world prices of some commodities, especially those of agricultural products. Currently the Soviet Union exports oil, energy products and imports grain, meat, and other agricultural products. Most of Soviet Union's import of grain and other agricultural products come from the United States. It is possible, however, that the Soviet Union will become a net exporter of some of these products.

There has been no economic theory developed that deal with the transition from a centrally planned to a market economy. The main theories in international trade are applicable mainly to industrial market economies. In attempting to predict the post-reform trade patterns in the Soviet Union, I use the Heckscher-Ohlin (HO) model, a standard international trade model that predicts trade patterns based solely on resource endowments. In all previous studies the HO model has been applied mostly to IMEs, and has focused on the validity of the model. Thus, in applying the HO model to a planned economy in transition, special attention is given to the severe distortions and disequilibria that have existed for several decades because of central planning.

1.5 Organization

Chapter 2 summarizes the theoretical model. The basic Heckscher-Ohlin model and its general extension are discussed briefly. The Heckscher-Ohlin-Vanek (HOV) equations, which are used to predict net trade, are derived in this chapter. Chapter 3 provides information on commodity and factor aggregation and data sources and methods of collection. Chapter 4 examines the results obtained from the HOV model and critically evaluates both the results and issues that arise from them. Chapter 5 predicts the post-reform Soviet agricultural trade patterns using a modified HOV model. Chapter 6 gives summaries and conclusions, and suggests implications for the future.

2. THEORETICAL MODEL

2.1 Introduction

There are no available models that are designed specifically to answer the question posed here because the transition from a centrally planned to a market economy is a new concept. This chapter reviews the Heckscher-Ohlin (HO) model because it is used to predict post-reform Soviet trade patterns. Section 2.2 examines general international trade theory. Section 2.3 reviews the basic HO model and also derives the Heckscher-Ohlin-Vanek (HOV) equations. Section 2.4 examines the validity of the HOV equations. Section 2.5 focuses on problems expected to be encountered in applying the HOV model to the Soviet economy. Section 2.6 is a summary of the chapter.

2.2 General International Trade Theory

International trade has existed for several centuries, but it was David Ricardo in 1821 who first developed a formal theory to explain trade patterns. The Ricardian trade model states that a country will export the good in which it has comparative advantage and import the good in which it has comparative disadvantage. The theory explains that, even if one country has absolute advantage (i.e., is more efficient) in producing both goods (in a two-good, two-country world), both countries can benefit by specializing in each of the goods and trading with each other. In this model, the main reason for trade is the differences in technology between countries. But the Ricardian model does not answer the question of why some countries have comparative advantage in some commodities.

A model to explain trade patterns using a different approach was presented initially by Eli Heckscher in 1919 and later developed by his student Bertil Ohlin in 1933. The Heckscher-Ohlin (HO) trade model, as it is known, was further modified by Paul Samuelson in 1948. The HO model is perhaps the most important theory in international trade today.

According to this model the only difference between nations is their relative factor endowments, which consequently is the only cause for trade. The HO trade model is important because it explains the differences in comparative advantage among countries. Its basic form is a general equilibrium model with two factors, two commodities, and two countries.

The model remained in this basic abstract form for quite a long time, since it was difficult to extend the model to a general many-factor, many-commodity, many-country world and test it empirically. However, after Leontief's (1953) empirical testing that challenged the results of the HO model, much of the focus of ensuing trade literature became empirical in nature, attempting to explain the Leontief paradox. One difficulty in testing the HO model is that trade, factor endowments, and technology data are required and are quite difficult to obtain.

The model also relies on seemingly restrictive assumptions, including the assumption that technology and preferences are identical across countries. Whether these and other assumptions hold in reality continues to be investigated and debated. The HO model has been applied mostly to market economies and not to centrally planned economies (CPEs). However, Rosefielde (1973) and Murrell (1981, 1982, 1990) have shown that the HO model, with some modifications, can also be applied to CPEs.

One recent criticism of the HO model is that it predicts net trade. Implicitly, this prediction implies that, for any country, either exports or imports are zero for any commodity. Recent international trade data, however, show that countries usually export and import different varieties of the same commodity. There is also the question of economies of scale and the size of a country. A country may enjoy economies of scale only because of its size, which can also make it infeasible for that country to produce certain commodities. Thus, a country's trade patterns can be attributed solely to its size, which is totally ignored by the HO model. The HO model does not deal with issues like the effects of multinational corporations and international arrangements on the patterns of trade.

Recent international trade literature has focused on finding new models that will consider some of these issues. Most work in this area has been concerned with finding models that will accommodate intra industry trade, product differentiation, and economies of scale. Perhaps the most important work in this effort is that of Helpman and Krugman (1985). The product differentiation and economies of scale (PE) model makes some assumptions similar to the HO model. But the PE model is different because it assumes that commodities come in many different varieties. The "love of variety approach"[1] states that individuals like to consume many varieties of commodities, so there is a demand for diversity in any economy. The PE model also assumes that each country engages in some amount of innovation so each country develops

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[1]This approach is used in Helpman and Krugman (1985). With this approach, preferences for variety are given by a utility function $U_i(D_{i1}, D_{i2}, \ldots)$, where $D_{i\omega}$ is the quantity of variety ω that is consumed of good i. This type of work is credited to Dixit and Stiglitz (1977).

its own new technology.

Thus, with product differentiation, the PE model predicts that a country can import and export the same commodity, a fundamental difference from the HO model. The main problem with the PE model is that it has not been developed to a point where it can undergo rigorous empirical testing. On the other hand, Vanek's (1968) contribution to the HO model has given it a concrete foundation for empirical use. The Heckscher-Ohlin-Vanek (HOV) equations give a unique relationship among trade, resource endowments, and technology, so this model is used to answer the questions proposed by this study.

2.3 The Heckscher-Ohlin Model

2.3.1 The Basic Heckscher-Ohlin Model

2.3.1.1 Introduction This section briefly introduces the basic Heckscher-Ohlin (HO) model and examines its underlying assumptions. Using a simple model with two commodities, two factors, and two countries, (a 2 x 2 x 2 model), the four theorems that make up the core of the model are derived. These theorems are the Rybczynski, Factor Price Equalization (FPE), Stolper-Samuelson (S-S), and the Heckscher-Ohlin (HO) theorems.

2.3.1.2 Assumptions and Basic Model The HO model uses the following assumptions:

1. Commodities can be transported internationally without any transportation cost or trade barriers;
2. Factors are perfectly mobile between domestic industries but internationally immobile;
3. There is perfect competition in both the commodity and factor markets;
4. The production functions are different among domestic industries and exhibit constant returns to scale (CRS);
5. There are identical production technologies across countries;
6. There is no specialization of commodities and no factor intensity reversal among industries.
7. All individuals have identical homothetic preferences.

To explain the HO model, we examine a simple model with two countries, A and B; two factors, capital (K) and labor (L); and two commodities, food (F) and manufactures (M). Let W be the wage rate and R the rental rate, and also let P_F and P_M be the output prices for food and manufactures respectively. Also, k = K/L, is the capital labor ratio. Let the production functions for producing goods F and M be

$$Q_F = F(K_F, L_F) ,$$

$$Q_M = M(K_M, L_M) .$$

Using the dual of the production function, the CRS assumption, and the perfect competition assumption, we have

$$MC_F = H(W, R) \geq P_F \tag{2.1}$$

and

$$MC_M = G(W, R) \geq P_M \tag{2.2}$$

where MC_F and MC_M are marginal cost for food and manufactures respectively, and H and G represent unknown functions. Then given output prices, both commodities are produced only with one set of factor prices. This is illustrated in Figure 2.1, where CXD, AXB, and EXF are the same as k_M, k_F and k, respectively. Hence in this diagram, industry M is more capital intensive. The points W^* and R^* are the set of factor prices for which both commodities are produced.

2.3.1.3 <u>Factor Price Equalization Theorem</u> The factor price equalization (FPE) theorem states that if there is incomplete specialization of goods, free trade will cause factor prices to be equalized across countries.

Assume both economies face the same nominal price vector. Then, Figure 2.1 is applicable to both countries and the only difference between them is their relative factor endowments. Then, if factor endowments for both countries lie in the same cone of diversification, i.e., if k^A and k^B are between k_M

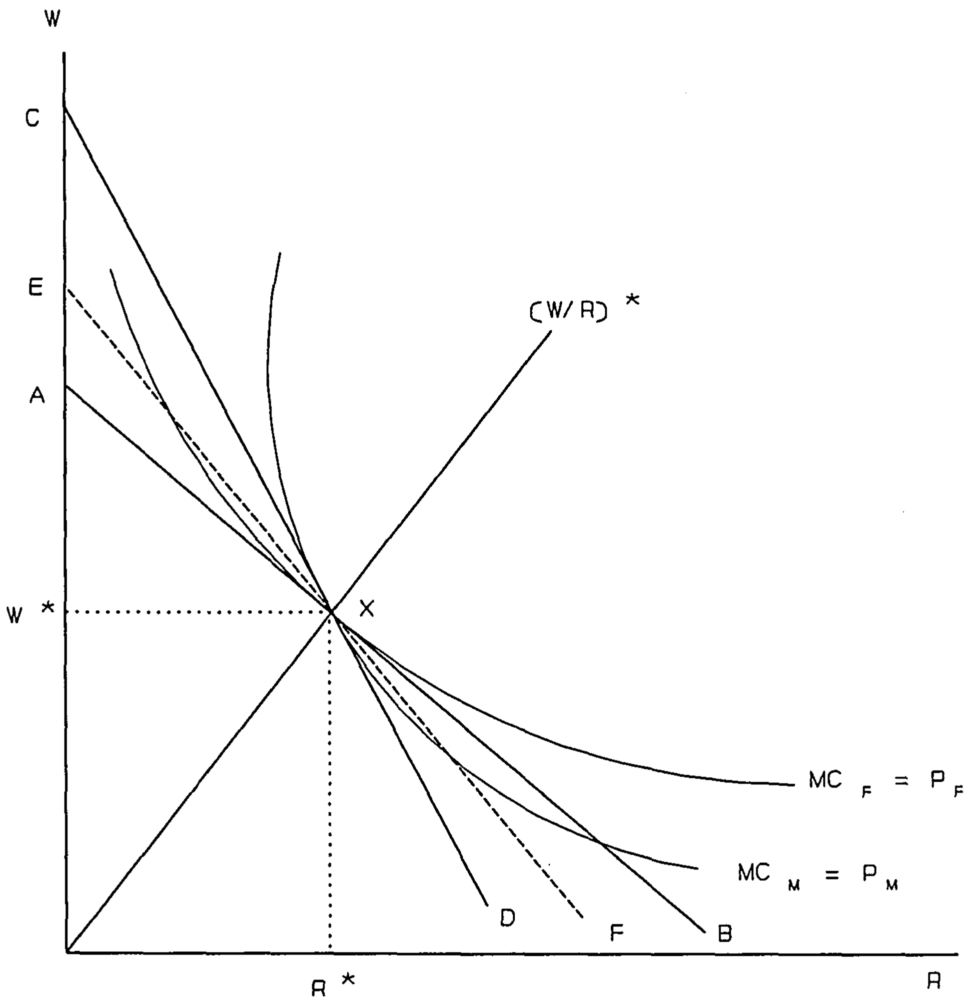

Figure 2.1. Optimal factor prices for both goods to be produced

(CXD) and k_F (AXB), then both goods will be produced and both countries will have the same optimal factor prices. Note that FPE will not be satisfied if factor endowments are not in the same cone of diversification, in which case there will be specialization in one of the commodities by at least one country.

2.3.1.4 Rybczynski Theorem The Rybczynski theorem states that an increase in the endowment of any factor, with commodity prices held constant, will result in an increase (decrease) in the output of the industry that uses the factor intensively (nonintensively).

Assuming all resources are utilized, the resource constraint will be given as

$$L_F + L_M = L$$
$$K_F + K_M = K.$$

Dividing through by L we can have

$$\alpha_F + \alpha_M = 1$$
$$\alpha_F k_F + \alpha_M k_M = k,$$

where $\alpha_F = L_F/L$ and $\alpha_M = L_M/L$. From these two equations we can have

$$\alpha_F k_F + (1-\alpha_F)\, k_M = k. \tag{2.3}$$

Assuming there is an increase in k, then since there is an increase in the right hand side (RHS) of Equation (2.3) α_F must change because k_M and k_F are fixed. Since $k_M > k_F$, α_F has to fall, which causes L_F to fall and L_M to rise. Since there are more of L_M and K_M available, the production of Q_M rises, so Q_F has to fall.

To examine the Rybczynski theorem graphically consider Figure 2.1. From Equation (2.3) we can solve for α_F in terms of k, k_F and k_M. Using this solution, α_F can be determined from Figure 2.1. Then we have

$$\alpha_F = \frac{k - k_M}{k_F - k_M} = \frac{EW^* - CW^*}{AW^* - CW^*} = \frac{CE}{CA}.$$

Similarly, α_M = EA/CA. If there is an increase in k, then the slope of EXF increases, which implies the distance CE reduces, i.e., α_F falls. The distance EA also increases which implies that α_M rises.

2.3.1.5 Stolper-Samuelson Theorem The Stolper-Samuelson (S-S) theorem states that an increase (decrease) in the relative price of some commodity (through some form of trade protection) will unambiguously raise (lower) the real return of the factor used intensively in the production of the good whose price has increased (decreased).

Taking total derivatives of Equations (2.1) and (2.2), we can have the following equations in matrix form

$$\begin{bmatrix} H_W & H_R \\ G_W & G_R \end{bmatrix} \begin{bmatrix} dW \\ dR \end{bmatrix} = \begin{bmatrix} dP_F \\ dP_M \end{bmatrix}. \qquad (2.4)$$

From Equation (2.4) we can have

$$\begin{bmatrix} \alpha_{HW} & \alpha_{HR} \\ \alpha_{GW} & \alpha_{GR} \end{bmatrix} \begin{bmatrix} \hat{W} \\ \hat{R} \end{bmatrix} = \begin{bmatrix} \hat{P}_F \\ \hat{P}_M \end{bmatrix},$$

where $\hat{P}_F = dP_F/P_F$, $\hat{P}_M = dP_M/P_M$, $\hat{W} = dW/W$, $\hat{R} = dR/R$ and $\alpha_{HW} = H_W W/P_F$, $\alpha_{HR} = H_R R/P_F$, $\alpha_{GW} = G_W W/P_M$, $\alpha_{GR} = G_R R/P_M$.
By the assumption of perfect competition we can have $\alpha_{HW} + \alpha_{HR} = 1$ and $\alpha_{GW} + \alpha_{GR} = 1$.

Solving for $\hat{W}$ and $\hat{R}$ gives

$$\begin{bmatrix} \hat{W} \\ \hat{R} \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} \alpha_{GR} & -\alpha_{HR} \\ -\alpha_{GW} & \alpha_{HW} \end{bmatrix} \begin{bmatrix} \hat{P}_F \\ \hat{P}_M \end{bmatrix},$$

where $\Delta = \alpha_{HW}\alpha_{GR} - \alpha_{GW}\alpha_{HR}$.

Since $\alpha_{GW} + \alpha_{GR} = 1$, it implies that $1/\Delta[\alpha_{GR} - \alpha_{HR}] = 1$. Then, since $k_M > k_F$, we have

$$\frac{\partial\left(\frac{W}{P_F}\right)}{\partial P_F} = \frac{1}{\Delta}(\alpha_{GR}) > 0 ,$$

which is precisely the S-S theorem. Note that in the two good, two factor world, the strong version of the S-S theorem is also its weak version.

The S-S theorem is illustrated by Figure 2.2, which shows that P_F^* increases to P_F^1, and because $k_M > k_F$, W^*, the reward of the labor intensive good, increases to W^1, and R^* decreases to R^1. Notice that the increase in W exceeds the increase in P_F, showing the strong form of the theorem.

2.3.1.6 <u>Heckscher-Ohlin Theorem</u> The Heckscher-Ohlin theorem states that a country will export the good which uses relatively intensively the factor which is relatively abundant in that country.

Assume without loss of generality that, country A is more capital abundant, (i.e., $k^A > k^B$). According to the HO theorem a country will export the commodity which is relatively cheaper in autarky. Thus, to show the HO theorem, it is sufficient to show the proposition which states that if country A is more capital abundant it implies that the capital intensive good, manufactures, will be cheaper in autarky in country A.

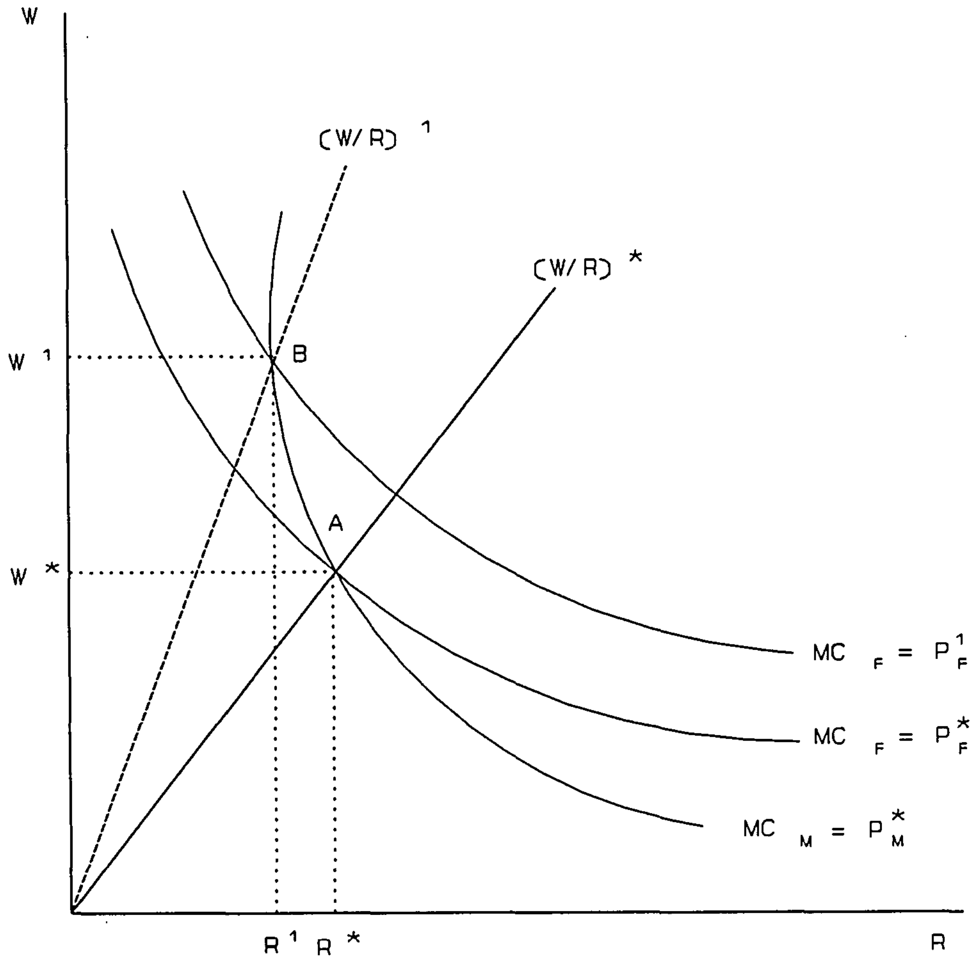

Figure 2.2. The Stolper-Samuelson theorem

Mathematically this proposition is stated as

Proposition 2.1

$$k^A > k^B \Rightarrow \frac{P_M^A}{P_F^A} < \frac{P_M^B}{P_F^B}$$

where P_j^i is the price of commodity j and country i, (j = M,F) and (i = A,B).

Suppose initially, that $k^A = k^B$. Then we have $P_M^A/P_F^A = P_M^B/P_F^B$ since the two countries are now the same in all aspects. Assume now there is an increase in k^A, (i.e., $k^A > k^B$). With prices held fixed, Q_M^A/Q_F^A will rise, according to the Rybczynski theorem. Since P_M^A/P_F^A is constant, this increase results in excess demand in Q_F^A and excess supply in Q_M^A, which cannot be an autarky equilibrium. To restore equilibrium P_M^A/P_F^A has to fall, which shows proposition 2.1.

Figure 2.3 illustrates the HO theorem. At A^o there is autarky equilibrium and P_o is the original relative price vector. After the increase in k^A, production moves to C and demand to Z^1, showing the excess demand of Q_F^A as BZ^1 and the excess supply of Q_M^A as CB. The final price vector is shown as P_1. Utilities U^o and U^1 are the respective utilities before and after the increase in capital endowment, under the original price vector.

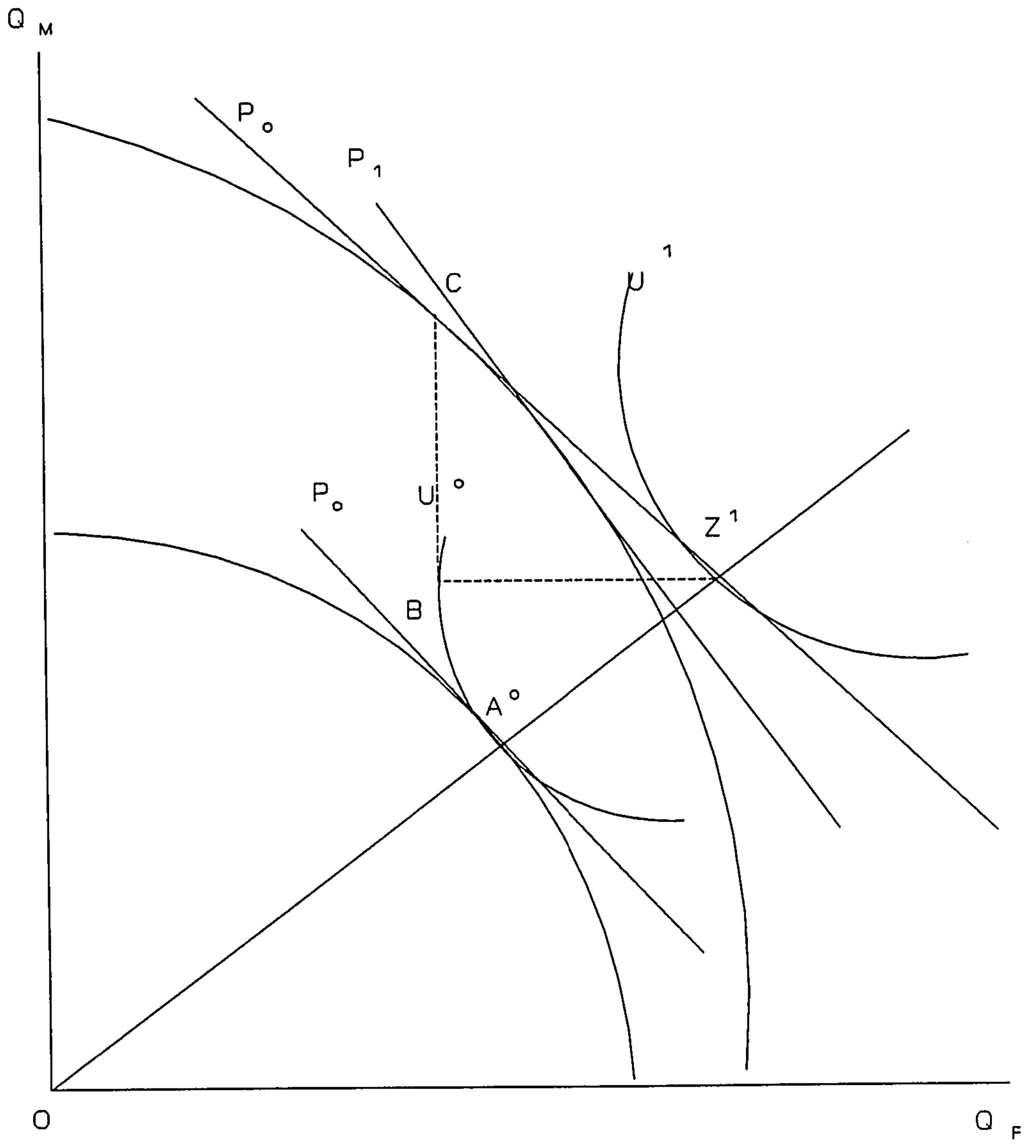

Figure 2.3. The Heckscher-Ohlin theorem

2.3.2 Extension of HO Model

A considerable number of papers have focused on the generalization of the HO model. Ethier (1984) is one of the papers that examines this issue in great detail. He shows that, when there are more goods than factors the FPE theorem can generalize to higher dimension without much difficulty. When there are more goods than factors, $(m > n)$, there may be specialization, since each country produces a subset of the total number of goods. Let r be the number of goods produced by all the countries, then the FPE theorem is satisfied if $r \geq n$. Thus if $n = m$ (the "even" case), FPE is satisfied if all goods are produced. If there are more factors than goods $(n > m)$, then for the theorem to be valid, factor prices have to be determined solely from post trade goods prices; however, this constitutes solving for n unknowns from m equations, which is impossible since $n > m$. Factor prices are determined from other information, and so the FPE theorem does not hold when the number of factors exceeds the number of goods.

The S-S theorem can be extended to a general, many-good many-factor world if $m \geq n$. There might be some difficulty if there is specialization in a subset of the commodities. In this case if the prices of some non-produced goods rise relative to produced goods and some fall, some factor rewards could rise relative to some goods and fall relative to others. The theorem runs into severe difficulty when $n > m$. When there are more factors than goods, changes in factor prices cannot be determined solely by changes in commodity prices. Thus, the S-S theorem cannot be satisfied when there are more factors than goods.

The Rybczynski theorem can be extended to a multifactor, multicommodity world when $n \geq m$. When there are more goods than factors, then a solution of the output vector will constitute solving n equations and m unknowns $(m > n)$. Output is indeterminate and a change in some factor endowment still leaves output indeterminate. Thus, the Rybczynski theorem will not hold when $m > n$.

Other papers that also examine the extension of the HO model include Jones and Scheinkman (1977), Diewert and Woodland (1977), Ethier (1974), Chang (1979), and Deardorff (1982).

There exist a dual relationship between the S-S and Rybczynski theorems that is based on the reciprocity relation, which is

$$\frac{\partial Q_j}{\partial V_i} = \frac{\partial W_i}{\partial P_j},$$

where Q and V are output and factor endowment, respectively, and W and P are factor and output prices.

2.3.3 Extension of HO Theorem

Deardorff (1979) looks at the HO theorem in a situation with several goods. Using the idea of chain proposition, he ranks the goods in order of factor intensities. If there is free trade, the patterns of trade are consistent with factor intensity ranking if $n \geq m$. Thus, the capital-abundant country exports goods with high capital intensity ranking, which is consistent with the HO theorem. But if there are trade impediments, like tariffs, the patterns of trade can be reversed and then will no longer be consistent with the HO theorem. Ethier (1984) writes that, in this case, if factor prices are not equalized, then "commodity trade flows are indeterminate and cannot be predicted by any theory." Jones and Scheinkman (1977) also discuss the extension of the HO theorem.

According to Vanek (1968), when there are more than two factors there is no unique ordering of technologies according to relative factor intensity. Because of this problem Vanek (1968) writes that "the usual way of stating the Heckscher-Ohlin theorem involves relative factor-endowments on the one hand and relative factor-intensities on the other; and it is the latter that causes all the trouble when more than two factors are considered." Several papers have expressed doubts about the generalization of the commodity version of the HO theorem. For example, Deardorff (1982) states that "despite several attempts to extend it, the Heckscher-Ohlin theorem in its traditional form is valid only in the highly abstract environment of two factors, two goods and two countries."

Rigorous empirical testing of the HO theorem intensified after Leontief's (1953) results that questioned its validity. Vanek (1968) restated the HO theorem for the case of two factors, in which he referred to amounts of factor services embodied in the goods traded rather than the products themselves. Leamer (1980) critically examined the Leontief paradox using Vanek's modified version of the HO theorem, the Heckscher-Ohlin-Vanek (HOV) theorem, and claimed to have resolved the paradox. The generalization of the HOV theorem has become the basis of most empirical work in international trade.

2.3.4 Derivation of the HOV Equations

Denote outputs by

$$Q = (Q_1, \cdots, Q_s, Q_{s+1}, \cdots, Q_m),$$

where $Q_1, \ldots, Q_s$ are intermediate goods and $Q_{s+1}, \ldots, Q_m$ are final goods. To simplify the notation, let $Q_i = X_i$, $i = 1, \ldots, s$ and $Q_i = \bar{Q}_i$, $i = s+1, \ldots, m$. Let the production technologies for producing intermediate and final goods be defined as

$$X_j = F_j(V_{1j},\cdots,V_{nj}), \quad j = 1,\ldots,s$$

$$\overline{Q}_j = G_j(V_{1j},\cdots,V_{nj},X_{1j},\cdots,X_{sj}) \quad j=s+1,\ldots,m.$$

Assume that the production functions are quasi-concave and also exhibit constant returns to scale. Let a_{ij} be the amount of factor i (direct and indirect) used in producing a unit of good j. Let $W = (W_1,\ldots,W_n)^t$ be the vector of factor prices, where the superscript t refers to the transpose of the vector W. For efficient production each firm producing an intermediate good will

$$\begin{array}{lll} \textit{minimize} & \sum_{i=1}^{n} V_{ij}W_i & \\ \textit{subject to} & F_j(V_{1j},\cdots,V_{nj}) \geq X_j & j = 1,\ldots,s. \end{array}$$

Similarly, for efficient production of final goods each firm will

$$\begin{array}{lll} \textit{minimize} & \sum_{i=1}^{n} V_{ij}W_i + \sum_{i=1}^{s} X_{ij}\overline{P}_i & \\ \textit{subject to} & G_j(V_{1j},\cdots,V_{nj},X_{1j},\cdots,X_{sj}) \geq \overline{Q}_j & j = s+1,\ldots,m, \end{array}$$

where $\overline{P}$ is the price vector of intermediate goods. The solutions of these optimization problems result in the factor demand functions for intermediate and final goods.

The cost function for producing an intermediate good j can be defined as

$$\Phi_j(W,X_j) = \min_{V_{ij}} \left(\sum_{i=1}^{n} V_{ij}W_i \mid F_j(V_{1j},\cdots,V_{nj}) \geq X_j \right) \qquad j = 1,\ldots,s,$$

and the cost function for producing a final good j is defined as

$$C_j(W,\overline{P},\overline{Q}_j) = \min_{V_{ij},X_{ij}} \left(\sum_{i=1}^{n} V_{ij}W_i + \sum_{i=1}^{s} X_{ij}\overline{P}_i \mid G_j(V_{1j},\cdots,V_{nj},X_{1j},\cdots,X_{sj}) \geq \overline{Q}_j \right)$$
$$j = s+1,\ldots,m.$$

By assuming constant returns to scale, the cost functions can be written as

$$\Phi_j(W,X_j) = X_j\Phi_j(W), \qquad j = 1,\ldots s$$

$$C_j(W,\overline{P},\overline{Q}_j) = \overline{Q}_j C_j(W,\overline{P}), \quad j = s+1,\ldots m.$$

Using the assumption of perfect competition, we have the constraints

$$\Phi(W) \geq \overline{P},$$

$$C(W,\overline{P}) \geq P.$$

If all factors are fully utilized we can have the full employment equations as

$$\begin{bmatrix} \frac{\partial \Phi}{\partial W} & \frac{\partial C}{\partial W} \\ 0 & \frac{\partial C}{\partial \overline{P}} \end{bmatrix} \begin{bmatrix} X \\ \overline{Q} \end{bmatrix} = \begin{bmatrix} V \\ X \end{bmatrix}.$$

If all goods are produced the zero-profit condition can be written as

$$\sum_{i=1}^{n} W_i \frac{\partial \Phi_j}{\partial W_i} = \overline{P}_j \qquad j = 1,\ldots,s,$$

$$\sum_{i=1}^{n} W_i \frac{\partial C_j}{\partial W_i} + \sum_{i=1}^{s} \overline{P}_i \frac{\partial C_j}{\partial \overline{P}_i} = P_j \qquad j = s+1,\ldots,m.$$

Define A as an (n x m) matrix of total factor input intensities, V as an (n x 1) matrix of primary factor endowments and Q as an (m x 1) matrix of final and intermediate goods. Then, we have

$$A = \begin{bmatrix} \frac{\partial \Phi}{\partial W} & \frac{\partial C}{\partial W} \end{bmatrix} \quad and \quad Q = \begin{bmatrix} X \\ \overline{Q} \end{bmatrix}.$$

Then, the full employment condition can be written as

$$AQ = V, \tag{2.5}$$

and similarly the zero-profit condition can be written as

$$W^t A = P^t. \tag{2.6}$$

Define V_w as the total world factor endowment vector and also define Q_w as the total world production. By linearity of Equation (2.5) and the fact that the A matrix is the same everywhere (FPE is satisfied), the total world factor endowment can be written as a function of world output:

$$AQ_w = V_w. \tag{2.7}$$

Since output prices are the same for all countries (derived from assumption 7) it is implied that each country consumes commodities in the same proportions. Hence, we have

$$C = sQ_w, \tag{2.8}$$

where

C = country's consumption vector

and s = country's consumption share of world output.

Suppose there is trade balance, then the value of production must be the same as the value of consumption; i.e., $P^tQ = P^tC = sP^tQ_w$. Hence the value of s is given as

$$s = \frac{P^t Q}{P^t Q_w} = \frac{Y}{Y_w}$$

where Y = country's GNP,

Y_w = world's GNP.

Define T as an (m x 1) vector of net exports. Then if $T_i > 0$, it implies that the country is a net exporter of good i and similarly if $T_i < 0$ then the country is a net importer of good i. Define the net export vector as the difference between production and consumption. Then

$$T = Q - C.$$

Replacing C by Equation (2.8) and multiplying through by A, gives

$$AT = AQ - sAQ_w.$$

Using Equations (2.5) and (2.7), gives

$$AT = V - sV_w. \tag{2.9}$$

Assuming m = n (the even model) and det(A) ≠ 0 (A is invertible), we can have

$$T = A^{-1}(V - sV_w) . \tag{2.10}$$

Equations (2.9) and (2.10) are known as the HOV equations. These equations are a set of relationships among factor intensities A, trade T, and excess factor endowment supplies $(V - sV_w)$. Most empirical studies in international trade have used measures of two of these sets of variables and have inferred the third. Leontief's (1953) pioneering work on testing of the HO theorem, takes measures of trade T, and factor intensities A, and from these he estimates the excess factor abundance vector $(V - sV_w)$. Baldwin (1971), in his cross section regression studies, also takes measures of A, and T, and infers $(V - sV_w)$. The well-known Leamer (1984) test takes measures of trade T, and factor endowment V, and estimates A^{-1} (inverse of the factor intensity matrix). Bowen, Leamer, and Sveikauskas (1987) use measures of all three sets of variables in their test.

2.4 Validity of the HOV Equations

2.4.1 Introduction

Almost all the empirical studies in this area have focused on the validity of the HOV equations. The question of the validity of the HOV equations has not been answered satisfactorily. Most of the papers in this area have been inconclusive so some of this work is discussed here.

2.4.2 Leamer (1984)

The most extensive and thorough tests of the HOV equations have been conducted by Leamer (1984). He uses a reduced form version of Equation (2.10) to conduct his analysis. Leamer bases his test on a large database compiled for 61 countries for 1958 and 1975. Ten commodity aggregates are formed from two and three Standard Industrial Trade Classification (SITC) commodity classes.

Two methods of aggregation are used. The first uses an algorithm based on the correlation matrix alone. In the second, net export data are regressed on a list of resources, and commodities are then aggregated to have similar regression coefficients. The outputs of these two methods, together with some amount of "fiddling," are used to obtain the ten commodity aggregates. These aggregates contain two primary products (petroleum and raw material), four agricultural products (forest products, tropical agriculture, animal products, and cereals), and four manufactured products (labor intensive, capital intensive, machinery and chemicals). Eleven different types of factors are used. These are capital, three types of labor (professional/technical, nonprofessional skilled, and unskilled), four types of land based on climate, and three aggregates for natural resources (coal, minerals, and oil).

The maintained hypothesis he uses is the even model (m = n) so the HOV equations are written as

$$T_j = \sum_{i=1}^{m} \beta_{ji}(V_i - sV_{w_i}) \qquad j = 1,2,\ldots,m,$$

where β_{ji} is an element of A^{-1} and all other variables are the same as were defined previously. Note that this is the same as Equation (2.10) in matrix form. Thus, the cross-country regression of net exports on excess factor supplies provide estimates for A^{-1}.

Instead of this test Leamer substitutes the hypothesis that T is a linear function of V, which is the test that is actually performed. He fits the following equations:

$$Y = \alpha V + U_1$$

$$T_j = \beta_j V + U_2, \qquad j = 1,2,\ldots,m.$$

where α is an estimate of the factor return vector W and β_j is an estimate of a vector in the inverse of the reduced form of the A matrix. U_1 and U_2 are stochastic error terms.

In the absence of alternative models, the best that can be done is to measure the accuracy of the maintained hypothesis. R^2 values for both 1958 and 1975 are quite high. Comparatively, the R^2 values are higher for 1958 than are for 1975. In 1958 eight of the ten aggregates have R^2 values greater than 0.8, with the lowest being 0.55. In 1975, four aggregates have R^2 values greater that 0.8. Machinery, raw material, and tropical agriculture have the three highest R^2 values for 1958, with these values being 0.97, 0.9, and 0.9, respectively. In 1975 petroleum has the highest R^2 value, 0.92, with raw material, cereals, and capital intensive all second with R^2 values of 0.8 each.

In conclusion Leamer writes that "there is a surprisingly good explanation of the main features of the trade data in terms of a relatively brief list of resource endowments." He further states that "there are apparent problems with measuring some of the resources, and there is some evidence of nonlinearities, but overall the simple linear model does an excellent job. It explains a large amount of the variability of net exports across countries."

About the HOV model in general he says, "though we can reject at the outset the HOV model as a complete description of reality, an empirical examination of the HOV proposition can nonetheless be fruitful if it focuses on the hypothesis that the HOV model is a sufficiently close approximation to reality that it can be useful for forecasting, for policy analysis, or for some other purpose."

2.4.3 Bowen, Leamer, and Sveikauskas (1987)

Another important study that tests the validity of the HOV model is Bowen, Leamer, and Sveikauskas (1987). In this study, the authors use measures of trade T, factor input requirements A, and factor endowments V. They use Equation (2.9) as the testable hypothesis. This analysis uses total factor input requirements, which are calculated from the 367-order U.S. input-output table for 1967. They also use 1966 supply of 12 resources from 27 countries and 1967 trade data for the 27 countries, which are obtained at four and five-digit SITC commodity classes. The 12 resources used are capital, total labor, the seven International Standard Classification of Occupations (ISCO) labor classes, and the three Food and Agricultural Organization (FAO) land classifications.

Unlike Leamer (1984), this study formulates alternative models. The authors test the null hypothesis that the HOV equations are exact against several alternative hypotheses, which are different combinations of considering one or more of the following: measurement errors in trade and endowments, and incomplete coverage of countries, nonproportional consumption, and technological differences. Ten alternative models are formulated. To determine whether or not to reject the null hypothesis, the authors form indexes based on the maximized value of the likelihood function associated with the most general model.

They define

$$L = (ESS)^{-(NK/2)}$$

where ESS is the error sum-of-squares (summed over countries and factors), and NK is the total number of observations. They use the asymptotic Bayes' formula[2]

$$L^{*} = L(NK)^{-(\rho/2)}$$

where ρ is the number of parameters under a given hypothesis. They form the ratio

$$\Lambda = \frac{L_j^*}{L_i^*},$$

where j = alternative hypothesis and i = null hypothesis. If $\Lambda > 1$, evidence is said to favor the alternative hypothesis. The alternative model most favored allows neutral differences in factor input matrices, biased measurements of factor

[2]This formula is proposed in the context of regression by Leamer (1978 p.113) and more generally by Schwartz (1978).

contents, and multiplicative errors in the endowments, but maintains the assumption of identical homothetic test and complete coverage of countries.

They conclude that the hypothesis that HOV equations are exact was not supported by the data. The data suggest measurement errors in both trade and factor endowments, and favor the alternative hypothesis of neutral technological differences across countries. Further, they examine the alternative model, which is most favored, and the assumption made about technology. They assume that input matrices differ by a proportional constant. This can be written as

$$A_{US} = \delta_i A_i ,$$

where $\delta_i > 0$ and $\delta_{us} = 1$.

The hypothesis that technology in other countries is the same as that in the U.S. ($\delta_i = 1$) is rejected for all but three countries. Eight countries have negative δ values, which does not make sense. Several countries also have δ values far in excess of 1, implying that their factors are more productive than that of the United States. Because of this problem Bowen, Leamer, and Sveikauskas state that "the HOV model does poorly, but we do not have anything that does better".

2.4.4 Other Papers

Maskus (1985) tests the HOV model by relating the labor and capital contents of U.S. net exports to measures of U.S. and world endowments of these factors for 1958 and 1972. He concludes that "the HOV theorem is inconsistent with available data on factor endowments, factor intensities, and trade, at least for the U.S." He agrees that, while factor endowments across countries play an important role in the determination of trade patterns, "the HOV assumptions are simply too restrictive to hold in an empirical context."

Another paper that examines this issue is Brecher and Choudhri (1989). They develop and test a two-country version of the HOV model. The U.S. and Canada are chosen, since according to the authors, these two countries may reasonably satisfy (approximately) the assumptions of the model. They conclude that the data do not satisfy the two-country version of the HOV model.

Harkness (1978) is an important study which tests the HOV equations. Using 18 factors, Harkness develops relative factor abundances for the U.S. for 1958. He concludes that the data are consistent with the HOV model.

There have been several other important tests of the validity of the HOV equations, including Harkness (1983) and Sveikauskas (1983).

2.4.5 Conclusion

It is evident from this literature review that the validity of the HOV model has not been satisfactorily resolved. But, as several of the papers point out, the wide diversity of the results has been partly due to methodology and to the data that were used. One issue that is reexamined is how much the types of factors used affect the results. For example, some of the differences in the types of factors used (especially in land and labor) in Leamer (1984) and Bowen, Leamer, and Sveikauskas (1987) could account for some of the differences in the findings. But, according to Bowen, Leamer, and Sveikauskas (1987), even though the HOV equations are not exact, it is the best available theory to explain the patterns of trade. For this reason it is justifiable to use the HOV model for this analysis.

2.5 Applying the HOV Model to the Soviet Economy

2.5.1 Introduction

The HOV equations assume cost minimization, however market economy has not yet materialized in the Soviet Union. Thus the HOV equations cannot be applied to the Soviet Union without first addressing some of the questions on distortions and disequilibrium caused by central planning.

2.5.2 Technology Matrix

The most important question is the appropriate technology matrix to use for this analysis. It should be emphasized that, according to the theory, the elements of the A matrix imply cost minimization. However, currently available data for Soviet input/output matrix have been collected under central planning. The data for Soviet technology matrix are determined by the central planners, and so do not reflect market economic efficiency. Because of this it is inappropriate to use the current Soviet I/O matrix for this analysis, considering the objective of this study.

My goal is to be able to find reasonable estimates of the technology matrix that will exist in the Soviet Union after its economy is liberalized. But it is impossible to find such estimates for the Soviet Union where central planning has existed for several decades. One way to resolve this problem is to use the technology matrix of a country that already has a well-developed market economy. The U.S. is an industrialized market economy of comparable size to the Soviet Union. If U.S. technology data are used, it changes the original objective slightly. The goal is then to predict the patterns of trade for the Soviet Union, when the technology available after economic liberalization becomes equivalent to that of the U.S. for the particular year chosen. Using the U.S. input/output matrix also assumes that both the U.S. and the USSR have the same factor and output price structure.

2.5.3 Factor Endowments and GNP

The data for the factor endowment vector are complied from what is currently available in the Soviet Union. The available resource endowments are not affected by the distortions that exist in the centrally planned economy since Soviet prices are not being used. Because of problems with the accuracy of Soviet data, sensitivity analyses are conducted for capital and labor.

The value of Soviet GNP is also important to this study because it is used to determine the value of s, the Soviet consumption share of world output.

2.6 Summary

This chapter examined the theoretical model that is the basis for the analyses that follow. The HO model has been introduced and the HOV equations examined. The question of the validity of the HOV model has not been satisfactorily resolved, but it is agreed by international economists that it is the best currently available theory to explain the patterns of trade. The PE model has not been developed to the point where it could be rigorously tested empirically. Some of the problems that exist in applying the theory to a centrally planned economy and ways of resolving these problems were also examined.

3. AGGREGATION PROCEDURE AND DATA

3.1 Introduction

This chapter describes the aggregation procedure, gives the sources of the data collected and explains the processes by which the data were transformed to conform to the model requirements. Section 3.2 explains how commodities and factors were aggregated. Section 3.3 gives the sources of the technology matrix data and explains how they were calculated. Section 3.4 provides Soviet data and an explanation of how the data were made to conform with international classifications. Section 3.5 gives data for the 45 countries that are used to represent the rest of the world. Section 3.6 is a summary of the chapter.

3.2 Aggregation Procedure

3.2.1 Commodity Aggregates

To derive commodity aggregates, I followed Leamer (1984). Leamer's ten aggregates were formed using two-and three-digit Standard Industrial Trade Classification (SITC) codes. Since

16 aggregates are formed in this model, a perfect match with Leamer's aggregates could not be achieved. However the 16 aggregates are formed as close to Leamer's as possible.

Commodity correlations in Leamer's aggregates were examined carefully to see which commodities were not well correlated with the aggregate group to which they belonged, and thus could be removed from the aggregates. New aggregates were formed with these commodities and those that made up large proportions of their aggregates. These 16 commodity aggregates were formed according to SITC codes. However, the input-output table from which the technology matrix (total input requirement matrix) is calculated is according to Standard Industrial Classification (SIC) codes. Thus, one difficulty in aggregating commodities is that while using SIC codes, they must be aggregated to conform as closely as possible to the SITC categories because trade data are reported by SITC codes. Leamer (1984) has carefully aggregated commodities so those in each aggregate are most likely to be all exported or all imported. With this goal in mind, the SIC industries are aggregated to be closely in line with the 16 SITC aggregates. A summary of the commodity aggregates are given in Table 3.1. The details of the types of industries in each commodity aggregate may be found in Table A.1.

Table 3.1. Commodity aggregates

Commodity Aggregate Number		Commodity Aggregate Name	Variable Name
	A.	**Primary Products**	
1.		Petroleum products	PETRO
2.		Ferroalloy products, etc.	FERRO
3.		Nonferrous metallic products	METAL
4.		Other mineral products	MINE
	B.	**Agricultural Products**	
5.		Forest products	FORE
6.		Meat and animal products	MEAT
7.		Fish and fish products	FISH
8.		Cereals, cotton, etc.	CEREA
9.		Fruit, vegetable, etc.	FRUIT
10.		Other foods and beverages	BEVER
	C.	**Manufactures**	
11.		Textile and leather products	TEXTI
12.		Labor-intensive products	LABIN
13.		Chemical products	CHEM
14.		Primary machinery	PMACH
15.		Secondary machinery	SMACH
16.		Capital-intensive products	CAPIN

3.2.2 Factor Aggregates

The factor aggregates have four main categories: capital, labor, land, and natural resources. The labor categories are actually those defined at the one-digit level of the International Standard Classification of Occupations (ISCO). Details of the one-and two-digit level ISCO codes are available in Table A.2. The three land definitions are those used by the Food and Agricultural Organization (FAO). Natural resources have five categories that are derived from the 367-order U.S. input-output table for 1967 from I/O sectors 5.00-10.00. Factor aggregates are summarized in Table 3.2.

3.3 Technology Matrix

The data for the technology matrix used for this model are the 1967 U.S. total (direct and indirect) input requirements.[1] The total input requirements are calculated from direct input requirements and the 367-order U.S. input-output table for 1967. These calculations are explained in Sveikauskas (1984). A brief summary of how the total input requirements were calculated is given here.

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[1]I express sincere appreciation to Professor Harry Bowen for providing me with the U.S. total input requirements for 1967 and the entire 1967 367-order U.S. input-output table.

Table 3.2. Factor aggregates

Factor Aggregate Number		Factor Aggregate Name	Variable Name
	A.	**Capital**	
1.		Capital	CAPIT
	B.	**Labor**	
2.		Professional/technical workers	PROF
3.		Managerial workers	MANAG
4.		Clerical workers	CLERK
5.		Sales workers	SALES
6.		Service workers	SERV
7.		Agricultural workers	AGRIC
8.		Production workers	PROD
	C.	**Land**	
9.		Arable land	ARABL
10.		Pasture land	PASTR
11.		Forest land	FORST
	D.	**Natural Resources**	
12.		Crude oil	OIL
13.		Coal	COAL
14.		Ferroalloys	FALOY
15.		Nonferrous	NFER
16.		Fertilizer and other minerals	OTMNE

To derive the direct labor requirements, Sveikauskas (1984) used data from the 1970 Census of Population and 1971 Survey on Occupational Employment. The total number of workers needed in an industry were given, together with the percentages for each labor category. Thus, the total number of workers was multiplied by the appropriate percentage to get the number of (direct) workers in each labor category for each industry. To derive the direct capital requirements, he divided the 1967 net capital stock for each industry by 1967 gross output.

Sveikauskas then calculated the total input requirements from the direct requirements through a standard input-output table procedure. Using the Leontief input-output terminology, the amount of total output required to sustain a given final demand is given by

$$X = (I - B)^{-1} C, \qquad (3.1)$$

where

I = an (n x n) identity matrix;

B = an (n x n) matrix where each element b_{ij} indicates the amount of output industry j must buy from industry i to produce one dollar's worth of its own product;

X = an (n x 1) matrix of total output;

C = an (n x 1) matrix of final demand; and

$(I - B)^{-1}$ = the Leontief inverse matrix.

Let R be an (m x n) matrix of direct factor requirements. The technology matrix can be derived from the formula

$$A = R(I - B)^{-1}. \tag{3.2}$$

The matrix A, with dimensions m and n is the total input requirements for capital and labor, with m as the number of commodities and n the number of factors.

The labor categories were classified according to ISCO's first (1958) edition, which had nine categories. Thus, the labor category were reclassified to conform to the ISCO second (1968) edition. The subcategories of craftsmen, operatives, and laborers were aggregated to form the production workers category.

The total input requirements for land were taken directly from the total requirements for detailed industries; Input-Output Structure of the U.S. Economy, Volume 3, 1967. Input/Output (I/O) sectors 1.01-1.03 were used for pasture land, 2.01-2.07 were used for arable land and 3.00 was used for forest land.

The total input requirements for natural resources were determined directly from the total requirements for detailed industries; Input-Output Structure of the U.S. economy, Volume 3, 1967. The I/O sectors used for natural resources are 5.00-

10.00. OIL is taken from I/O sector 8.00, COAL from 7.00, FALOY from 5.00, NFER from 6.01 and 6.02, and OTMNE from 9.00 and 10.00.

The total input requirements were then aggregated to conform with the commodity aggregates. This aggregation was achieved by taking weighted averages of all the industries in each aggregate. The weights used were gross outputs for each industry (I/O sector), from the transaction data for detailed industries; Input-Output Structure of the U.S. economy, Volume 1, 1967. Sector 99.03 was used as total output. The units of the technology matrix data are: capital, land, and natural resources - value (in U.S. dollar terms) required per million dollars of output; and labor, - the number of workers required per million dollars of output.

3.4 Soviet Factor Endowments

3.4.1 Introduction

The most important aspect of this project is the data collection for Soviet factor endowments. Data for Soviet resources are collected from three main sources. Data for capital, labor, and land are collected from official Soviet Statistical Yearbook (SSY) *(Narodnoye Khoziaistvo, 1989)*. Data for Soviet natural resources are collected from U.S. Central

Intelligence Agency's (CIA's) *Handbook of Economic Statistics* and the *Mineral Yearbook* produced by the Bureau of Mines, U.S. Department of Interior. All the data in SSY are not given according to United Nations classifications, the form required by the model. So, all the data from this source are reclassified. Data for Soviet labor and land are reclassified according to ISCO codes and FAO land classifications, respectively. Several tables taken directly from the SSY are used to construct the data for capital, labor, and land.

3.4.2 Soviet Capital

According to Soviet methodology, capital is one of the components of national wealth. It is determined as the sum of three components: fixed assets, residential (household) assets and current material assets. Fixed assets are further subdivided into productive and nonproductive assets. The SSY contains data on national wealth and fixed assets. Table 3.3 gives the structure of fixed production assets in Soviet industry by type of asset. Table 3.4 gives the structure of fixed production in Soviet agriculture by type of asset.

The capital used as a factor in the technology matrix is an aggregate of equipment, plants, and inventories. Thus the total of these subdivisions determines 1989 Soviet capital stock. To arrive at the figures for these subaggregates, Tables 3.3 and 3.4 are used. For each of the three

Table 3.3. Structure of fixed production assets in Soviet industry for 1989, by type of asset

Asset Type	Amount[a]	Percent[b]
Buildings	245.8	26.7
Structures	182.3	19.8
Conveying equipment	94.8	10.3
Machinery and equipment, Total	365.0	39.6
Power machinery and equipment	68.1	7.4
Operative machinery and equipment	267.9	29.1
Laboratory tools, etc.	16.6	1.8
Computer and data processing equip.	12.9	1.4
Transportation equipment	22.1	2.4
Miscellaneous	10.1	1.1
TOTAL	**920.5**	**100.0**

Source: Narodnoye Khoziaistvo SSSR V 1989 godu Moscow, 1990 pp. 350, 351, 347.

[a]In billion rubles.
[b]Of total fixed production in industry.

Table 3.4. Fixed production assets in Soviet agriculture[a] for 1989, by type of asset

Asset Type	Amount[b]	Percent[c]
Building and construction	235.6	64.9
Machinery and equipment, Total	59.2	16.3
Power machinery and equipment	23.6	6.5
Operating machinery and equipment	33.4	9.2
Transportation (vehicles)	14.5	4.0
Draft animals	1.5	0.4
Productive animals	33.7	9.5
Perennial plantations	9.4	2.8
TOTAL	**363.0**	**100.0**

Source: Narodnoye Khoziaistvo SSSR V 1989 godu Moscow, 1990 pp 477.

[a]Includes collective and state farms and interfarm associations.
[b]In billion rubles.
[c]Of total fixed production in industry.

subdivisions the appropriate categories are added together in industry and agriculture. The capital stock of the Soviet Union for 1989 is given in Table 3.5.

In the equipment category, industry is the sum of conveying equipment, machinery and equipment, and transportation equipment all from Table 3.3; agriculture is the sum of machinery and equipment and transportation equipment from Table 3.4.

For the plant category, industry is the sum of building and structures from Table 3.3 and agriculture is the building and construction category from Table 3.4.

For the industry category in inventories, the miscellaneous category from Table 3.3 is used and the sum of draft animals, productive animals and perennial plantations from Table 3.4 are used for agriculture.

Thus the capital stock for the Soviet Union for 1989 is 1.274 trillion rubles. This value is converted to U.S. dollars by using the Purchasing Power Parity (PPP) exchange rate.

3.4.3 Soviet Labor

The data for Soviet labor are taken as the economically active population in 1989, which totalled 139.3 million. This number did not include 11.7 million persons who listed their main occupation as students. Also excluded from this group were 4 million people in military service. Others excluded

Table 3.5. Soviet Union capital stock data for 1989, by equipment, plant, and inventories

Subaggregate	**Value**[a]
Equipment	
Industry	481.9
Agriculture	73.7
TOTAL	555.6
Plant	
Industry	428.1
Agriculture	235.6
TOTAL	663.7
Inventories	
Industry	10.1
Agriculture	44.6
TOTAL	54.7
Total (Capital)	**1274.0**

[a]In billion rubles.

from the economically active population were 4 million people who were in the process of looking for new jobs and 4.9 million persons who were engaged primarily in household activities.

According to the official *Soviet Statistical Yearbook* (SSY), labor in the Soviet Union is classified by social status: blue-collar workers, white-collar employees, and collective farmers. This yearbook also gives information on some of the following: number of government employees, percentage of workers in each of seven different economic branches, number of workers with university (higher education) and college (specialized secondary education) degrees, both by profession and branches of the economy. Soviet labor for the seven ISCO labor classifications are derived from tables given in SSY. The data from SSY that are most relevant to this project include those given in Tables 3.6, 3.7, and 3.8.

The data for Soviet labor by ISCO categories are given in Table 3.9. These data are derived using information from Tables 3.6, 3.7, 3.8, and other relevant information from SSY. The procedure by which the data are aggregated to conform to ISCO codes is described below.

Professional/technical workers (ISCO category 0/1) was derived by adding the number of workers with university degree in these categories: engineers, agronomists, economists, accountants, legal advisors, and school teachers (college

Table 3.6. Average yearly number of workers and employees in the Soviet Union for 1989, by branches of the economy

Category	**number[a]**
Industry, Total	36414
Industry blue-collar workers	29742
Agriculture, Total	11166
State farms, Total	10121
Blue-collar workers	9052
Forestry	393
Construction, Total	13184
Industrial construction, Total	9953
Blue-collar workers	8095
Transportation, Total	8684
Railroads	2363
Waterways	419
Automobile[b]	5902
Communications	1539
Retail, restaurants, procurement	9877
Information processing	352
Miscellaneous	1804
Housing maintenance	5049
Medical care, sports, social services	7479
Education	11024
Culture	1582
Arts	475
Science	4105
Banking and Insurance	689
Managerial personnel[c]	1597
Grand Total	**115433**

Source: Narodnoye Khoziaistvo SSSR V 1989 godu Moscow, 1990 pp 48,49.

[a]In thousand persons.
[b]Includes public/city transportation and hauling operatives.
[c]Employees of government and public organizations.

Table 3.7. Managerial personnel in the Soviet Union for 1989, by branches of the economy

Category	**Number**[a]	**Percent**[b]
Managerial personnel of enterprise	13205	11.4
Industrial enterprises	4796	11.7
Agriculture and forestry	1016	7.7
Transport and Communication	1004	10.0
Construction	2038	15.7
Retail, restaurant, procurement	1333	13.7
Housing maintenance	485	14.6
Medical care, sports, social service	382	5.4
Education, culture and science	1525	10.2
Banking and insurance	314	45.5
Managerial personnel[c]	1685	100.0
Grand Total	**14890**	**12.7**

Source: Narodnoye Khoziaistvo SSSR V 1989 godu Moscow, 1990 pp 51.

[a]In thousand persons.
[b]As a percentage of total workers in the category.
[c]Includes those of government enterprises and cooperatives and public organization.

Table 3.8. Number of people with university and college degrees employed in the Soviet Union for 1989, by types of profession

Category	Number[a]
Total with university degrees	15869.8
Engineers	6593.5
Agronomist[b]	729.3
Economist	1601.1
Accountants	198.1
Legal advisors	237.8
School teachers[c]	4757.8
Total with college degrees	20614.5
Technicians	9393.2
Agronomist[b]	1075.9
Accountants	1152.0
Legal advisors	62.8
School teachers[d]	2280.7
Grand Total	**36484.3**

Source: Narodnoye Khoziaistvo SSSR V 1989 godu Moscow, 1990 pp 60.

[a]In thousand persons.
[b]Includes veterinarians and technicians.
[c]Secondary school teachers and college and university professors.
[d]Mostly elementary school teachers.

professors and secondary school teachers). This number was added to technicians, with college degrees. These categories are listed in Table 3.8.

Managerial workers (ISCO category 2) was derived by taking the total of managerial personnel, minus managers of agriculture and forestry minus managers of transport and communication, minus managers of retail trade all from Table 3.7. This number is added to legislative officials and government administrators which is given in SSY as two percent of the economically active population.

Clerical workers (ISCO category 3) was taken as communication workers plus workers in information processing plus transport and communication managers. This number is added to government executive officials. Also added to this category is transport conductors, etc. which is taken as half of transportation workers listed in Table 3.6.

Sales workers (ISCO category 4) was derived by taking the sum of retail trade workers plus banking and insurance workers in Table 3.6.

Service workers (ISCO category 5) was taken as housing maintenance workers plus social and other service workers who are taken as 70 percent of medical care, sports and social services from Table 3.6.

Agricultural workers (ISCO category 6) was derived by multiplying the percentage of agricultural and forestry

Table 3.9. Data for Soviet labor for 1989, by seven ISCO codes

ISCO Code	Major Group	Number[a]
0/1	Professional/technical workers	23511
2	Managerial workers	14323
3	Clerical workers	8910
4	Sales workers	7818
5	Service workers	10246
6	Agricultural workers	26467
7/8/9	Production workers	45983

[a]In thousand persons.

workers in the total work force, which is given as 19 percent in SSY, by the economically active population.

Production workers (ISCO category 7/8/9) were derived by taking the sum of industry blue collar workers, blue collar construction workers, half of transportation workers and other physical production workers which is given as miscellaneous workers. These categories are found in Table 3.6.

3.4.4 Soviet Land

The USSR covers 2227.6 million hectares, of which approximately 27 percent is available for agricultural purposes. Soviet land data are given in Table 3.10. In this study land classifications are, arable land, pasture land, and forest land. Data for these three classifications are derived from Table 3.10. Irrigated and drained land available in the Soviet Union in 1989 is given as 20 and 15 million hectares respectively. Land covered by forest is 814.3 million hectares, and 85.9 million hectares is used for timber, (SSY, pp. 455,498).

Data for Soviet land classified according to the three FAO land classifications are given in Table 3.11. To aggregate the land data into these classifications, total cropland in use was used for arable land. The sum of grass land and pasture land is used as pasture land. The sum of land used for timber and land covered by forest is used for forest land.

Table 3.10. Total land available and land in use in the Soviet Union for 1989

	Land Category[a]				
Land Use	**Agriculture[b]**	**Crop[c]**	**Grass[d]**	**Pasture**	**Total**
Land in use	557.9	225.4	30.5	296.5	1055.0
Collective Farms	173.7	101.2	9.9	60.9	245.9
State Farms	377.2	120.7	20.1	283.9	801.3
Land Reserves[e]	27.4	0.4	4.4	22.5	1098.5
Miscellaneous uses	17.5	0.3	0.9	16.3	74.1
Total	**602.8**	**226.1**	**35.8**	**335.3**	**2227.6**

Source: Narodnoye Khoziaistvo, SSSR V 1989 godu, Moscow, 1990, pp. 432, 455, 498.

[a]In million hectares.
[b]Includes cropland, grass land, pasture land, and idle land, orchards vineyards.
[c]Includes irrigated and drained land.
[d]Used primarily for hay.
[e]Includes forest land.

Table 3.11. Data for Soviet land for 1989, according to the three FAO land classifications

Land Category	Area[a]
Arable land	225.4
Dry land	189.3
Irrigated land	20.7
Drained land	15.4
Forest land	900.2
Timber resource	85.9
All other forestland	814.3
Pasture land	327.0
Grassland (Hay)	30.5
All other pastureland	296.5

[a]In million hectares.

3.4.5 Soviet Natural Resources

Much of the trade literature that use resource endowments to predict trade patterns by using the Heckscher-Ohlin model, use value of production rather than the value of reserves of the resources. The data for production, prices and value of Soviet natural resources are reported in Table 3.12. The data for Soviet natural resource production are taken from three main sources. (See Table 3.12 for data sources). The model requires value of production, and the five natural resource categories are aggregated from several minerals.[2] So world prices of the minerals used in the survey are required. But mineral prices are extremely volatile and region dependent. Determining world prices for these minerals can affect the accuracy of the natural resource data. World prices of some minerals are taken as U.S. or other western countries' prices. Some prices are taken as the value of U.S. production divided by its quantity. The 1989 prices are taken from the CIA's *Economic and Energy Indicators* and other prices from the Bureau of Mines' *Mineral Statistics Yearbook*. (See Table 3.12 for source summary of price data).

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[2]The minerals in this study are those given in the Standard Industrial Classification manual for the input/output (I/O) sectors 5.00 - 10.00. Some of the minerals in the manual were excluded because of lack of data availability. Some minerals were also excluded because their production value were not considered significant. (See Standard Industrial Classification Manual, 1972, U.S. Government printing press, Washington D. C.).

Table 3.12. Production, prices[a], and value of natural resource endowments of the Soviet Union, for 1988 or 1989

Resource	Production Units	Price Units	Production	Price[b]	Value[c]
Crude oil	million barrels/day	barrel	11.4	17.37	72276.57
Natural gas	trillion cubic feet	mcf[d]	28.1	1360.36	38226.11
Coal	million metric tons	metric ton	740.0	52.59	38916.60
Antimony	thousand short tons	pound	10.6	1.14	24.17
Aluminum	million metric tons	pound	2.4	0.89	4709.88
Barite	thousand short tons	ton	595.0	35.00	20.83
Bauxite	million metric tons	metric ton	6.8	183.00	1244.40
Chrome ore	million metric tons	metric ton	3.8	61.80	234.84
Cobalt	million pounds	pound	6.3	8.40	52.92
Copper	thousand metric tons	pound	640.0	1.35	1905.12
Gold	million troy ounces	troy ounce	11.0	380.00	4180.00
Iron ore	million metric tons	metric ton	241.0	26.41	6364.81
Fluorspar	million metric tons	ton	1.4	77.35	119.39
Lead	thousand metric tons	pound	440.0	0.31	300.76
Manganese	million metric tons	long ton	8.8	204.00	1766.93
Magnesium	thousand metric tons	pounds	91.0	1.60	321.05
Mercury	thousand flasks	flask	67.0	345.00	23.12
Molybdenum	thousand metric tons	pound	11.5	3.17	80.38
Nickel	thousand metric tons	pound	215.0	6.00	2844.45
Platinum-group	million troy ounces	troy ounce	4.1	510.00	2091.00
Silver	million troy ounces	troy ounce	49.0	5.10	249.90
Tungsten ore	thousand metric tons	metric ton	16.0	89.29	1.43
Tin	million metric tons	pound	16.0	3.90	137.59
Zinc	thousand metric tons	pound	810.0	0.75	1339.54

Cement	million metric tons	ton	139.0	63.53	9736.13
Diamond	million carats	carat	11.0	373.00	4103.00
Nitrogen	million metric tons[e]	ton	20.1	145.00	3213.34
Phosphate rock	million metric tons[f]	ton	34.3	7.00	264.72
Potash	million metric tons[g]	ton	11.3	169.15	2107.38
Salt	million metric tons	long ton	14.8	132.00	1922.83
Sulphur	million metric tons	80 pounds	10.6	4.30	1256.30

Sources (production data): 1989 production values are from Narodnoye Khoziaistvo SSSR V 1989 godu, Moscow, 1990 pp. 375-81, 392-95, 399, and from Central Intelligence Agency's Handbook of Economic Statistics, 1990 pp 69-74. 1988 values are from Mineral yearbook, 1988, various pages.

Sources (price data): 1989 prices were from Central Intelligence Agency's Economic and Energy Indicators, 25 January, 1991, pp. 8, 10, and 1988 prices were from Mineral Yearbook, 1988, various pages.

[a]World prices or prices from United States or other western countries.
[b]U.S. dollars/unit.
[c]In million U.S. dollars.
[d]Million cubic feet.
[e]N content of ammonia.
[f]P_2O_5 content.
[g]K_2O equivalent.

Table 3.13 summarizes the Soviet natural resource data according to the five aggregates required by the model. The total value for each aggregate gives the Soviet endowment for the particular natural resource.

3.4.6 Soviet GNP and Exchange Rate

The Soviet Union has been characterized by comprehensive government controls because of central planning, which does not allow domestic prices to be determined by supply and demand. Thus domestic prices are not related in any way to international prices, and the exchange rate is useful only as an accounting identity.

Therefore it is difficult to estimate the Soviet GNP in U.S. dollars and compare it with other countries' GNPs. The CIA, in its attempt to make comparisons between the Soviet and U.S. GNPs, has relied on the idea of purchasing power parity (PPP) between the Soviet ruble and the U.S. dollar.

The PPP ratio indicates the number of rubles (dollars) required to purchase the same quantity of goods and services that can be bought with one dollar (rubles). To use the PPP approach, price ratios constructed for individual goods and services are aggregated into category ratios using expenditures as weights. Soviet-weighted dollar-ruble ratios for a category use Soviet outlays for the weighting, while U.S.-weighted ruble-dollar ratios use U.S. outlays for

Table 3.13. Aggregates of the value of natural resource endowments of the Soviet Union

Factor Aggregate	Resources	Value[a]
OIL		
	Crude oil	72276.57
	Natural gas	38226.11
	TOTAL	**110502.60**
COAL		
	Coal	**38916.60**
FALOY		
	Chrome ore	234.84
	Cobalt	52.92
	Iron ore	6364.81
	Primary Magnesium	321.05
	Manganese ore	1766.93
	Molybdenum	80.38
	Nickel	2844.45
	Tungsten ore	1.43
	TOTAL	**11666.81**
NFER		
	Antimony	24.17
	Primary aluminum	4709.88
	Bauxite	1244.40
	Copper	1905.12
	Gold	4821.41
	Lead	300.76
	Mercury	23.12
	Platinum-group metals	2091.00
	Silver	249.90
	Tin	137.59
	Zinc	1339.54
	TOTAL	**16846.88**
OTMNE		
	Barite	20.83
	Fluorspar ore	119.39
	Hydraulic cement	9736.13
	Diamond (Natural)	4103.00
	Nitrogen	3213.34
	Phosphate rock	264.72
	Potash	2107.38
	Salt	1922.83
	Sulphur	1256.30
	TOTAL	**22743.92**

[a]In million U.S. dollars.

weighting. Price ratios for various categories such as consumption, investment, defense, and administration are summed together as the GNP. The U.S. GNP is valued at Soviet ruble prices and the Soviet GNP is also valued at U.S. dollar prices. The Soviet GNP is a larger share of U.S. GNP when comparisons are made in dollars since dollar prices place greater weight on investment and defense goods, in which the Soviet Union specializes. In 1976, Soviet GNP was 50 percent of U.S. GNP when comparisons were made in ruble prices and this number increased to 74 percent when the GNPs were measured in dollar prices. In 1989, however, Soviet GNP was 39 percent of U.S. GNP when GNPs were measured in rubles and 66 percent when measured in dollars. To get a reasonable estimate, a geometric mean of the two is used.[3] The Soviet GNP value used is the value reported in the *Handbook of Economic Statistics* for 1986. This year is chosen for consistency, since the GNP data for the 45 survey countries are given for 1986.

Similar work has been conducted by Kravis, Heston, and Summers (1982) in the U.N. sponsored International Comparison Project (ICP). This study provides geometric mean values of GNP and refers to them as an "even-handed compromise" between

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[3]The value of the geometric mean is taken as the dollar value for consistency with other GNP values, and it is this value that is reported by the CIA as the GNP of the USSR in the *Handbook of Economic Statistics* in current U.S. dollars.

the two estimates. Estimates for GNPs are given for 60 countries in Phase IV of the ICP, but the Soviet Union is excluded from this list of countries.

Even though the CIA's GNP estimation procedure does not use explicit ruble/dollar exchange rate, it can be inferred that the PPP exchange rate is used. The PPP exchange rate has been estimated for the Soviet ruble in terms of U.S. dollars in the PlanEcon Report, and they use the same procedure that is used in the ICP.[4] The PPP exchange rate for the Soviet ruble in 1989 is given as 0.64 rubles per U.S. dollar. The commercial rate is given as 1.27 rubles per U.S. dollar, which is about twice the PPP rate.

This ratio seems to be consistent with those found in the ICP project for Eastern European countries in 1980. For example, the ICP estimate of the PPP exchange rate for Poland in 1980 was 16.14 zlotych per U.S. dollar while the official exchange rate was 31.05 zlotych per U.S. dollar. The PPP rate is used as the exchange rate for this analysis in part because it is consistent with the CIA's estimate of the Soviet GNP.

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[4]In Phase IV of the ICP, PPP rates are derived for 60 countries. The ICP procedure is to collect the price of each item in all the countries in which that commodity is produced. These prices are used to estimate a basic parity (BP) for each of the 151 detailed categories. The BPs are used to derive quantity ratios from expenditure ratios. These are aggregated to form the GNPs and then PPP rates are derived. See Kravis, Heston, and Summers (1982) for a more complete explanation.

3.5 World Factor Endowments

3.5.1 World Capital

Data for capital stock for the 45 countries used to represent the rest of the world are estimates of net capital stock that were compiled by summing gross domestic investment flows over a 15-year period (1972-86).

Gross domestic investment is made up of all outlays of industries, producers of general government services, and private nonprofit institutions. This category includes all new items produced domestically or purchased from abroad, as well as all imported second-hand goods. Also included are all new dwellings, expenditures to improve durable goods, and nonreducible tangible assets such as land, mineral deposits, plantations, orchards and livestock herds. Government outlays for construction and durable goods for military purposes, which are classified by the U.N. System of National Accounts (SNA) as current consumption, are excluded. Also excluded are increases in natural resources due to growth, such as forests, and new discoveries such as mineral deposits.

This approach of summing gross domestic investment to estimate capital stock assumes a specific time as the average life of assets and a corresponding rate of depreciation. The average life of assets is 15 years and a corresponding depreciation rate of 13.3 percent.[5] The data for gross domestic investment are available in the World Bank's *World Tables* (1987), for 1966-1986.[6] These figures are in nominal terms and also in home country currency. Implicit gross domestic product (GDP) deflator[7] was used to convert the figures to specific base year prices and the exchange rate was used to convert the values from home country currency to U.S. dollars.

The translation of home currency gross domestic investment at current prices to U.S. dollars at a fixed year prices is crucial. To do this let

I_t = gross domestic investment (GDI) in year t in home country

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[5]Estimating net capital stock by this method or one similar to it has been used in almost all previous studies. The 15-year asset life and 13.3 percent depreciation rate are used in Leamer (1984) and Bowen, Leamer, and Sveikauskas (1987). Leamer (1984) also considered three different asset lives 10, 15, 20 years but determined asset life seemed to makes little difference in statistical analysis. The 15-year asset life was selected in Leamer (1984) because of missing data problem in the 20-year asset life.

[6]The 1986 gross domestic investment (GDI) flows for Ghana and Mexico were not available. These values were estimated by multiplying the 1985 value by 1 plus the growth rate multiplied by 1 plus the inflation rate; i.e., let V = 1985 value for GDI for any of these countries. let g = the growth rate, and π = the inflation rate. Then 1986 GDI = $V(1 + g)(1 + \pi)$, where g = [1986 GNP - 1985 GNP]/1985 GNP and π = [1986 GDP deflator minus 1985 GDP deflator]/1985 GDP deflator.

[7]Implicit GDP deflator is derived by dividing current price estimates of GDP at purchaser values (market prices) by constant price estimates; also known as the overall GDP deflator.

currency units;

P_t = implicit gross domestic product (GDP) deflator at time t with base year, b (1980 for this data set), $P_b = 1$.

e_t = exchange rate in time period t, home country currency units per U.S. dollar;

δ = rate of depreciation; and

$K_T^{\$}$ = net capital stock in U.S. dollars for time period T, where T represent the last time period.

Equation (3.3) is the used to estimate net capital stock:

$$K_T^{\$} = P_T(US) \sum_{t=0}^{T} (1-\delta)^{T-t} \left[\frac{I_t}{P_t(US)\, e_t} \right], \qquad (3.3)$$

where $P_t(US)$ is the implicit (GDP) deflator for the U.S. in time period t.

Two other equations were examined. Estimates using these equations for countries with severe hyperinflation seemed unreasonable when compared with estimates from Equation (3.3).[8] Capital stock estimated by Equation (3.3) gives the capital stock in current 1986 U.S. dollars. World capital stock data are given in Table B.1.

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[8]For instance, using Equation (3.3) to estimate the net capital stock for Chile = US$23.98 billion. Using a slightly different equation; $K_T^{\$} = \Sigma(1-\delta)^{T-t}[I_t/P_t e_t]$, to estimate net capital stock for Chile = US$532.8 billion. This is due to very severe hyperinflation prior to 1980. See Appendix B of Leamer (1984) for further details.

3.5.2 World Labor

Data for the rest of the world labor are from the International Labor Office (ILO) *Yearbook of Labor Statistics*. The data for the rest of the world labor are taken as a country's economically active population. According to the U.N. system of national accounts and balances, the economically active population comprises of all persons who furnish labor to produce economic goods and services, during a specified time period. In most countries, the economically active population includes persons seeking their first job, seasonal workers, and persons engaged in part-time economic activities. However, in general, economically active population excludes students, persons occupied solely with domestic duties, retired workers, people living entirely on their own means, and those wholly dependent upon others.

The sources of the data on economically active population are usually given as national census, labor force or household surveys, and other official estimates. Since these data are not compiled regularly, the latest years for which the data were available were used. The year for which the latest data were available for all the countries ranged from 1983 to 1989. The data for the labor categories are those defined at the one-digit level of the ILO's ISCO. The data for world labor are given in Table B.1.

3.5.3 World Land

Data for rest of the world land are from the FAO *Production Yearbook*. The model uses the three FAO land classification: arable land, pasture land and forest land.

The arable land category includes land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens, or land temporarily fallow or lying idle. The pasture land category includes permanent meadows and pastures (land used permanently for herbaceous forage crops), either cultivated or growing wild. The forest land category is forest and woodland, which refers to land under natural or planted stands of trees, whether productive or not, and includes land from which forests have been cleared but that will be forested again soon.

Because the land coefficients in the total input requirements are measured in dollars and the land endowments are measured in hectares, appropriate adjustments are necessary. The land endowments are adjusted by these prices: arable land, $437.68 per hectare; pastureland, $333.99 per hectare and forest land, $17.44 per hectare.[9] The data for

[9]These prices were taken from Bowen, Leamer, and Sveikauskas (1987). These prices were in 1967 dollars and thus were multiplied by a factor of 3.0657 to get the given prices. The factor of 3.0657 is the U.S. 1986 implicit GDP deflator divided by U.S. 1967 implicit GDP deflator. U.S. implicit GDP deflator is taken from World Bank's World Tables (1987).

world land, given according to the three FAO classifications (in U.S. dollars) are reported in Table B.1.

3.5.4 World Natural Resources

Natural resource data for the rest of the world are derived from the *1988 Minerals Yearbook*, published by the Bureau of Mines, U.S. Department of the Interior. The data are from tables listing the leading world producers of several minerals. Countries producing little amounts were grouped together as the "other" category. The mineral production of countries that were not included in the sample were excluded from the natural resource aggregate. The total of the remaining countries (including the "other"[10] category) was taken as world production of that particular mineral. The data for the rest of the world natural resources, given according to the five aggregates are reported in Table B.2.

3.5.5 World GNP

Data for the rest of the world GNP are from the World Bank's *1987 World Table.* The latest GNP figures are for 1986 and are in the home country's currency. These figures were given in current home country currency (1986 prices) and were

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[10]The other category may include countries not included in the 45 selected countries. The production of this category was only a small percentage of the total, and so the error introduced from this in negligible.

converted to current U.S. dollars. To explain the conversion process, let $GNP_i(\$)$ = the GNP in 1986 U.S. dollars for country i. Then

$$GNP_i(\$) = \frac{GNP_i(HC)}{e_i},$$

where $GNP_i(HC)$ = GNP in home country currency for country i and e_i = 1986 exchange rate for country i. The values for GNP are given in Table B.1.

3.6 Summary

This chapter has presented all the data that are required for the model simulation that follows. The sources of the data have been adequately documented. The methods of how the data were derived and the aggregation that had to be made for some of the data to compatible with standard United Nations data have been explained and the necessary literature have been cited where necessary.

Deriving Soviet resource data for capital, labor, and land was a very delicate process. These data had to be put in a form that was required by the model. Matching ISCO labor codes with Soviet labor data was most difficult. Estimating world capital stock also seemed to be a delicate process, but the results conform with other capital stock data in the literature.

4. MODEL SIMULATION AND RESULTS

4.1 Introduction

This chapter presents the primary results of the study, and examines of some of the underlying assumptions made by the model. Section 4.2 describes and quantifies the factors in which the Soviet Union is relatively abundant or scarce. Section 4.3 reports the post-reform Soviet net trade vector. Section 4.4 gives a sensitivity analysis of the results by examining how changes in Soviet resource endowments affect trade patterns. Section 4.5 examines the reliability of the results. Section 4.6 is a summary of the chapter.

4.2 Soviet Factor Abundance Vector

4.2.1 Introduction

The Soviet GNP used for this model is the CIA estimate, which is US$2525.2 billion. This GNP results in an s value of 0.178. Because the model uses U.S. technology which may increase Soviet production an s value of 0.188 is used. Under these conditions, the Soviet Union is factor abundant in 10 of the 16 factor aggregates used in the study. Table 4.1 gives the factor aggregates, world and Soviet factor endowments, Soviet factor abundance ($V - sV_w$), and the rank value.[1]

4.2.2 Capital

The data for Soviet capital are the only resource in which the data are originally given in Soviet rubles. For uniformity with estimation of the GNP, the purchasing power parity (PPP) exchange rate of 0.64R/US$, is used to convert capital from Soviet rubles to U.S. dollars.

The Soviet Union is relatively factor scarce in CAPIT. With a rank value of -6.96, CAPIT is third among the six factors in which the Soviet Union is relatively scarce. The U.S. is relatively more capital abundant than the Soviet Union, having a positive value for $V - sV_w$. When the number of countries is reduced to only 11[2], CAPIT becomes the most factor scarce resource in the Soviet Union.

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[1]The value of the rank is $(V - sV_w)/V_w * 100$. The purpose of this column is to rank the factor abundance (scarcity) in order of magnitude.

[2]The eleven countries are United States, Canada, Japan, Australia, Italy, West Germany, France, United Kingdom, Switzerland, Belgium and the Soviet Union. The rest of the countries (excluding the Soviet Union) are supposed to represent the most industrialized countries, with well developed market economies.

Table 4.1. World[a] and Soviet factor endowments, Soviet factor abundance supply, and Rank[b]

Factor Aggregate	V_w	V	$V - sV_w$	Rank
a. Capital[c]				
CAPIT	16842.30	1990.63	-1171.59	-6.96
b. Labor[d]				
PROF	92.79	23.51	6.09	6.56
MANAG	48.04	14.32	5.30	11.04
CLERK	83.39	8.91	-6.75	-8.09
SALES	75.20	7.82	-6.30	-8.38
SERV	73.86	10.25	-3.62	-4.90
AGRIC	126.56	26.47	2.70	2.14
PROD	211.48	45.98	6.27	2.97
c. Land[c]				
ARABL	362.09	96.40	28.41	7.85
PASTR	504.35	109.21	14.51	2.88
FORST	46.90	15.70	6.89	14.70
d. Natural Resources[c]				
OIL	331.20	110.50	48.32	14.59
COAL	137.26	38.92	13.15	9.58
FALOY	47.38	11.67	2.77	5.85
NFER	133.10	16.85	-8.14	-6.12
OTMNE	150.43	22.74	-5.50	-3.66

[a]World = 45 survey countries and the Soviet Union.
[b]Rank = $(V - sV_w)/V_w * 100$.
[c]In billion U.S. dollars.
[d]In million persons.

4.2.3 Labor

Labor is the only resource in which the units are not given in value terms. Of the seven labor categories, the Soviet Union is relatively abundant in four: PROF, MANAG, AGRIC, and PROD. In labor, the Soviet Union is most factor abundant in MANAG, with a rank value of 11.04. The Soviet Union is factor scarce in CLERK, SALES, and SERV, with SALES being the most factor scarce. Even though the Soviet Union is factor abundant in AGRIC, the value of the rank is quite small. On the other hand, the U.S. is most factor scarce in AGRIC, and most factor abundant in MANAG. With the number of countries reduced to 11, the Soviets become most factor abundant in AGRIC.

4.2.4 Land

The Soviet Union is factor abundant in all three land classifications. FORST is the most factor abundant resource in land, with a rank value of 14.70, followed by ARABL and then PASTR. Land is the only resource for which the Soviet Union is relatively factor abundant in all the aggregates. The U.S., on the other hand, is relatively most land abundant in ARABL, followed by PASTR, with FORST third. Comparing the two countries, the Soviet Union is more land abundant than the United States in all three categories. Reducing the number of countries to 11 does not change the ranking order of land.

4.2.5 Natural Resources

The Soviet Union is factor abundant in three of the five natural resources: OIL, COAL, and FALOY. OIL is the most factor abundant natural resource, with a rank value of 14.59, followed by COAL and then FALOY. The Soviet Union is factor scarce in NFER and OTMNE. The U.S. is most natural resource abundant in COAL and most scarce in FALOY. Reducing the number of countries to 11 does not affect on the ranking order in this category.

4.2.6 All Resources

The Soviet factor abundance can be put into three groups: very factor abundant, factor abundant, and factor scarce. Four factors can be classified as very factor abundant. These are FORST, OIL, MANAG, and COAL, with factor abundance rankings greater than 9.0. The following factors belong to the factor abundant group: PROF, AGRIC PROD, ARABL, PASTR, and FALOY. These factors all have rankings ranging from 0 to 9.0. The rest of the resources: CAPIT, CLERK, SALES, SERV, NFER and OTMNE, have negative factor abundance rankings and can be grouped in the factor scarce category.

Overall, the Soviet Union is most factor abundant in FORST with a rank of 14.70, followed closely by OIL at 14.59. SALES is the most factor scarce resource with a rank value of -8.38. When the number of countries are reduced to 11, the

Soviet Union becomes most factor abundant in AGRIC and most factor scarce in CAPIT. This shows that the resource endowments of the Soviet Union in labor and capital resemble more a developing rather than a developed country. But the Soviet Union is factor abundant in PROF and MANAG, which seems to contradict the previous assertion. Using the total number of countries (45 survey countries and the Soviet Union), the U.S. is most factor abundant in COAL, followed by MANAG and CAPIT and most factor scarce in AGRIC. In general, the Soviet Union is relatively more factor abundant in more of the resources when compared with the United States.

4.3 Soviet Net Trade Vector

4.3.1 Introduction

The Soviet trade vector is estimated using the HOV equations derived in Chapter 2. As in Leamer (1984), the even model is used, so Equation (2.10) is the appropriate equation for finding the post-reform Soviet net trade vector.

4.3.2 Post-reform Soviet Net Trade Vector

The results from calculating the post-reform Soviet net trade vector T, are given in Table 4.2. The 16 commodity aggregates are divided into four primary products, six agricultural products, and six manufactures.

According to the HOV equations, the Soviet Union is expected to be a net exporter in two of the four commodity aggregates under primary products: PETRO and METAL. Among the four primary products, the aggregate for which the Soviets will have the largest net export in absolute value terms is PETRO, with a value of US$23.7 billion. METAL is second. Both FERRO and MINE have small negative trade balances. Overall, the Soviet Union is expected to be a net exporter of primary products with a trade balance value of US$32.1 billion.

According to 1989 official Soviet trade data, the Soviet Union has a positive trade balance of US$44.0 billion in primary products, and is a net exporter of all four commodity aggregates in this category. Thus, after the market economy has been developed, Soviet trade patterns do not seem to change significantly in primary products. After economic liberalization, net exports of PETRO are reduced significantly, while the net exports of METAL increases. The reason for this is perhaps that U.S. technology is quite intensive in its use of OIL, which is the main contributor to the positive net trade value of PETRO.

Despite the fact that the HOV predictions are larger in absolute value terms than Soviet trade data, the trade balance from Soviet trade data for primary products is larger than the model results. It can be concluded that the Soviet Union will

Table 4.2. Soviet post-reform net trade vector, calculated using the HOV equations, and official Soviet trade data for 1989

Commodity Aggregate Number	Commodity Aggregate Name	Net Trade[a] HOV Prediction	Net Trade[a] Soviet Trade Data[b]
	a. **Primary Products**		
1	PETRO	23717.20	38072.12
2	FERRO	-1431.05	1125.93
3	METAL	12755.82	1195.59
4	MINE	-2891.82	3628.83
	b. **Agricultural Products**		
5	FORE	48248.48	2072.68
6	MEAT	-4149.08	-1650.78
7	FISH	13032.27	793.78
8	CEREA	-19135.88	-4782.97
9	FRUIT	19360.55	-6999.65
10	BEVER	42528.94	-1576.70
	c. **Manufactures**		
11	TEXTI	-46202.38	-7085.22
12	LABIN	-33434.38	-1463.19
13	CHEM	-98810.77	-7296.27
14	PMACH	26117.32	-12994.27
15	SMACH	36923.23	-7660.54
16	CAPIN	-16646.87	-2413.72
	Trade Balance	**-18.41**	**-7134.36**

[a]In million U.S. dollars.
[b]From Soviet *Foreign Trade Statistical Yearbook.* (See Table B.4. for details.)

continue to export primary products, but the volume of trade will be significantly reduced.

In agricultural products, the model predicts that the Soviet Union will become a net exporter of four of the six commodity aggregates. The Soviet Union will be a net exporter of FORE, FISH, FRUIT and BEVER, and a net importer of the remaining two aggregates; MEAT, CEREA. In this category FORE has the largest value in absolute terms, with a net export value of $48.2 billion, followed by BEVER. In agricultural products, the Soviet Union will become a net exporter with a balance of trade value in this category of US$99.8 billion.

In agricultural products there seems to be a complete reversal of trade patterns after the market economy has been developed. Official Soviet trade data for 1989 show that the Soviet Union is a net exporter of two of the six agricultural products: FORE and FISH. The trade data also show that the Soviet Union exhibits a negative trade balance in the category. The most important result to note is that after a market economy is developed, the Soviet Union moves from being a net importer in agricultural commodities to being a net exporter. This finding seems reasonable since the Soviet Union is relatively abundant in arable land and forest.

In manufactures, the HOV model predicts that the Soviet Union will be a net exporter in only two of the aggregates: PMACH and SMACH. The model predicts that the Soviet Union will be a net importer of the remaining four aggregates, TEXTI, LABIN, CHEM, and CAPIN. In absolute value terms, CHEM has the largest net trade value of $98.8 billion, followed by TEXTI with CAPIN having the smallest net trade value. The Soviet Union has a large negative trade balance of US$132.1 billion in this category. Hence, the Soviet Union will become a net importer of manufactured products after a market economy developed. In manufactures the HOV prediction does not seem to vary much from Soviet trade data. While the model predicts that the Soviet Union will be a net importer in four of the six commodity aggregates in this category, official Soviet trade data show that it is a net importer of all the commodity aggregates under manufactures. The main conclusion in this category is that the trade situation is improved because the Soviets export PMACH and SMACH after economic reform, but continue to have a large negative trade balance in this category.

The 1989 Soviet trade data have a balance of trade value of -US$7.1 billion. Overall the HOV model predicts a negative trade balance of US$18.41 million[3], which is approximately trade balance, an assumption required by the model.

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[3]Some data adjustments were necessary to achieve this approximate trade balance. The earlier version of the model resulted in a trade surplus of US$32 billion. The data was adjustment so as to decrease net exports and increase net imports by a fixed proportion to eliminate the trade surplus.

In general, the HOV model predicts that, if the Soviet Union develops a market economy, it will become a net exporter of primary and agricultural commodities and a net importer of manufactures. When compared with 1989 Soviet trade data one can conclude that, after a market economy has developed, trade patterns will significantly change in agricultural products. Another result worth mentioning is that the post-reform net trade values predicted by the HOV model are larger in absolute value terms than Soviet trade data for 1989. This implies that after the market economy has been developed, the Soviet Union will have an increase in its volume of trade. This is not surprising since the usual trade policy objective of the centrally planned economic system has been autarky. The Soviet Union also has had to conduct barter trade because of the nonconvertibility of the ruble. With the ruble becoming convertible, the Soviets will be able to conduct international trade more freely, and increase its trade volume.

In examining the results, one should be aware that certain assumptions were made to make the HOV model applicable to the Soviet economy. One such assumption is that the Soviet Union will adopt U.S.-type technology after economic liberalization because current Soviet technology is not cost-efficient due to distortions from central planning. These results also rely on the regular underlying assumptions of the HO model. The one, which may most severely affect the results is the no specialization of commodities assumption, which states that countries should not produce a subset of the commodities. Other important assumptions include constant returns to scale technology, and identical homothetic demand among countries. Because of the importance of the effects of some of these assumptions on the accuracy of the results, they are examined in detail in section 4.5.

4.4 Sensitivity Analysis

4.4.1 Introduction

This section examines how changes in Soviet resources affect the results. In section 4.4.2 the effect of changes in Soviet capital on the results are examined. The effect of changes in Soviet labor on the results are investigated in section 4.4.3.

4.4.2 Effects of Changes in Soviet Capital on Results

Soviet capital investment increased tremendously in the 1950s and 1960s. However since the late 1970s Soviet capital investment has declined rapidly. In 1979, total funds committed to capital investment grew by 0.6 percent compared with 7.6 percent in 1968 (Rumer 1984). This has caused the current Soviet capital stock to be significantly smaller than it was in the middle 1970s. A change in the exchange rate being used only affects capital. When the commercial exchange rate of 1.27R/US$ is used this reduces capital by approximately 49 percent. So it is reasonable to reexamine the model by reducing capital by 50 percent.

When the model is rerun with this change, CAPIT becomes the most factor scarce resource, with a rank value of -12.49. Table 4.3 reports the resulting net trade vector. When capital is reduced by 50 percent, the signs of the net trade values remain the same for all the commodity aggregates. This change in capital causes a decrease in the net trade values in absolute terms for most of the commodity aggregates. The smallest change occurs in PETRO, where the 50 percent reduction in CAPIT results in a 0.26 percent decrease in the net trade value of PETRO.

The Soviet Union remains a net exporter of primary and agricultural products and a net importer of manufactures. Thus it can be concluded that a change in Soviet capital reduces the volume of trade slightly, but does not alter the basic results of the model. In this model a reduction in capital also constitute a depreciation of the Soviet ruble. The model is not sensitive to changes in the exchange rate, so using a different exchange rate will not significantly change the Soviet net trade vector.

Table 4.3. Soviet net trade vector, calculated with a 50 percent reduction in capital

Commodity Aggregate Number	Commodity Aggregate Name	Net Trade[a]
	a. Primary Products	
1	PETRO	23655.75
2	FERRO	-546.62
3	METAL	10968.36
4	MINE	-3416.50
	b. Agricultural Products	
5	FORE	46939.62
6	MEAT	-4800.68
7	FISH	13314.42
8	CEREA	-16400.13
9	FRUIT	16328.91
10	BEVER	41722.93
	c. Manufactures	
11	TEXTI	-50240.52
12	LABIN	-20922.17
13	CHEM	-96700.75
14	PMACH	1029.86
15	SMACH	48373.95
16	CAPIN	-14715.51
	Trade Balance	**-5409.07**

[a]In million U.S. dollars.

4.4.3 Effects of Changes in Soviet Labor on Results

The data for Soviet labor which are given in SSY are not given according to ISCO codes. Thus in analyzing the model one has to examine the different labor categories that were used for the seven ISCO codes.

In the PROF category, the number used was "appropriate" workers in the sector of workers with university and college degrees. But according to the SSY, many of the workers with university and college degrees do not use their acquired skills, but instead work as industrial or blue-collar workers, and usually receive higher salaries when compared with professional or technical (white-collar) workers. (See Dunstan 1987 p. 18 for further details).

The number for MANAG was taken from managers and government legislators. Most managers in the Soviet Union, however, face soft budget constraints and are given specific guidelines about amounts of inputs needed and the levels of production. Thus, the productivity of many of the workers in this category may not compare equally with their counterparts in western countries. Another problem is that there seem to be too many government legislators in this category. Thus, in using U.S. technology, it seems reasonable to reduce both PROF and MANAG by 50 percent. To maintain the same number of total labor (the economically active population), this number is added to PROD. The model is then rerun with these changes.

When these changes are made, both PROF and MANAG move from being factor abundant to factor scarce with rank values of -4.27 and -1.26, respectively. PROD becomes the most factor abundant resource in the labor category.

The post-reform net trade vector with the changes in labor is reported in Table 4.4. The signs of the net trade values remain the same for all the commodity aggregates except FERRO. The reduction in PROF and MANAG and the increase in PROD seem to cause a decrease in the net trade values, in absolute terms, of all the commodity aggregates. Changes in Soviet labor reduce the trade volume, but do not seem to change the results of the model. The conclusion that the Soviet Union will be a net exporter of primary and agricultural commodities and a net importer of manufactured commodities still holds.

The reduction in the volume of trade caused by the changes in labor exceeds the volume of trade reduction caused by the reduction in capital. Thus the net trade vector is more sensitive to changes in labor than in capital.

The sensitivity analysis was also conducted with changes in labor and capital grouped together. The results of the model still hold when the changes in capital and labor are grouped together.

Table 4.4. Soviet net trade vector, calculated with changes in labor

Commodity Aggregate Number	Commodity Aggregate Name	Net Trade[a]
	a. Primary Products	
1	PETRO	17997.63
2	FERRO	130.63
3	METAL	6989.33
4	MINE	-317.32
	b. Agricultural Products	
5	FORE	29595.14
6	MEAT	-2260.39
7	FISH	6204.98
8	CEREA	-11373.23
9	FRUIT	10973.16
10	BEVER	26886.19
	c. Manufactures	
11	TEXTI	-21823.87
12	LABIN	-23359.12
13	CHEM	-64294.96
14	PMACH	8398.80
15	SMACH	21658.50
16	CAPIN	-5663.82
	Trade Balance	**-258.38**

[a]In million U.S. dollars.

4.5 Issues Concerning Accuracy of Model

4.5.1 Input Variables

The factor aggregates can shed some light on how accurate the model results were. Thus, we have to examine how the input variables are able to explain trade patterns.

The factor aggregates for labor in this model are the one-digit level of the U.N. ISCO labor codes. There are seven different aggregates in the 1968 revised edition. All the empirical work that has been done in relation to the HOV model has used either the one-digit ISCO codes or the three labor classifications started by Leamer (1984), or a slight variation of either classifications. The three labor classifications are represented by skilled, semi-skilled and unskilled labor. In addition to Leamer (1984), these classifications are used by Maskus (1985) and Murrell (1990). The seven ISCO codes have been used in Harkness (1978), Sveikauskas (1984), and Bowen, Leamer, and Sveikauskas (1987). The papers that use the seven ISCO codes usually test the HOV model using data for all three sets of variables of the HOV model: trade vector T, factor intensity matrix A, and the excess factor endowment supplies $V - sV_w$. This is true because the technology matrix was calculated for the seven ISCO labor classification from the 367-order U.S. input-output table. One disadvantage is that this classification does not seem to capture the human capital element of labor. Even though PROF, can be considered as skilled labor and hence the human capital element in this classification, several other ISCO categories also contain some skilled labor. However, it is impossible to use the three Leamer classifications because of lack of data availability.

The question of which of the two options - the seven ISCO codes or the three Leamer classifications explains net trade better has not been a central issue in the empirical trade literature. The only mention is in Maskus (1985), where human capital, which is represented by PROF, ranks very highly in its contribution to trade. The pure labor component is usually described by unskilled labor, which is closely approximated here by PROD. Thus, the seven ISCO codes do not distinguish among the different elements of labor, so they may not explain trade as well as the three Leamer classifications. It is, however, the only classification that can be used in this instance because of data availability.

Land also seems to pose a problem when one examines the aggregates. This model uses land aggregates from the three FAO land classifications: arable land, pasture land, and forest land. First these classifications totally ignore the effect of climate on land differences. Leamer (1984) classifies land according to different climatic conditions. He identifies four land groups using six different climatic conditions based on temperature and rainfall. However, this classification also has its problems. As Murrell (1990) notes, if one is to follow Leamer's land classifications the Soviet Union in effect will only have two land classes because tropical and dry, are almost nonexistent there. The Leamer classifications do not take into account differences in land quality. The FAO land classification does not perform any better on this issue. Even though arable land is the highest quality land, with pasture land and forest land ranked second and third, these categories are too broad. For example, the arable land category is too broad to allow for a more detailed examination of agricultural commodities. Different kinds of soil quality with varying levels of productivity are not captured, and trade patterns associated with these land differences are ignored.

Natural resources in this model have five categories. This does not seen to cause any problems. On examination of the empirical trade literature associated with the HOV model, there have been several different categories, ranging from three in Leamer (1984) to six in Harkness (1978). The natural resource category is totally ignored by Bowen, Leamer, and Sveikauskas (1987).

It can be agreed that different input classifications do affect the patterns of trade. However, there is no consensus about which classifications best explain trade patterns. The input classifications used in this model are chosen because of data availability.

4.5.2 Examination of HOV Model Assumptions

4.5.2.1 Introduction The HO model uses a set of seemingly restrictive assumptions. It may be fair to state that all of these underlying assumptions may not hold in the real world. However, the focus of this section is not to examine all the assumptions individually. There is already a fairly large volume of literature on the subject of determining how the HO model is affected if any of the assumptions is relaxed. Rather, the assumptions that seem to seriously affect the net trade patterns, if they are violated, are examined.

4.5.2.2 No Specialization Assumption The assumption that prevents the specialization of commodities among countries may be the one that is most severely violated, and may seem to affect the results the most. This assumption ensures that all commodities will be produced by all countries and that the factor price equalization theorem will be satisfied among countries. The factor price equalization theorem does not hold if there is factor intensity reversal.

In this model, the no specialization of commodities assumption seems to be violated. The evidence for this is given by the fact that five of the commodity aggregates have negative output values. According to the HO theory, if countries have sufficiently different factor endowment vectors that do not fall into the same cone of diversification, the countries will completely specialize in the production of a subset to the commodities. This causes factor prices to be different between countries, which affects the linear HOV equations given in Equation (2.10).

To examine this problem further, we first note that $Q_j = \Sigma a_{ji}^{-1} V_i$. A further step is to examine the matrix D, defined by $[a_{ji}^{-1} V_i]_{i,j=1}^{n\ m}$, where m = n = 16. This matrix gives the effect of each factor endowment on output. From D one can determine that the output vector is seriously affected by using the U.S. technology matrix. The impact of the factors for which there were obvious differences between U.S. and Soviet factor endowment were quite distinct. For example, the effect of AGRIC on output was the largest, and also the difference between U.S. and Soviet endowment for AGRIC was largest. The effect of CAPIT was quite small, which was evidence that Soviet capital stock is too small to use U.S. technology. Thus, violating the no specialization of commodities assumption leads to the conclusion that because the factor endowments of the United States and the Soviet Union may not lie in the same cone of diversification, the Soviet Union will not necessarily adopt a U.S.-type technology after market economy has been developed. Hence, the assumption that U.S. technology can be used as the A matrix, for this model has also been violated.

To examine how seriously this affects the results, consider the following. Since there is specialization in some commodities, some of the factors may be underutilized. Maximizing $\Sigma P_j Q_j$ subject to $AQ \leq V$, $Q \geq 0$ gives the factors that are underutilized and also the commodities in which the Soviet Union specializes. Upon solving this problem, however, only seven of the 16 factors are fully utilized: CAPIT, CLERK, SALES, SERV, PROD, FALOY, and NFER. The Soviets also specialize in seven commodity aggregates, which are PETRO, METAL, FORE, FISH, BEVER, SMACH, and CAPIN. On examination of these results, FRUIT is the only commodity aggregates in which the Soviets have a positive net trade value and do not specialize. This suggests that violating this assumption may not adversely affect the results. In Leamer (1984) even though there was evidence that this assumption was violated, he concluded that the simple linear HOV equations perform very well in explaining U.S. trade patterns. The HOV predictions of net trade values should not be taken as exact, but rather reasonable approximations based primarily on relative factor endowments.

4.5.3 Examination of Data Accuracy

4.5.3.1 Resource Endowments For Soviet resources, the data for labor may be most inaccurate. These data, taken from SSY, were a series of tables on several different aspects of Soviet labor, and were not classified according to ISCO codes. Reclassification of the data to conform to ISCO codes was difficult because the two- and three-digit ISCO codes, which are subaggregates of the seven one-digit ISCO codes did not exist for several categories of the Soviet labor data. Even though the reclassification was done very carefully and after consulting some Soviet data experts and other information about Soviet data, there is still the possibility of errors in the aggregation. But this may be partly resolved by the sensitivity analysis.

The data for the rest of the world labor were available from the ILO's *Yearbook of Labor Statistics.* These were classified according to ISCO codes, and thus did not present any aggregation problems. The only problem with this data is perhaps the fact that such data are not compiled regularly. The latest years for which the data were available for all the 45 countries, used to represent the rest of the world, ranged from 1983 to 1989. The latest available data for most of these countries were compiled after 1986, with several of them having theirs compiled in 1988 or 1989.

The data for Soviet capital seemed reasonably accurate.

The only cause for concern here is perhaps the exchange rate problem. Data estimates for the rest of the world capital stock were derived by summing gross domestic investment with an asset life of 15 years and a depreciation rate of 13.3 percent. This method of estimating capital stock has been used extensively in the literature. These capital stock data estimates are consistent with other results in the literature. The fact that capital stock data for the Soviet Union and the rest of the world were derived by different methods may cause some discomfort. Compilation of Soviet capital stock is not consistent with the rest of the world because the Soviet data for gross domestic investment are not available.

The accuracy of the natural resources data for both the Soviet Union and the rest of the world also seems to be a cause for concern. One of the problems encountered was determining which minerals had to be included in the aggregation. The 1972 SIC manual was a very important source in resolving this problem. The minerals included in this study were the ones considered "most" significant. Availability of data was also a contributing factor in determining whether to exclude some minerals from the aggregation.

The main source of data inaccuracy in natural resources, however, was the difficulty in securing accurate price data for the selected minerals. The price data taken from the CIA's *Economic and Energy Indicators* seemed the most accurate. Some prices were taken from the *Mineral Statistics Yearbook*, and others were derived by dividing the value of production by the amount of production. U.S. and Canadian prices were used to represent most world prices. Any data errors introduced this way seem irreconcilable, and it is due purely to lack of accurate world price data for minerals.

Land data seemed to be the most accurate for both the Soviet Union and the rest of the world. Soviet land data from SSY are consistent with other non Soviet data sources like the CIA's *USSR Agricultural Atlas*. The rest of the world data from the FAO *Production Yearbook* seem reasonable. The only cause for concern seem to be land prices, which are needed because the input coefficients for land are in value terms. These prices were taken from Bowen, Leamer, and Sveikauskas (1987) and multiplied by the appropriate inflation factor as have been described previously.

4.5.3.2 Technology Matrix The data for the technology matrix in capital and labor were calculated by multiplying the direct input requirements by the appropriate industries in the total requirements for detailed industries; the 1967 367-order input/output structure of the U.S. Economy. These calculations were done by Sveikauskas (1984). The data for both land and natural resources were taken directly from the total requirements of detailed industries. These have already been explained in Section 3.2.

The resource for which the data cause the greatest discomfort is land. Taking the data directly from the I/O table seems to imply that land is an intermediate input like natural resources. Land input data for pasture land were taken from I/O sector 1, arable land from I/O sector 2, and forest land from I/O sector 3. On examining these I/O sectors, several questions come to mind. For I/O sector 1, some of the livestock are grain fed, rather than roughage fed, and hence some of the purchases in this sector should appropriately belong to arable land. In I/O sector 2, I/O purchase 2.07, which contains forest products, should have been eliminated from this category. Another problem is that I/O sector 3 includes fishery, thus making it difficult to distinguish between FISH and FORE. Some data adjustments were made to rectify these problems, but it is probable that some errors still remain in this category.

The use of 1967 data for the technology matrix together with 1989 data for resource endowments may also result in some data inaccuracies. Relative factor and commodity prices may have changed during this period, and this cannot be accounted for by any data adjustments. This data was used because there is no recent data for the technology. Because of these problems it seems reasonable to conclude that, the data for the technology matrix may be the most inaccurate.

4.5.3.3 Other Data Some of the other data used in the model that should be examined include Soviet GNP data. Because of the difficulty in estimating Soviet GNP, the CIA estimate was used because the most thorough work on this problem has been conducted by them and their estimate seemed the most accurate. Determining the GNP endogenously, by taking $\Sigma w_i V_i$, did not seem as accurate because capital stock was relatively too large for some of the countries and would have resulted in biased estimates. Another reason for not using endogenous GNP was that it was impossible to obtain reasonably accurate wage data.

The PPP exchange rate of 0.64 R/US$1 was used as the Soviet exchange rate. After a careful examination of this value it seems quite reasonable. Other PPP exchange rate estimates from the ICP for Eastern Europe are quite consistent with the Soviet PPP rate. On average, the PPP exchange rate was about half of the official exchange rate for most of the Eastern European countries. The U.S. dollar has appreciated against the ruble recently, however, the value for the PPP exchange rate is quite reasonable for 1989.

4.6 Summary

This chapter has given the results of the model for the whole economy. The main results are the Soviet factor abundance supply and post-reform net trade vectors. The Soviet Union is factor abundant in 10 of the 16 commodity aggregates. They are most factor abundant in FORST, followed closely by OIL, and most factor scarce in SALES. The HOV model predicted that the Soviet Union would be a net exporter in eight of the 16 commodity aggregates. The model predicts that the Soviets have positive net trade values in these commodity aggregates: PETRO, METAL, FORE, FISH, FRUIT, BEVER, PMACH, and SMACH. According to the HOV model after a transition to a market economy, the Soviet Union would be a net exporter in primary and agricultural products and a net importer in manufactured products. Sensitivity analysis showed that changes in labor did reduce the net trade values in absolute value terms, but did not alter the main conclusions of the model. Changes in capital did not seriously affect the results. This finding also implied that the choice of the exchange rate did not matter as much.

The net trade vector may be affected by the fact that the Soviet Union does specialize in a subset of the commodities if they use the United States technology. The fact that 1967 data for technology matrix were used may also be a problem. There were also problems of aggregation in some of the Soviet resources, the most serious of these being labor. Another problem that was encountered was that, there was lack of accurate data for some resources. However, the results seem quite reasonable in general, with some important findings.

The finding that the trade patterns will change significantly in agricultural products after market economy has been developed is important. It is also consistent with the theory of comparative advantage, since the Soviets are relatively very factor abundant in land, a resource that is used intensively in the agricultural sector. They move from a negative to a positive trade balance in this sector. Another result that must be emphasized is that the Soviet will increase its volume of trade after transition to a market oriented economy.

5. SOVIET AGRICULTURAL TRADE

5.1 Introduction

The agricultural sector is a very important sector in Soviet economy. According to the CIA's *Handbook of Economic Statistics*, agriculture alone accounted for 20 percent of Soviet GNP in 1989. Based on official Soviet statistics, agricultural products accounted for 16.8 percent of total imports in 1989. Furthermore in Soviet hard currency trade, about 25 percent of the total imports were for agricultural goods, with grain alone accounting for 51.5 percent of agricultural imports. This demonstrates the importance of agricultural trade in the Soviet Union. The economywide HOV model predicted that the Soviet Union would become a net exporter of agricultural products after a market economy is developed. Because of possible effects on world and U.S. agricultural prices, it seems important to reexamine this finding in more detail.

Despite the fact that the Soviet Union has more arable land than any other country in the world, it is the world's largest importer of grain and meat. Several interrelated factors account for the size of Soviet Union's import of agricultural products, which was almost nonexistent until the early part of the 1970s.

One reason may be the policy of self-sufficiency in agriculture, which was begun in the 1960s during the Khrushchev era. Corn production was introduced as a way to improve livestock production. However, because of the climatic needs of corn, land that was better suited for wheat was diverted for the production of corn. Thus, one result of this policy was suboptimal allocation of land for the production of various crops, which might have eventually resulted in reduced productivity.

Another reason for the huge agricultural imports in the 1970s and 1980s may ironically be attributed to the Soviet establishment's dislike of international trade. According to Zeimetz (1991), the traditional view was that the USSR sought to avoid international trade because they feared dependence on an antagonistic world and because integration into the world economy introduced additional complexities and uncertainties into a centrally managed economy. Imports were a way of covering internal shortages and exports were only a means of payment. Thus, the trade policy objective of the Soviet Union was that of zero balance. Hence there was no need for a change in policy when agricultural imports became increasingly necessary to prevent shortages, because oil export revenues continued to rise in the 1970s. This is perhaps the reason for the poor performance of Soviet agriculture during the Brezhnev era.

With the transition from a centrally planned to a market economy, a change is expected in Soviet agricultural trade patterns. The effect of this change could be felt in several agricultural regions including the midwest region of the United States, so it is important to examine post-reform Soviet agricultural trade patterns.

5.2 Review of Soviet Agricultural Reform Literature

5.2.1 Introduction

Several papers have been written on Soviet agricultural reform as they move toward a market economy. Most of these papers, however, are descriptive and do not present any empirical evidence about a change in Soviet agricultural production or trade. Many of these papers only present methods of how the so-called agricultural reform should proceed. However, most of these descriptive papers provide insight into Soviet agricultural reform and must not be discarded. One paper that examines the impact of economic liberalization on Soviet agricultural trade with the help of a nondescriptive model is Liefert, Koopman, and Cook (1990).

5.2.2 Liefert, Koopman, and Cook (1990)

The first paper, to my knowledge, that looks intensively at economic liberalization in the Soviet Union as it pertains to agricultural trade patterns is Liefert, Koopman, and Cook (1990). They use a modeling framework known as Static World Policy Simulation (SWOPSIM). SWOPSIM is a spreadsheet-based modeling framework created to examine the effects of agricultural trade liberalization, primarily in industrialized market economies. In order to apply SWOPSIM to the USSR they incorporate market disequilibrium into the model. They focus on agricultural products such as livestock products, grains, oilseeds, cotton and sugar.

Producer and consumer support, measured as producer and consumer subsidy equivalents (PSEs and CSEs) are the model's policy variables. SWOPSIM works by using PSEs and CSEs to form price wedges in the model's supply and demand equations. These price wedges represent price distortions, so their removal represents getting rid of all price distorting policies. This is illustrated in Figure 5.1.

Initially, Soviet domestic producers receive P_p^1 and produce Q_s^3 while consumers pay P_c^1 and consume Q_d^1, even though total quantity demanded is Q_d^4. PSE equals P_p^1 - P_w^1 and CSE equals P_w^1 - P_c^1. After liberalization the operative demand curve becomes D^2, since domestic markets must now be in equilibrium.

Removing the price wedges, i.e., using world prices, reduce consumption from Q_d^4 to Q_d^3 and reduce production from Q_s^3 to Q_s^1. Net imports now equal Q_d^3 - Q_s^1. Since the Soviet Union is considered a large country, an increase in import demand causes the world price of the representative commodity to rise to P_w^2. Assuming that agricultural reform will increase productivity causes the supply curve to shift to the right, reducing net imports.

Estimation of the PSEs and CSEs requires knowledge of the exchange rate for converting Soviet domestic rubles into U.S. dollars, since all prices are in Soviet domestic rubles. Liefert, Koopman, and Cook estimate a shadow exchange rate (SER) between the U.S. dollar and the ruble of 1.91 rubles/dollar for 1986. A value of 2.5 rubles/dollar is also used as an upper limit. Their model results are very sensitive to the SER value.

They conclude, among other things, that liberalization would reduce grain imports substantially and perhaps even make the Soviet Union a net exporter. With 1.91 SER, net grain imports fall from 28 to 1.5 million tons. Although corn imports would remain relatively high, they expect the USSR to become a wheat exporter. Consumption of foodstuffs is expected to fall as subsidies are removed. Imports of soybean meal are expected to rise irrespective of which SER is used. Using the SER rate of 1.91, meat imports are expected to rise from 0.8

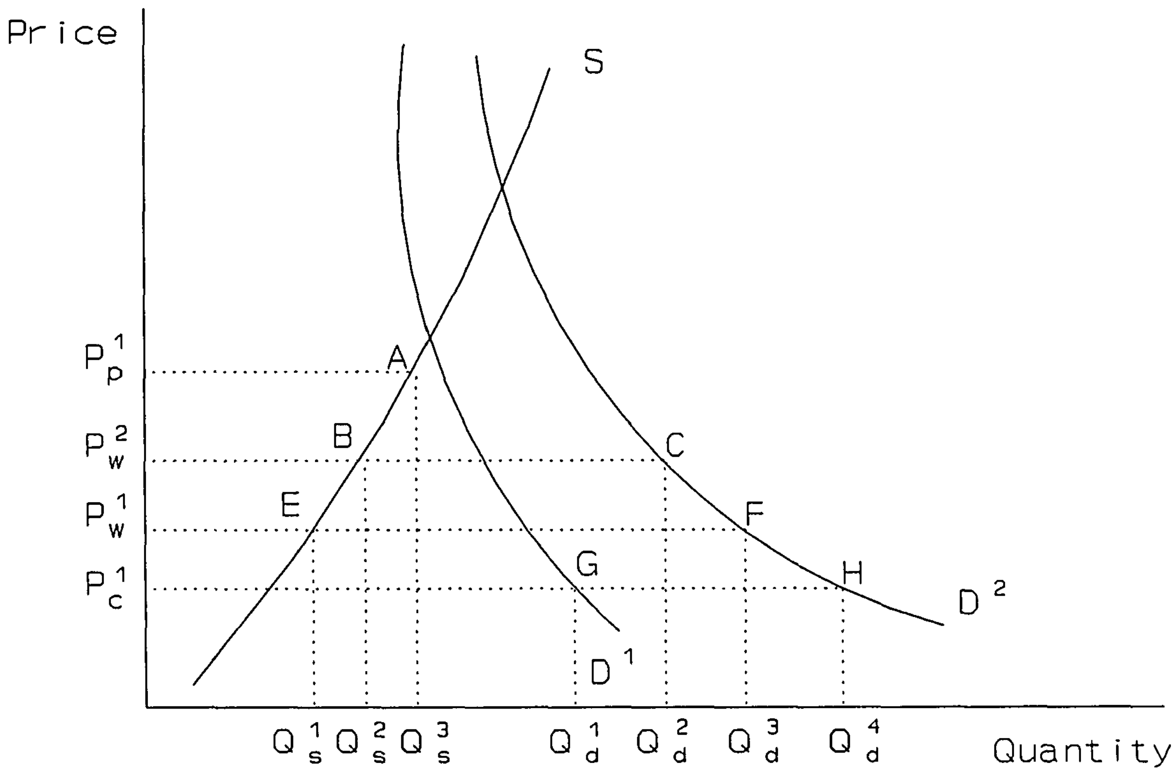

Figure 5.1. The effect of Soviet agricultural trade liberalization

to 3.6 million tons. However, with depreciation of the ruble to an SER rate of 2.5, this increase reduces to almost zero. Overall, the estimates do not support a strong conclusion about changes in meat imports. They also predict a decline in cotton production due largely to reduced crop acreage after liberalization.

This paper gives clear predictions about Soviet patterns of agricultural trade after economic liberalization. The study is also important because it is a pioneering work that attempts to predict post-reform agricultural trade patterns in the Soviet Union. But the results seem to rely too heavily on the SER, which is not known with any certainty. Another problem is that the SWOPSIM model is based primarily on prices and the demand sector and not factor endowments, so the results seem to be influenced by market disequilibria and price distortions.

5.2.3 Other Papers

Most of the other papers in the Soviet agricultural reform literature seem to describe possible ways of achieving successful agricultural reform.

One such paper is Brooks et al. (1991). This paper examines agricultural transition and compares the present agricultural situation with that of the market economies of the West. According to the authors, macroeconomic stabilization, price liberalization, and a policy of decollectivization are key elements for successful transition.

Another paper that provide insight into Soviet agricultural reform is Braverman and Guasch (1990). They acknowledge the lack of economic theory to analyze some of the issued concerning agricultural reform. They compare the experience of structural adjustment programs in developing countries to the reforms in Eastern Europe and the Soviet Union and draw some insights from these programs. They conclude that reform must include monetary and fiscal policies; exchange rate and domestic price reforms; reforms in credit, land, and property rights; and policies that will lead to improved technology.

Some other interesting papers on Soviet and Eastern European agricultural reform include Johnson (1990), Csaki (1990), and Cook (1990).

5.3 Agricultural Trade Model and Aggregation

5.3.1 Introduction

This section gives a summary of the model that is used to predict post-reform Soviet agricultural trade. The Liefert, Koopman, and Cook (1990) paper uses the SWOPSIM model, which is based primarily on prices and the demand sector, and hence do not seem to capture the effects of factor endowments on trade patterns. Here, Soviet agricultural trade after economic liberalization is assessed using the HOV model, which predicts the patterns of trade based solely on resource endowments. This section also provides information on which commodity and factor aggregates are considered in this model.

5.3.2 Modified HOV Model

Using the HOV equations from Equation (2.10) to predict Soviet post-reform agricultural trade patterns requires resource endowments for several countries. It is impossible, however, to secure data for agricultural resource endowments for all the countries included in this study.

A modified version of the HOV model, which reduces the number of countries to just two, and provides multilateral trade patterns, is developed. To examine this model further, we note that, unless otherwise stated, variables used here have the same definition as those given in Chapter 2.

Suppose, now there are only two countries, the United States and the Soviet Union. Let the variables with u and s superscripts, represent variables that pertain to the United States and the Soviet Union, respectively. Thus C^s represents Soviet Union consumption and C^u represents U.S. consumption. Let g be defined as the Soviet consumption share of U.S.

output.

Assume that

$$\frac{C^s}{C^u} = \frac{Y^s - B^s}{Y^u - B^u}, \tag{5.1}$$

where B^u and B^s are the U.S. and Soviet balance of trade, respectively. $B > 0$ implies a positive trade balance. From Equation (5.1) we can have

$$C^s = gC^u, \tag{5.2}$$

where $g = (Y^s - B^s)/(Y^u - B^u)$. By the definition of the net trade vector, as output minus consumption, U.S. consumption can be given as $C^u = Q^u - T^u$, where T^u and Q^u are U.S net export and output vectors, respectively.

Then, define the Soviet trade patterns as

$$T^s = Q^s - C^s. \tag{5.3}$$

Using Equation (5.2) and the fact that $Q = A^{-1}V$, Equation (5.3) can be rewritten as

$$T^s = A^{-1}V^s - g(A^{-1}V^u - T^u). \tag{5.4}$$

Simplifying Equation (5.4) we have

$$T^s = A^{-1}(V^s - gV^u) + gT^u. \tag{5.5}$$

Equation (5.5) provides patterns of trade predictions that are identical to the HOV model in Equation (2.10), if U.S. trade data conform to the HOV model, while utilizing only two countries. To see this assume that the U.S. trade patterns, T^u have been derived using the HOV equations. Then Equation (5.5) becomes

$$T^s = A^{-1}(V^s - gV^u) + g[A^{-1}(V^u - kV_w)], \tag{5.6}$$

where V_w is the world factor endowment vector and k is the U.S. consumption share of world output defined by $(Y^u - B^u)/Y_w$. Equation (5.6) can be simplified to

$$T^s = A^{-1}(V^s - gkV_w). \tag{5.7}$$

Note that gk is the Soviet consumption share of world output defined by s in Equation (2.10). Thus, Equation (5.7) is identical to the HOV equations given in Equation (2.10).

One advantage to using Equation (5.5) is that only two countries are used in the model, thereby reducing the possibility of data errors. Another advantage is that the possibility of violating the factor price equalization theorem is reduced with fewer countries. However, Equation (5.5) relies on the assumption that U.S. and Soviet consumption are the same, scaled only by income difference. This model also relies on the assumption that U.S. net trade data can be explained accurately by the HOV model. Violating these two assumptions may reduce the accuracy of the results.

The HOV model is a general equilibrium model, which considers all sectors of the economy. However, because of data inaccuracies in the economywide model, especially in the technology matrix, only the agricultural sector is considered in this model. The addition of further aggregates of primary and manufactured products will contribute to additional data errors. Hence, Equation (5.5) is used with the agricultural sector representing the whole economy.

5.3.3 Commodity and Factor Aggregates

The use of Equation (5.5) presupposes an even model i.e., the number of factors equals the number of commodities. The model contains nine agricultural commodities and factors. Since a partial equilibrium model is used, only commodities in the agricultural sector are considered. The nine commodity aggregates for the agricultural trade model are wheat, barley, corn, other grains (sorghum, oats, rye, and rice), Soybeans, other oilseeds (sunflower seeds and rapeseed), cotton, beef, and pork/chicken. These commodities can be summarized into four categories: grain (wheat, barley, corn and other grain), oilseeds (soybeans and other oilseeds), cotton, and meat (beef and pork/chicken). These were chosen because they are important in current Soviet and U.S. agricultural trade data.

The nine factor aggregates used in the model are the ones that would best explain agricultural trade patterns. These factors are capital, skilled labor, unskilled labor, land I, land II, land III, fertilizer, chemicals, and energy. The land categories are the most important in the production and trade of agricultural goods. The last three factor aggregates can be considered as manufactured inputs.

5.4 Data Sources and Derivation

5.4.1 Introduction

This section gives the sources of the data that are used in this model, and also the procedure in which the data was collected or derived. The sources of the data and the procedure used to collect them are important to an understanding of both the model and the overall accuracy of the results.

5.4.2 Soviet Factor Endowments

Soviet capital is the amount of capital used for the agricultural sector. Labor is divided into two categories, skilled and unskilled. Soviet skilled labor is the part of the agricultural work force with university or college degrees and this number is taken from *Soviet Statistical Yearbook* (SSY). The remainder of the work force in the agricultural sector is considered unskilled labor.

The arable land category is considered the most important in the Soviet factor endowment category, so more emphasis is placed on the derivation of data for this category.

Arable land is divided into three different categories based on temperature and precipitation. To determine the amount of Soviet arable land in each of the categories, data for normal monthly temperature and precipitation for 32 Soviet weather stations are used. Data, are obtained from several issues of the *Weekly Weather and Crop Bulletin*. From these data, average normal monthly temperatures between April and October, the normal planting season for most crops, and normal annual precipitation for each of the weather stations are calculated. Differences in arable land were based primarily on temperature differences among the 32 cities. Differences in precipitation did not seem to matter as much, and thus served only as a secondary factor. Table 5.1 gives the average normal monthly temperature from April to October, and total normal annual precipitation for the 32 Soviet weather stations. The data for average temperatures in Table 5.1 were divided into three categories: high, medium and low, while precipitation

Table 5.1. Normal monthly average[a] temperature and normal annual precipitation for 32 weather stations in the Soviet Union

Weather Station	Temperature[b]	Precipitation[c]
Tallinn	10.77	584.7
Leningrad	11.34	586.9
Kaunas	12.46	608.4
Minsk	12.36	614.5
Kazan	12.40	490.3
Moscow	12.29	650.6
Sverdlovsk	10.71	465.7
Omsk	11.61	354.0
Kustanay	13.07	295.0
Krasnoyarsk	11.43	450.6
Novosibirsk	10.17	375.9
Barnaul	11.86	429.2
Khabarovsk	12.93	627.9
Vladivostok	12.36	821.9
Kiev	14.54	615.1
Lvov	13.14	718.0
Kirovograd	15.29	464.9
Odessa	16.33	462.5
Yalta	18.60	563.5
Voronezh	14.04	534.7
Saratov	14.16	411.4
Kharkov	14.99	529.0
Volgograd	16.56	364.2
Rostov	17.10	573.0
Astrakhan	18.27	199.8
Krasnodar	17.84	671.4
Orenburg	14.74	372.4
Tselinograd	12.04	242.5
Karaganda	12.91	302.8
Tbilisi	19.11	500.1
Tashkent	20.94	437.6
Ashkhabad	23.73	241.1

[a]Normal monthly temperatures were averaged for months between April and October.
[b]Temperature in degree celsius.
[c]Precipitation in millimeters.

data were divided into high and low. If the average temperature is denoted as temp, then, high ≡ temp ≥ 18°C, medium ≡ 14°C ≤ temp < 18°C and low ≡ temp < 14. Precipitation was divided so that cities with annual precipitation greater that 400 millimeters were considered high.

The amount of Soviet arable land in each of the three categories is determined using data on temperature and precipitation together with data on the amount of arable land available in each of the 19[1] economic regions of the USSR. Data for arable land in each of the economic regions were calculated using information from the CIA's USSR Agricultural Atlas and Lydolph (1979). Table 5.2 gives total land area, percentage of total land area as arable land, and arable land in each economic region of the USSR. Soviet factor endowments for land I, land II, and land III are determined using data given in Tables 5.1 and 5.2. The division of arable land into the three different categories is summarized in Table 5.3.

Soviet resource endowment of fertilizer is the amount of nitrogen, phosphate, and potash fertilizers used in the production of agricultural commodities. The amount of Soviet fertilizer consumed by the agricultural sector is given in SSY. These figures are compatible with Soviet fertilizer production figures given in the U.N. Fertilizer Yearbook.

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[1]Moldavian SSR in included in this number.

Table 5.2. Total land area, percentage of total land area considered as arable land, and arable land in the Soviet Union, by Soviet economic region

Economic Region	**Total Land Area**[a]	**Percent**	**Arable Land**[a]
Northwest	166.2	2.9	4.82
Central	48.6	30.9	15.02
Volga-Vyatka	26.3	29.7	7.81
Central Chernozem	16.7	66.2	11.06
Volga	68.0	43.8	29.78
North Caucasus	35.6	46.2	16.45
Urals	68.1	26.5	18.05
West Siberia	242.8	8.2	19.91
East Siberia	412.4	2.0	8.25
Far East	621.6	0.6	3.73
Donets-Dnieper	22.2	64.4	14.30
Southwest	27.1	48.6	13.17
South	11.4	58.8	6.70
Baltic	18.9	29.0	5.48
Transcaucasus	18.7	15.2	2.84
Central Asia	127.7	4.4	5.62
Kazakhstan	271.9	12.3	33.44
Belorussia	20.7	29.2	6.04
Moldavia S.S.R.	3.4	60.0	2.04
USSR	**2228.3**	**10.1**	**224.51**

[a]In million hectares.

Table 5.3. Data for Soviet factor endowments of the three land classifications, by Soviet economic region

Land Classification	Economic Regions	Arable Land[a]
Land I		
	Baltic	5.48
	Belorussia	6.04
	Central	14.82
	Central Chernozem	11.02
	Middle Volga (East)	9.61
	Northwest	4.82
	Southwest	13.17
	Urals (North)	13.54
	Volga-Vyatka	7.68
	East Siberia	8.25
	Far East	3.73
	West Siberia (Rest)	11.59
	TOTAL	109.77
Land II		
	Donets-Dnieper	14.30
	Lower Volga	10.35
	Middle Volga (West)	9.61
	Moldavia S.S.R.	2.04
	North Caucasus	16.45
	South	6.70
	Transcaucasus	2.84
	Urals (South)	4.51
	TOTAL	66.80
Land III		
	Central Asia	5.62
	Kazakhstan	33.44
	West Siberia (Southwest)	8.23
	TOTAL	47.30

[a]In million hectares.

These figures are converted into value terms using U.S. fertilizer prices given in the U.N. Fertilizer Yearbook.

Endowment for Soviet chemicals is the amount of pesticide used in their agricultural sector. This number is given in the SSY, in 100 percent of active ingredient of the type of pesticide. These figures are again converted to value terms using U.S. herbicide prices from the USDA's *Agricultural Resources*.

Soviet endowment for energy is taken as the value of fuel and electricity used in the agricultural sector. The data for Soviet agricultural consumption of fuel and electricity are given in *Soviet Agricultural Yearbook* (Sel'skol Khoziaistvo, SSSR). These figures are converted into value terms using U.S. electricity prices from in the USDA's *Agricultural Statistics*. Data for Soviet factor endowments for agriculture are given in Table B.3.

5.4.3 U.S. Factor Endowments

Resource endowment for capital is the amount of machinery used as inputs for the agricultural sector of the U.S. economy. The number of workers considered skilled labor are the part of the agriculture work force who are able to operate machinery and other technical equipments. These data are available from the USDA's *Agricultural Statistics*. Other workers are considered as unskilled labor.

Table 5.4 shows the divisions of U.S. arable land into the three categories. This division was based primarily on temperature differences. Three weather stations were selected from each USDA region[2], except for the Mountain region in which four were selected. Data for normal average monthly temperatures for the 31 selected weather stations were taken from the *Insulation Data Manual*. Monthly temperatures, averaged between April and October were grouped into high, medium, and low. The average temperatures for each group in the U.S. were similar to those used for the Soviet Union, but were slightly higher. Temperatures greater than 21°C were considered high, between 16°C and 21°C as medium, and below 16°C as low. Data for the amount of arable land for each USDA region were taken from the USDA's *Agricultural Resources*. Data for the amount of arable land for each state is from *Agricultural Statistics*.

The other U.S. resources were taken from two other sources. U.S. fertilizer endowment is taken as the production of nitrogen, phosphate, and potash fertilizers. The data are from the U.N. *Fertilizer Yearbook*. These figures were multiplied by fertilizer prices to convert them into value terms. Both pesticide use and production were taken from the

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[2]The ten USDA regions are: Northeast, Lake States, Corn Belt, Northern Plains, Appalachians, Southeast, Delta States, Southern Plains, Mountain, and Pacific.

Table 5.4. Data for U.S. factor endowments of the three land classifications, by USDA region

Land Classification	**USDA Region**	**Arable Land**[a]
Land I		
	Northeast	5.91
	Lake States	17.17
	Northern Plains I	20.66
	Mountain I	11.42
	Pacific I	5.43
	TOTAL	60.59
Land II		
	Northern Plains II	24.26
	Corn Belt	41.47
	Mountain II	5.99
	Appalachians	10.94
	TOTAL	82.66
Land III		
	Pacific II	4.70
	Mountain III	2.15
	Southern Plains	22.19
	Delta States	10.25
	Southeast	7.41
	TOTAL	46.70

[a]In million hectares.

Northern Plains I: North Dakota and South Dakota.
Mountain I: Idaho, Montana and Wyoming.
Pacific I: Oregon and Washington.
Northern Plains II: Nebraska and Kansas.
Mountain II: Nevada, Utah and Colorado.
Pacific II: California.
Mountain III: Arizona and New Mexico.

USDA's *Agricultural Resources*. Energy is taken as the sum of oil and electricity used in agriculture. Data for U.S. factor endowments for agriculture are given in Table B.3.

5.4.4 Technology Matrix

In order to calculate the data for the technology matrix, an assumption is made that, crops are produced on land for which climatic conditions are suitable. Hence, the model assumes that some of the land groups may not be used to produce certain kinds of crops. Information on the types of land (climatic conditions) needed for the production of a particular crop was available from the USDA agriculture handbook; *Major World Crop Areas and Climatic Profiles*. In addition, information on the "ideal" growing climatic conditions for several of the crops were available from several other sources. For example, information on ideal weather conditions for growing corn is from the Corn Handbook, by Iowa State University (ISU) extension.

The data used to calculate the amount of land required to produce a unit of each of the agricultural crops are from USDA's *Crop Production*. Data required to calculate land needed to produce a unit of meat is from *Livestock Enterprise Budgets for Iowa*. The data for the amount of arable land required to produce a unit of an agricultural crop were taken from a five year (1986-90) U.S. average yield of the crops being used. The data in the *Crop Production*, originally in units (usually bushels) per acre, were converted to value per hectares, using crop price data from the USDA's *Agricultural Statistics*. The reciprocals of these values were multiplied by 1000, to have hectares per $1000 of output. For meat data the amount of feed required for each unit of weight was converted to amount of arable land by the yield and prices of the crops involved. Amount of pasture required were taken directly from the *Livestock Enterprise Budgets for Iowa*.

The data for the remaining inputs are calculated using information from the *U.S. Average Cost of Production for Major Field Crops*. These data, given in dollars per acre were converted to dollars per $1000 of output using U.S. average crop yield and price data. The data for labor were further converted into man hours per $1000 using a wage rate of $6 per hour.[3]

Data for the amount of capital required to produce a unit of commodity were taken as the sum of capital replacement, operating capital, and other nonland capital. Data for skilled and unskilled were taken as amount of unpaid labor and hired labor, respectively. The justification for this is that most of the unpaid labor was labor that required the operation of

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[3]The wage rate of $6/hour was taken from "Estimated cost of crop production in Iowa - 1992", November 1991, by Iowa State University extension.

machinery and other technical equipments, which needed considerable amount of skill. The data for fertilizer and chemicals were taken from similar categories in the *U.S. Cost of Production* (COP) data. Data for energy were taken from fuel, lubrication and electricity category also from the COP data.

A few agricultural commodities are considered in the model but total agricultural resources are used. To adjust for this each element in the technology matrix data is multiplied by a factor of 100. The data for technology matrix are given in Table B.3.

5.5 Model Simulation and Results

5.5.1 Introduction

This section reports the results of the agricultural trade model. The modified HOV model is used to calculate Soviet post-reform agricultural trade patterns. The results are examined in section 5.5.2. Section 5.5.3 analyzes the results and examines the model's underlying assumptions, which are important elements in the overall accuracy of the results of the model.

5.5.2 Post-reform Agricultural Trade Patterns

Since the model considers the agricultural sector as the whole economy, C^u and C^s are considered U.S. and Soviet agricultural consumptions, respectively. The ratio g is defined as the Soviet agricultural consumption share of U.S. agricultural consumption and it equals 1.09. The modified HOV model, as given in Equation (5.5) relies heavily on the assumption that U.S. agricultural trade data are reasonably explained by the HOV model from Equation (2.10). The accuracy of the results may be severely affected if this assumption fails to hold. However, the question of whether U.S. agricultural trade data are reasonably explained by the Heckscher-Ohlin theory cannot be answered adequately in this model because of lack of data availability. Another problem that could affect the model's results is the fact that $g > 1$. Since $g > 1$, the Soviet net trade vector seems to be overshadowed by U.S. agricultural trade data.

In attempting to solve these problems, the model is run using the following equations:

$$T^s = A^{-1}(V^s - gV^u) + xgT^u, \qquad x = 0,\ \tfrac{1}{2},\ 1. \qquad (5.8)$$

The post-reform agricultural trade patterns for $x = 0, 1/2, 1$ are reported in Table 5.5.

Table 5.5. Post-reform Soviet agricultural trade patterns calculated using Equation (5.8), for different values of x

	Net Trade Values[a]		
Commodity Aggregates	**x = 0**	**x = 1/2**	**x = 1**
Wheat	3412.24	6599.79	9787.33
Barley	1403.39	1494.86	1586.33
Corn	-4709.84	-1107.56	2494.73
Other Grains	1030.81	1962.36	2893.91
Soybeans	-4284.91	-2120.33	44.25
Other Oilseeds	1178.94	1246.36	1313.78
Cotton	-1567.49	-333.91	899.66
Beef	-582.31	-691.57	-800.83
Pork/Chicken	-1699.21	-1615.26	-1531.31
Trade Balance	**-5818.37**	**5434.74**	**16687.84**

[a]In million U.S. dollars.

The trade vector for x = 0, constitutes a U.S. and Soviet bilateral trade pattern. This model assumes the existence of only two countries in the world. With x = 0, the Soviet Union is a net exporter in wheat, barley, other oilseeds, and other grains. Wheat is the largest export, while corn is the largest import. Using this model, the Soviet Union exhibits a trade deficit of US$5.8 billion, for the commodities being considered.

The results for x = 1 can be interpreted as Soviet multilateral trade patterns, assuming the U.S. agricultural trade data are explained by Equation (2.10) and the factor g reasonably represents the Soviet and U.S. agricultural consumption share. When this model is used, the Soviet Union is a net exporter of all the commodities except for beef and pork/chicken. When x = 1 the Soviets exhibit a positive trade balance of US$16.7 billion.

The model results with x = 1/2 are taken as a reasonable approximation of Soviet multilateral trade patterns. In this model, the Soviet Union exports wheat, barley, other oilseeds and other grains. The patterns of trade are identical to the case where x = 0, but the volume of trade is quite different between the two models. The Soviet Union exhibits a trade surplus of US$5.4 billion compared with a trade deficit of US$5.8 billion in the x = 0 case.

5.5.3 Analysis of Results

U.S. and Soviet agricultural trade data, which are needed to analyze the results are presented in Table 5.6.

The U.S. trade vector given in Table 5.6, shows that U.S. agricultural trade data seem to influence the results for the x = 1 model. The signs for the Soviet net trade values predicted by the modified HOV model with x = 1, (from Table 5.5) are the same as U.S. trade data (in Table 5.6) in all but one of the commodities. These results are quite reasonable, considering the model that was used to derive them.

The Soviet Union, when compared with the United States, is factor abundant in land I and factor scarce in land II and land III. However, since the model attributes U.S. corn exports mainly to its factor abundance in land II, it is possible for the Soviet Union to also be factor abundant in land II when compared with the rest of the world. So it is reasonable for the Soviets to also export corn and soybeans, crops that are factor intensive in land II.

When the x = 1 model is used, Soviet trade patterns for agricultural commodities seem to change most significantly. Based on 1989 Soviet agricultural trade data from Table 5.6, the signs of the net trade values are reversed for wheat, barley, corn, soybeans, and other grains, implying that the Soviet Union will become a net exporter of these commodities. Based on this model, the Soviets move from a trade deficit of

Table 5.6. U.S. and Soviet agricultural net trade data for 1989

Commodity Aggregates	Agricultural Trade Data[a]	
	United States	**Soviet Union**
Wheat	5805.7	-2108.5
Barley	166.6	-426.4
Corn	6561.1	-2221.1
Other Grains	1696.7	-237.0
Soybeans	3942.5	-256.1
Other Oilseeds	122.8	75.7
Cotton	2246.8	1320.9
Beef	-199.0	-819.0
Pork/Chicken	152.9	-284.7
Trade Balance	**20496.1**	**-4956.2**

[a]In million U.S. dollars.

US$5.0 billion to a trade surplus of US$16.7 billion for these commodities.

The model with x = 1/2 is examined because it is possible that U.S. agricultural trade patterns may be explained by factors different from the HOV model, and also because the factor g may not accurately represent the Soviet, U.S. agricultural consumption share. This model may not attribute U.S. corn export mainly to U.S. factor abundance in land II. In this case the Soviet Union may not be factor abundant in land II, and may not export corn and soybeans. Therefore the results predicted by this model are justifiable.

Both models agree that the Soviet Union will export wheat, barley, other oilseeds, and other grains. Sunflower and rye, which are dominant in other oilseeds and other grains, respectively, are both factor intensive in land I. Thus it can be concluded that the Soviets export commodities grown on land I, irrespective of which model is used. Both models also agree that the Soviet Union will continue to import meat, perhaps because, in this model, most of the feed needed for livestock is from crops grown on land II.

The model with x = 0 is a two-country model. The results predicted by this model imply that in a two-country (U.S. and Soviet Union) world, the U.S. would import wheat, barley, other oilseeds, and other grains from the Soviet Union while exporting corn, soybeans, cotton, beef, and pork/chicken.

These results seem to conform to the theory of comparative advantage.

The results obtained by the modified HOV model are partially consistent with the Liefert, Koopman and Cook (1990) results. Both models predict that the Soviets will become a wheat exporter and will continue to be a meat importer. But in the Liefert et. al. model meat imports are significantly reduced. According to the modified HOV model, the Soviets will either export corn or import only small amounts, but in the Liefert et. al. model corn imports remain relatively high. Perhaps the main difference between the results from the HOV model and the SWOPSIM model is that in the SWOPSIM model the Soviets remain a net agricultural importer but in the HOV model they become a net exporter of agricultural commodities.

The model results are primarily influenced by differences in land, as evidenced by the matrix defined by $[a_{ji}^{-1}(V^s - gV^u)]$. However, the model ignores important land differences like soil quality, which affects yield, and influences the types of crops grown on such land. The temperature for the U.S. is generally higher and the cutoff points were slightly different for each country. Hence, land I in the Soviet Union may not be exactly the same as land I in the United States. Thus, the model ignores differences in agricultural production, resulting from the fact that the Soviet Union is further north than the United States. Differences in the length of days between the two countries are not accounted for in the model.

The underlying assumptions of the HOV model may also affect the accuracy of the results if they do not hold. For instance, the assumption that prevents the specialization of a subset of the commodities may fail to hold in this model. This is discussed in Chapter 4. The fact that the HOV model is applied only to the agricultural sector may also cast some doubt on the results.

5.6 Summary

This chapter examined some of the studies that address the question of Soviet agricultural reform. The Liefert, Koopman, and Cook (1990) paper, a pioneering effort in predicting Soviet agricultural trade patterns after economic liberalization is examined. A modified HOV model is developed to examine agricultural trade patterns. The modified HOV model in Equation (5.8) is used to predict post-reform Soviet agricultural trade patterns. The main results are summarized as follows: the Soviet Union will become a net exporter of grain and will probably be a net importer of oilseeds and cotton; the Soviets will continue to be a net importer of meat; and will become a net exporter of agricultural commodities. Thus, the results obtained here support those from in the economywide model.

6. SUMMARY AND CONCLUSIONS

6.1 Summary

This study assessed the impact of an economic transition from a centrally planned to a market economy on trade patterns of the Soviet Union. The Heckscher-Ohlin model, which is a standard general equilibrium model in international trade that predicts the patterns of trade based solely on resource endowments, was chosen for this study. The linear HOV equations have been proven in Leamer (1984) and in other studies, to be very potent in their explanation of trade patterns.

Because the Soviet Union has not fully liberalized its economy, some additional assumptions were necessary to make the model applicable to the Soviet economy. The main one was the use of U.S. technology as the matrix of factor intensities. Using the HOV equations in their general form requires extensive data. Data on capital, labor, land, and natural resources were collected for the Soviet Union and 45 other countries. Data for the resource endowments were from several different sources, and translation from Russian to English was required for some of the Soviet data. The data for the technology matrix were calculated by Sveikauskas (1984) from the U.S. 367-order input-output table. The model also required Soviet consumption share of world output, and was calculated by taking the Soviet GNP divided by world GNP. The model was simulated using data on Soviet and world resource endowments, Soviet consumption share, and the technology matrix.

According to the HOV model, the net trade vector can be obtained by multiplying the inverse of the factor intensity matrix by the excess factor abundance supply. The Soviet excess factor abundance supply was calculated by subtracting their consumption share of world output, multiplied by the world factor endowment, from the Soviet factor endowment vector. A modified version of the HOV model that utilizes only two countries to determine the patterns of trade was developed to examine post-reform Soviet agricultural trade.

6.2 Conclusions and Further Research

The main results of the study seem quite reasonable. After a market economy has been developed, the Soviet Union will continue to be a net exporter in primary products, even though the balance of trade in this sector would be significantly reduced. In agricultural products, the Soviet

Union will move from being a net importer to being a net exporter. This is perhaps due to the factor abundance of land, a resource that is used intensively in the agricultural sector.

Even though there will be some improvement in the balance of trade for manufactured products, the Soviet Union will continue to be a net importer. The reason for this may be due to the fact that the Soviet Union is relatively scarce in capital. Another finding was that after a market economy is developed, the volume of Soviet trade is expected to increase. The fact that the Soviets may specialize in a subset of the commodities may seem to cast some doubt on these results, but additional analysis revealed that this does not adversely affect the net trade vector.

The agricultural trade model was run using agricultural factor endowments from the United States and the Soviet Union. The model predicts that the Soviet Union will become a net exporter in grain. In particular, the Soviets will export wheat after economic liberalization. This result could affect the U.S. price of wheat since the Soviet Union currently imports most of its wheat from the United States. The Soviets may, however, continue to import corn. The model also predicts that the Soviet Union will continue to import oilseeds because imports of soybeans may actually increase. In addition the Soviets will continue to import meat. On the whole, the Soviet

Union will become a net exporter of agricultural commodities.

Improvement of this study can be made in a few areas. Thus, further work in predicting the trade patterns after a transition from a centrally planned to a market economy can benefit firstly, from an improvement of the data required for the model. Even though particular attention was focused on data collection and aggregation, some of the problems encountered in this area may still be unresolved. Data for Soviet labor was perhaps the one that caused the greatest difficulty in aggregation. Sensitivity analysis proved helpful in this area, however, more accurate data that do not result in aggregation problems would be the ideal solution. The data for the technology matrix were calculated from 1967 U.S. input-output table and seemed to contain some inaccuracies. A more recent data for the technology matrix would improve the results.

The choice of a different model, if possible, may be helpful in improving the results. One major flaw of the HO model is its reliance on constant returns to scale and also the fact that it ignores issues like intra-industry trade and product differentiation. The economies of scale and product differentiation (PE) model does account for some of the shortcomings of the HO model. However it does not possess any well structured equations like the HOV equations, for empirical work.

A challenging assignment would be to develop the PE model into a form more suitable for empirical work and use it to predict Soviet trade patterns as its economy is transformed from a centrally planned to that of a western-style, market-based system.

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ACKNOWLEDGEMENTS

I would like to express my deep appreciation to Drs. Dermot Hayes and Stanley Johnson, for their invaluable help and guidance throughout the dissertation stage of my Ph.D. program. I would also like give special thanks to Drs. Harvey Lapan, Hylke Van de Wetering, and Yasuo Amemiya for their helpful comments and suggestions during the research and writing of the dissertation.

I also express appreciation to all those who helped me collect data. In this regard, special thanks go to Dr. Bill Liefert and other workers at the Centrally Planned Economies Branch of the U.S. Department of Agriculture. I also express sincere appreciation to Professor Harry Bowen of New York University for providing me with the data for U.S. technology.

I also give special thanks to Dr. Seigey V. Sotnikov, who provided me with most of the data on Soviet resources and also translated them from Russian to English. I thank Mr. Yuri Yurmakov for helping me with data translation.

Last but not least I give special thanks to by brothers Fred, Seth, and Emmanuel; sisters Patricia and Evelyn and especially to my mother Beatrice for their support and encouragement throughout my college career.

APPENDIX A: COMMODITY AND LABOR AGGREGATES

Table A.1. Explanation of commodity aggregates from industry classification of 1967 input-output table

I/O	Aggregates/Industry Classification	SIC Codes
	1. PETROLEUM PRODUCTS	
8.00	Crude petroleum and natural gas	1311, 1321
31.01	Petroleum refining and related products	2911, 299
	2. IRON, FERROALLOY PRODUCTS	
5.00	Iron and ferroalloy ores mining	1011, 106
37.02	Iron and steel foundries	332
37.03	Iron and steel forging	3391
37.04	Primary metal products, n.e.c.	3399
	3. NONFERROUS PRODUCTS	
6.01	Copper ore mining	102
6.02	Nonferrous metal ores mining, except copper	103-5, 108-9
38.01	Primary copper	3331
38.02	Primary lead	3332
38.03	Primary zinc	3333
38.04	Primary aluminum	3334, 28195
38.05	Primary nonferrous metals, n.e.c	3339
38.06	Secondary nonferrous metals	3341
38.07	Copper rolling and drawing	3351
38.08	Aluminum rolling and drawing	3352
38.09	Nonferrous rolling and drawing, n.e.c.	3356
38.10	Nonferrous wire drawing and Insulating	3357
38.11	Aluminum castings	3361
38.12	Brass, bronze, and copper casting	3362
38.13	Nonferrous castings, n.e.c.	3369
38.14	Nonferrous forging	3392
	4. FERTILIZER, OTHER MINERAL PRODUCTS	
7.00	Coal mining	11, 12
9.00	Stone and clay mining and quarrying	141-2,144-5 148-9
10.00	Chemicals and fertilizer mineral mining	147
35.01	Glass, and glass products, except containers	3211,3229 3231

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
35.02	Glass containers	3221
36.01	Cement, hydraulic	3241
36.02	Brick and structural clay tile	3251
36.03	Ceramic wall and floor tile	3253
36.04	Clay refractories	3255
36.05	Structural clay products, n.e.c.	3259
36.06	Vitreous plumbing fixtures	3261
36.07	Food utensils, pottery	3262, 3263
36 08	Porcelain electrical supplies	3264
36.09	Pottery product. n.e.c.	3269
36.10	Concrete block and brick	3271
36.11	Concrete products	3272
36.12	Ready-mixed concrete	3273
36.13	Lime	3274
36.14	Gypsum products	3275
36.15	Stone cut and stone products	3281
36.16	Abrasive products	3291
36.17	Asbestos products	3292
36.18	Gaskets and insulations	3293
36.19	Minerals, ground treated	3295
36.20	Mineral wool	3296
36.21	Nonclay refractories	3297
36.22	Nonmetallic mineral products, n.e.c.	3299
	5. FOREST PRODUCTS	
2.07	Forest, greenhouse, and nursery products	0102, pt. 014
20.01	Logging camps and logging contractors	2411
20.02	Sawmills and planing mills, general	2421
20.03	Hardwood dimensions and flooring	2426
20.04	Special product sawmills, n.e.c	2429
20.05	Millwork	2431
20.06	Veneer and plywood	2432
20.07	Prefabricated wood structures	2433
20.08	Wood preserving	2491
20.09	Wood products, n.e.c	2499
21.00	Wooden containers	244
24.01	Pulp mills	2611
24.02	Paper mills, except building paper	2621
24.03	Paperboard mills	2631
24.04	Envelopes	2642
24.05	Sanitary paper products	2647
24.06	Wallpaper and building paper and board mills	2644, 2661

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
24.07	Converted paper, products, n.e.c., except containers and boxes.	2641, 2643, 2645-6,2649
25.00	Paperboard containers and boxes	265
26.01	Newspapers	2711
26.02	Periodicals	2721
26.03	Book printIng and publishing	273
26.04	Miscellaneous publishing	2741
26.05	Commercial printing	2751, 2752
26.06	Manifold business forms blank-books, and binders	2761, 2782
26.07	Greeting card publishing	2771
26.08	Miscellaneous printing services	2753, 2789, 279
	6. MEAT AND ANIMAL PRODUCTS	
1.01	Dairy farm products	0132
1.02	Poultry and eggs	0133-4 pt 014
1.03	Meat animals and miscellaneous livestock products	0135-6,0139, pt 014,0193 pt. 0729
14.01	Meat products	201
14.02	Creamery butter	2021
14.03	Cheese, natural and processed	2022
14.04	Condensed and evaporated milk	2023
14.05	Ice cream and frozen desserts	2024
14.06	Fluid milk	2026
	7. FISH PRODUCTS	
3.00	Forestry and fishery products	074,081-2,084 086,091
14.07	Canned and cured sea foods	2031
14.12	Fresh or frozen packaged fish	2036
	8. GRAIN, CEREAL, ETC.	
2.01	Cotton	0112, pt 014
2.02	Food feed grains and grass seeds	0113,pt 0119 pt 014
14.14	Flour and cereal preparation	2041, 2043 2045
14.15	Prepared feeds for animals and fowls	2042
14.17	Wet corn milling	2046
14.16	Rice milling	2044

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
14.24	Cottonseed oil mills	2091
14.25	Soybean oil mills	2092
	9. FRUITS, VEGETABLES, ETC.	
2.04	Fruits and tree nut	0122,pt 014
2.05	Vegetables, sugar, miscellaneous crops	0123,pt 014 pt 0119
2.06	Oil bearing crops.	pt 0113 pt 0119
14.09	Canned fruits and vegetables	2033
14.13	Frozen fruit vegetables	2037
14.26	Vegetable oil mills	2093
14.19	Sugar	206
14.28	Roasted coffee	2095
	10. OTHER FOODS AND BEVERAGES	
2.03	Tobacco	pt 0114
14.08	Canned specialties	2032
14.10	Dehydrated food products	2034
14.11	Pickles, sauces and salad dressings	2035
14.18	Bakery product	205
14.20	Confectionery and related products	207
14.21	Alcoholic beverage	2082-5
14.22	Bottled and canned soft drinks	2086
14.23	Flavoring extracts and sirups, n.e.c	2087
14.27	Animal and marine fats and oils	2094
14.29	Shortening and cooking oils	2096
14.30	Manufactured ice	2097
14.31	Macaroni and spaghetti	2098
14.32	Food preparations, n.e.c.	2099
15.01	Cigarettes, cigars, etc	2111, 2121, 2131
15.02	Tobacco stemming and redrying	2141
	11. TEXTILE, AND LEATHER PRODUCT	
16.01	Broadwoven fabric mills and fabric finishing plants	2211,2221,2231 2261-2
16.02	Narrow Fabric mills	2241
16.03	Yarn mills and finishing of textiles, n.e.c.	2269, 2281-3
16.04	Thread mills	2284
17.01	Floor coverings	227
17.02	Felt goods, n.e.c.	2291
17.03	Lace goods	2292

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
17.04	Paddings and upholstery fillings	2203
17.05	Processed textile waste	2204
17.06	Coated fabrics, not rubberized	2295
17.07	Tire cord and fabric	2296
17.08	Scouring and combing plants	2297
17.09	Cordage and twine	2208
17.10	Textile goods, n.e.c	2299
18.01	Hosiery	2251, 2252
18.02	Knit apparel mills	253,2254,2259
18.03	Knit fabric mills	2256.
18.04	Apparel made from purchased materials	23 (excl 239), 39996
19.01	Curtains and draperies	2391
19.02	House furnishings, n.e.c	2392
19.03	Fabricated textile products n.e.c.	2393-9
33.00	Leather tanning and industrial leather products	3111, 3121
34.01	Footwear cut stock	3131
34.02	Footwear except rubber	314
34.03	Other leather products	3151, 3161, 317,3199
	12. LABOR INTENSIVE PRODUCTS	
22.01	Wood household furniture	2511, 2519
22.02	Upholstered household furniture	2512
22.03	Metal household furniture	2514
22.04	Mattresses and bedsprings	2515
23.01	Wood office furniture	2521
23.02	Metal office furniture	2522
23.03	Public building furniture	2531
23.04	Wood partitions and fixtures	2541
23.05	Metal partitions and fixtures	2542
23.06	Venetian blinds and shades	2591
23.07	Furniture and fixtures, n.e.c	2599
64.01	Jewelry, including costume, and silverware	391, 3961
64.02	Musical instruments and parts	3931
64.03	Games, toys, etc	3941-3
64.04	Sporting and athletic goods, n.e.c	3949
64.05	Pens, pencils, etc	395
64.06	Artificial flowers	3962
64.07	Buttons, needles, pins and fasteners	3963-4
64.08	Brooms and brushes	3991
64.09	Hard surface floor covering	3996

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
64.10	Morticians	3994
64.11	Signs and advertising displays	3993
64.12	Miscellaneous manufactures, n.e.c	3999 (excl. 39996)
	13. CHEMICAL PRODUCTS	
27.01	Industrial inorganic and organic chemicals	281 (excl. 28195)
27.02	Fertilizers	2871, 2872
27.03	Agricultural chemicals, n.e.c.	2879
27.04	Miscellaneous chemical products	2861, 289
28.01	Plastics materials and resins	2821
28.02	Synthetic rubber	2822
28.03	Cellulosic man-made fibers	2823
28.04	Organic fibers, noncellulosic	2824
29.01	Drugs	283
29.02	Cleaning preparations	284 (excl. 2844)
29.03	Toilet preparations	2844
30.00	Paints and allied products	2851
31.02	Paving mixtures and blocks	2951
31.03	Asphalt felts and coatings	2952
32.01	Tires and inner tubes	3011
32.02	Rubber footwear	3021
32.03	Reclaimed rubber and miscellaneous rubber products	3031, 3069
32.04	Miscellaneous plastics products	3079
	14. PRIMARY MACHINERY	
43.01	Steam engines and turbines	3511
43.02	Internal combustion engines, n.e.c.	3519
44.00	Farm machinery	3522
45.01	Construction machinery	3531
45.02	Mining machinery	3532
45.03	Oil field machinery	3533
46.01	Elevators and moving stairways	3534
46.02	Conveyors and conveying equipments	3535
46.03	Hoists, cranes, and monorails	3536
46.04	Industrial trucks and tractors	3537
47.01	Machine tools, metal cutting types	3541
47.02	Machine tools, metal forming types	3542
47.03	Special dies and tools and machine tool accessories	3544, 3545
47.04	Metalworking machinery, n.e.c	3548

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
48.01	Food products machinery	3551
48.02	Textile machinery	3552
48.03	Woodworking machinery	3553
48.04	Paper industries machinery	3554
48.05	Printing trades machinery	3555
48.06	Special industry machinery, n.e.c	3559
49.01	Pumps and compressors	3561
49.02	Ball and roller bearings	3562
49.03	Blowers and fans	3564
49.04	Industrial patterns	3565
49.05	Power transmission equipment	3566
49.06	Industrial furnaces and ovens	3567
49.07	General industrial machinery, n.e.c.	3569
50.00	Machine shop products	359
51.01	Computing and related machines	3573, 3574
51.02	Typewriters	3572
51.03	Scales and balances	3576
51.04	Office machines, n.e.c	3579
54.01	Household cooking equipment	3631
54.02	Household refrigerators and freezers	3632
54.03	Household laundry equipment	3633
54.04	Electric housewares and fans	3634
54.05	Household vacuum cleaners	3635
54.06	Sewing machine	3636
54.07	Household appliances, n.e.c	3639
	15. SECONDARY MACHINERY	
13.01	Complete guided missiles	1925
13.02	Ammunition, except for small arms, n.e.c.	1929
13.03	Tank and Tank components	1931
13.04	Sighting arid fire control equipment	1941
13.05	Small arms	1951
13.06	Small arms ammunition	1961
13.07	Other ordnance and accessories	1911, 1999
52.01	Automatic merchandising machines	3581
52.02	Commercial laundry equipment	3582
52.03	Refrigeration machinery	3585
52.04	Measuring and dispensing pumps	3586
52.05	Service industry machines, n.e.c	3589
53.01	Electric measuring instruments	3611
53.02	Transformers	3612
53.03	Switchgear and switchboard apparatus	3613
53.04	Motors and generators	3621

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
53.05	Industrial controls	3622
53.06	Welding apparatus	3623
53.07	Carbon and graphite products	3624
53.08	Electrical industrial apparatus, n.e.c.	3629
56.01	Radio and television receiving sets	3651
56.02	Phonograph records	3652
56.03	Telephone and telegraph apparatus	3661
56.04	Radio and television communication equipment	3662
57.01	Electron tubes	3671-3
57.02	Semiconductors	3674
57.03	Electronic components, n.e.c	3679
58.01	Storage batteries	3691
58.02	Primary batteries, wet and dry	3692
58.03	X-ray apparatus and tubes	3693
58.04	Engine electrical equipment.	3694
58.05	Electrical equipment, n.e.c	3699
59.01	Truck and truck bodies	3713
59.02	Truck trailers	3715
59.03	Motor vehicles and parts	3711, 3714
60.01	Aircraft.	3721
60.02	Aircraft engines and parts	3722
60.03	Aircraft propellers and parts	37295
60.04	Aircraft equipment., n.e.c	3729, (excl 37295)
61.01	Shipbuilding and repairing	3731
61.02	Boatbuilding and repairIng	3732
61.03	Locomotives and parts	3741
61.04	Railroad and street cars	3742
61.05	Motorcycles, bicycles and parts	3751
61.06	Trailer coaches	3791
61.07	Transportation equipment, n.e.c	3799
62.01	Engineering and scientific instruments	3811
62.02	Mechanical measuring devices	3821
62.03	Automatic temperature controls	3822
62.04	Surgical and medical instruments	3841
62.05	Surgical appliances and supplies	3642
62.06	Dental equipment and supplies	3843
62.07	Watches, clocks and parts	387
	16. CAPITAL INTENSIVE	
37.01	Blast furnaces and basic steel products	331

Table A.1. (Continued)

I/O	Aggregates/Industry Classification	SIC Codes
39.01	Metal cans	3411
39.02	Metal barrels, drums, and pails	3401
40.01	Metal sanitary ware	3431
40.02	Plumbing fittings and brass goods	3432
40.03	Heating equipment, except electric	3433
40.04	Fabricated structural steel	3441
40.05	Metal doors sash and trim	3442
40.06	Fabricated plate work (boiler shops)	3443
40.07	Sheet metal work	3444
40.08	Architectural metal work	3446
40.09	Miscellaneous metal work	3449
41.01	Screw machine products and bolts, nuts rivets and washers.	345
41.02	Metal stampings	3461
42.01	Cutlery	3421
42.02	Hand and edge tools including saws	3423,3425
42.03	Hardware, n.e.c	3429
42.04	Coating, engraving, and allied services	3471,3479
42.05	Miscellaneous fabricated wire products	3481
42.06	Cafes and vaults	3492
42.07	Steel springs	3493
42.08	Pipe, valves, and pipe fittings	3494,3498
42.09	Collapsible tube	3496
42.10	Metal foil and leaf	3497
42.11	Fabricated metal products, n.e.c	3499
55.01	Electric lamps	3641
55.02	Lighting fixtures	3642
55.03	Wiring devices	3643,3644
63.01	Optical instruments and lenses	3831
63.02	Ophthalmic goods	3851
63.03	Photographic equipment and supplies	3861

Source: U.S. Bureau of Economic Analysis, "Input-Output Structure of the U.S. Economy": 1967, Survey of Current Business, Appendix B, February 1974.

Table A.2. Labor categories - major[a] and minor[b] groups of the ISCO

ISCO Codes	Major and Minor Groups
	0/1. PROFESSIONAL, TECHNICAL AND RELATED WORKERS
0-1	Physical scientists and related technicians
0-2/3	Architects, engineers and related technicians
0-4	Aircraft and ships' officers
0-5	Life scientists and related technicians
0-6/7	Medical, dental, veterinary and related workers
0-8	Statisticians, mathematicians, systems analysts and related technicians
0-9	Economists
1-1	Accountants
1-2	Jurists
1-3	Teachers
1-4	Workers in religion
1-5	Authors, journalists and related writers
1-6	Sculptors, painters, photographers and related creative artists
1-7	Composers and performing artists
1-8	Athletes, sportsmen and related workers
1-9	Professional, technical and related workers not elsewhere classified
	2. ADMINISTRATIVE AND MANAGERIAL WORKERS
2-0	Legislative officials and government administrators
2-1	Managers
	3. CLERICAL AND RELATED WORKERS
3-0	Clerical supervisors
3-1	Government executive officials
3-2	Stenographers, typists and card and tape-punching machine operators
3-3	Bookkeepers, cashiers and related workers
3-4	Computing machine operators
3-5	Transport and communications supervisors
3-6	Transport conductors
3-7	Mail distribution clerks
3-8	Telephone and telegraph operators

Table A.2. (Continued)

ISCO Codes	Major and Minor Groups
3-9	Clerical related workers not elsewhere classified
	4. SALES WORKERS
4-0	Managers (wholesale and retail trade)
4-1	Working proprietors (wholesale and retail trade)
4-2	Sales supervisors and buyers
4-3	Technical salesmen, commercial travellers and manufacturers' agents
4-4	Insurance, real estate, securities and business services salesman and auctioneers
4-5	Salesmen, shop assistants and related workers
4-9	Sales workers not elsewhere classified
	5. SERVICE WORKERS
5-0	Managers (catering and lodging services)
5-1	Working proprietors (catering and lodging services)
5-2	Housekeeping and related service supervisors
5-3	Cooks, waiters, bartenders and related workers
5-4	Maids and related housekeeping service workers, not elsewhere classified
5-5	Building caretakers, charworkers, cleaners and related workers
5-6	Launderers, dry-cleaners and pressers
5-7	Hairdressers, barber- beauticians and related workers
5-8	Protective service workers
5-9	Service workers not elsewhere classified
	6. AGRICULTURE, ANIMAL HUSBANDRY AND FORESTRY WORKERS, FISHERMEN AND HUNTERS
6-0	Farm managers and supervisors
6-1	Farmers
6-2	Agriculture and animal husbandry workers
6-3	Forestry workers
6-4	Fishermen, hunters and related workers

Table A.2. (Continued)

ISCO Codes	Major and Minor Groups
	7/8/9. PRODUCTION AND RELATED WORKERS, TRANSPORT EQUIPMENT OPERATORS AND LABOURERS
7-0	Production supervisors and general foremen
7-1	Miners, quarrymen, well drillers and related workers
7-2	Metal processers
7-3	Wood preparation workers and paper makers
7-4	Chemical processers and related workers
7-5	Spinners, weavers, knitters, dyers and related workers
7-6	Tanners, fellmongers and pelt dressers
7-7	Food and beverage processers
7-8	Tobacco preparers and tobacco product makers
7-9	Tailors, dressmakers, sewers, upholsterers and related workers
8-0	Shoemakers and leather goods makers
8-1	Cabinetmakers and related woodworkers
8-2	Stone cutters and carvers
8-3	Blacksmiths, toolmakers and machine-tool operators
8-4	Machinery fitters, machine assemblers and precision instrument makers (except electrical)
8-5	Electrical fitters and related electrical and electronics workers
8-6	Broadcasting station and sound equipment operators and cinema projectionists
8-7	Plumbers, welders, sheet metal and structural metal preparers and erectors
8-8	Jewellery and precious metal workers
8-9	Glass formers, potters and related workers
9-0	Rubber and plastics product makers
9-1	Paper and paperboard products makers
9-2	Printers and related workers
9-3	Painters
9-4	Production and related workers not elsewhere classified
9-5	Bricklayers, carpenters and other construction workers
9-6	Stationary engine and related equipment operators

Table A.2. (Continued)

ISCO Code	Major and Minor Groups
9-7	Material-handling and related equipment operators, dockers and freight handlers
9-8	Transport equipment operators
9-9	Labourers not elsewhere classified

Source: International Labor Office, Yearbook of Labor Statistics, 1945-89 p XXVIII.

[a]Major groups (one-digit codes) are those used by the model.
[b]Minor groups are two-digit codes.

APPENDIX B: DATA

More details on the data used are given in the following tables. Table B.1 gives the world resource endowments for GNP, capital, labor, and land for all the 46 (Soviet Union included) countries used in the survey. Table B.2 is world aggregate for natural resources. Table B.3 is the data for the technology matrix, Soviet and U.S. resources for the agricultural trade model. Table B.4 gives details on Soviet trade data.

Table B.1. World resource endowments: GNP, capital stock, labor, and land

Country	GNP	CAPIT	PROF	MANAG	CLERK	SALES	SERV	AGRIC	PROD	ARABL	PASTR	FORST
Algeria	59.48	123.24	598.7	57.3	418.4	282.9	346.1	682.1	1446.1	3.22	10.15	0.082
Burundi	1.19	1.11	20.9	0.8	9.0	17.3	47.7	2244.9	70.3	0.57	0.30	0.001
Cameroon	10.90	13.02	67.0	2.7	52.1	88.6	54.8	2032.1	311.0	3.00	2.70	0.432
Egypt	40.37	55.22	1415.7	317.1	1070.7	756.4	891.0	4718.7	2665.4	1.10	0.00	0.001
Ghana	5.63	2.55	221.7	16.2	127.6	750.2	130.7	3228.8	887.2	1.23	1.13	0.143
Nigeria	48.60	102.94	1681.5	110.7	1143.7	6954.6	973.1	13235.5	3797.9	13.40	7.01	0.244
So Africa	58.09	129.67	713.8	256.0	740.9	426.9	1460.2	1206.2	3034.3	5.63	27.18	0.079
Tunisia	8.58	17.06	55.8	28.9	213.2	42.6	174.9	469.5	692.4	2.06	1.02	0.010
Zambia	1.49	5.02	78.2	12.4	47.1	84.1	100.7	652.7	202.7	2.24	11.69	0.507
Zimbabwe	5.27	8.19	140.0	25.0	112.0	87.0	233.0	2084.0	301.0	1.20	1.62	0.348
Brazil	258.54	357.43	3895.4	2486.6	5119.6	5232.4	5628.4	13521.4	13656.7	33.59	5.64	9.689
Canada	351.65	503.44	2185.0	1606.0	2243.0	1246.0	1834.0	654.0	3664.0	19.66	10.85	6.209
Chile	14.93	23.98	362.7	171.9	509.9	488.9	580.4	872.6	1393.0	1.87	4.48	0.153
Colombia	31.25	46.35	475.0	73.6	465.5	738.9	665.4	44.8	1204.2	2.29	13.43	0.888
Costa Rica	3.98	6.69	97.4	29.6	82.6	106.5	135.3	256.8	300.1	0.23	0.77	0.029
Mexico	121.37	273.23	1981.0	279.8	2497.4	1997.4	2262.4	6852.9	6981.3	10.57	24.88	0.759
Peru	24.53	40.03	404.5	23.9	567.0	527.6	371.7	1840.5	1020.4	1.59	9.06	1.202
U.S.A.	4219.20	4584.06	19551.0	15196.0	19154.0	14708.0	16644.0	3655.0	34179.0	81.22	80.65	4.625
Uruguay	5.95	6.66	97.9	31.6	139.3	117.4	173.3	171.7	302.4	0.57	4.52	0.012
Venezuela	48.44	93.42	816.0	250.5	704.8	973.1	962.4	851.4	2220.8	1.66	5.88	0.540
Hong Kong	37.42	57.40	211.1	106.9	517.8	331.4	465.6	32.6	1083.1	0.00	0.00	0.000
Israel	28.25	38.93	363.3	85.2	266.5	129.4	203.5	63.9	411.1	0.19	0.05	0.002
Japan	1962.68	2711.19	6650.0	2350.0	11010.0	9370.0	5190.0	4590.0	21830.0	2.00	0.21	0.438
Jordan	4.47	8.70	50.6	6.8	25.3	31.0	27.3	46.5	218.6	0.16	0.26	0.001
Korea, S.	95.11	158.52	1204.0	247.0	2180.0	2568.0	1883.0	3388.0	6046.0	0.91	0.03	0.113
Malaysia	25.52	58.56	452.1	117.7	566.1	711.9	704.3	1845.8	1586.1	2.09	0.01	0.337
Philippines	29.93	57.38	1310.0	207.0	943.0	2999.0	1934.0	9720.0	4691.0	3.41	1.14	0.021

Table B.1. (Continued)

Country	GNP	CAPIT	PROF	MANAG	CLERK	SALES	SERV	AGRIC	PROD	ARABL	PASTR	FORST
Syria	17.32	26.58	151.7	2.4	144.2	150.5	107.3	495.1	829.9	2.38	2.75	0.009
Turkey	56.31	90.63	1072.2	307.7	806.1	1407.2	1345.4	9318.2	4583.6	11.86	2.87	0.352
Austria	93.05	132.23	469.7	188.8	556.5	306.3	375.3	273.7	1207.6	0.64	0.66	0.056
Belgium	111.51	134.20	623.2	75.2	701.2	309.2	327.1	117.8	1275.7	0.35	0.23	0.012
Denmark	79.09	93.10	603.0	99.7	500.1	195.0	327.3	130.0	887.5	1.10	0.07	0.009
Finland	69.01	98.29	609.0	99.0	367.0	244.0	275.0	229.0	707.0	1.04	0.04	0.405
France	721.53	932.58	3359.1	58.3	4062.5	1866.7	2544.1	1803.4	7236.8	8.36	3.92	0.256
Germany, W.	897.70	1121.71	4014.0	1001.0	5173.0	2412.0	3058.0	1280.0	9077.0	3.19	1.49	0.128
Greece	39.26	70.46	461.9	72.1	382.0	388.0	352.4	977.1	1095.7	1.68	1.76	0.046
Italy	596.57	748.51	2600.8	3609.7	2164.6	2501.1	2610.1	2097.3	4662.9	5.20	1.64	0.117
Netherlands	175.18	220.80	1428.0	237.0	1073.0	673.0	731.0	305.0	1465.0	0.40	0.36	0.005
Norway	68.56	115.13	465.0	132.0	233.0	224.0	284.0	136.0	597.0	0.37	0.03	0.145
Spain	226.95	286.32	1235.8	199.7	1473.3	1442.6	1865.2	1921.0	4916.8	8.72	3.41	0.273
Sweden	128.87	161.22	1418.0	108.1	618.9	413.0	424.0	161.0	1315.0	1.26	0.19	0.489
Switzerland	141.39	184.00	467.9	73.6	625.4	252.1	350.6	199.5	1064.2	0.18	0.54	0.018
U.K.	552.68	596.77	4137.8	2311.7	3945.3	1404.1	3062.7	353.3	8004.7	2.99	3.86	0.041
Australia	177.79	309.11	833.3	974.1	461.5	1275.7	1350.9	1174.4	1912.4	20.09	141.97	1.849
New Zealand	25.30	46.10	224.9	74.1	262.1	152.1	149.8	162.5	460.1	0.22	4.60	0.127
USSR	2525.20	1990.63	23511.0	14323.0	8910.0	7818.0	10246.0	26467.0	45983.0	96.40	109.21	15.699
World[a]	14206.0	16842.3	92786.7	48044.2	83386.0	75201.8	73863.5	126563.5	211477.0	362.09	504.35	46.903

[a]World = 45 survey countries and Soviet Union.

GNP, capital, and land in billion U.S. dollars.
Labor in thousand persons.

Table B.2. Aggregate of world natural resource endowments

Aggregate	Resource	Value[a]
CRUDE OIL		
	Crude oil	245930.54
	Natural gas	85267.36
	TOTAL	**331197.82**
COAL		
	Coal	137259.90
FERROALLOY		
	Chrome ore	666.20
	Cobalt	378.84
	Iron ore	31440.43
	Manganese ore	2389.16
	Magnesium	2608.50
	Molybdenum	662.33
	Nickel	9221.31
	Tungsten ore	12.75
	TOTAL	**47379.52**
NONFERROUS		
	Antimony	83.17
	Primary aluminum	40457.22
	Bauxite	20701.84
	Copper	25730.09
	Gold	27198.81
	Lead	2116.95
	Mercury	54.12
	Platinum-group metals	4528.80
	Silver	2032.86
	Tin	1008.12
	Zinc	9184.93
	TOTAL	**133096.91**
OTMNE		
	Barite	115.89
	Fluorspar ore	328.24
	Hydraulic cement	65025.95
	Diamond (Natural)	35300.59
	Nitrogen	20197.96
	Phosphate rock	894.57
	Potash	5262.86
	Salt	18023.97
	Sulphur	5276.46
	TOTAL	**150426.47**

[a]In million U.S. dollars.

Table B.3. Data for technology matrix and resource endowments used for the agricultural trade model

Factor Aggregates	Wheat	Barley	Corn	Other grain	Soybeans	Other Oilseeds
Capital	32856.1	50926.5	15766.8	30555.9	16486.6	38560.4
Skilled	3352.9	4331.0	1563.3	2704.5	1759.2	4142.5
Unskilled	1486.7	1982.2	444.2	2239.2	286.9	495.4
Land I	75.1	74.8	0.0	88.4	0.0	72.3
Land II	242.6	241.5	123.4	414.7	226.7	233.4
Land III	368.3	366.8	171.9	327.2	342.7	354.4
Fertilizer	14355.4	13907.5	7775.2	11958.5	7298.7	12646.7
Chemicals	8948.8	9969.2	4434.8	10511.9	6653.0	15361.1
Energy	5853.5	5941.5	2248.6	8658.7	2351.4	3131.7

Factor Aggregates	Cotton	Beef	Pork/ Chicken	U.S. Resources	Soviet Resources
Capital	23639.9	36694.9	36664.8	79800	82540
Skilled	1239.3	3557.7	3964.1	2261	2022
Unskilled	2344.0	1581.2	1420.9	1349	1897
Land I	0.0	5.8	59.9	60600	109800
Land II	0.0	207.2	256.7	82700	66800
Land III	165.7	48.7	0.0	46700	47300
Fertilizer	5363.4	4494.4	9289.7	10450	12510
Chemicals	7355.1	2234.7	6734.0	4340	4570
Energy	4738.6	1160.4	7032.8	7500	8447

Notes: For resource endowments units are as follows: Capital, fertilizer, chemicals and energy in million U.S. dollars; labor categories in million man hours; land categories in thousand hectares.

Table B.4. Soviet Union Trade[a] data for 1989

CODE	Aggregates and Commodities	Export	Import	Net Export
	1. PETROLEUM PRODUCTS			
21	Crude Oil	20429.26	1711.19	18718.08
22	Petroleum products	8687.66	647.81	8039.85
23	Natural gas	11314.19	0.00	11314.19
	TOTAL	40431.12	2359.00	38072.12
	2. IRON, FERROALLOY PRODUCTS			
24	Iron ores	1221.64	0.00	1221.64
26	Ferrous metals	5224.06	5319.76	-95.70
	TOTAL	6445.70	5319.76	1125.93
	3. NONFERROUS PRODUCTS			
25	Nonmetal ores	1503.69	294.64	1209.05
273	Nonferrous metal products	0.00	13.46	-13.46
	TOTAL	1503.69	308.10	1195.59
	4. FERTILIZER/OTHER MINERAL PRODUCTS			
200	Coal	1943.62	0.00	1943.62
201	Coke	340.39	0.00	340.39
340	Phosphoric fertilizer	99.55	6.57	92.98
341	Potassium fertilizer	478.90	0.00	478.90
342	Nitrogen fertilizer	772.94	0.00	772.94
	TOTAL	3635.40	6.57	3628.83
	5. FOREST PRODUCTS			
35	Natural rubber	0.00	174.02	-174.02
412	Constr. material from lumber	0.00	103.37	-103.37
50	Lumber and paper products	3744.50	1394.43	2350.08
	TOTAL	3744.50	1671.82	2072.68
	6. MEAT AND ANIMAL PRODUCTS			
601	Animals for breeding	0.00	22.62	-22.62
710	Cattle for slaughter	0.00	94.01	-94.01
800	Meat	45.75	1137.27	-1091.52
801	Butter	80.94	408.06	-327.12
802	dairy products	52.96	168.47	-115.51
	TOTAL	179.65	1830.42	-1650.78
	7. FISH AND FISH PRODUCTS			
810	Fish	734.76	156.94	577.82
813	Canned fish	148.17	32.21	115.96
	TOTAL	882.93	189.15	693.78

Table B.4. (continued)

CODE	Aggregates and Commodities	Export	Import	Net Export
	8. GRAIN, CEREALS, ETC.			
700	Grains	207.96	4893.12	-4685.15
55	Seeds	44.48	142.30	-97.82
	TOTAL	252.44	5035.41	-4782.97
	9. FRUIT, VEGETABLES, ETC.			
721	Coffee, cocoa, tea	0.00	1081.22	-1081.22
722	Spices	0.00	92.12	-92.12
723	Raw sugar, starch, etc	0.00	4406.94	-4406.94
82	Beans/beans products	125.20	259.36	-134.16
83	Fruits and vegetables	72.65	696.05	-623.40
840	Sugar, etc	0.00	236.18	-236.18
841	Vegetable oils	79.54	505.17	-425.63
	TOTAL	277.39	7277.03	-6999.65
	10. OTHER FOODS AND BEVERAGES			
720	Oil seeds	49.42	257.17	-207.75
726	Tobacco	0.00	155.25	-155.25
729	Malt from barley	0.00	28.20	-28.20
842	Margarine	19.03	0.00	19.03
849	Honey	24.05	0.00	24.05
850	Wine and vodka	162.66	425.90	-263.24
851	Tobacco production	5.49	673.71	-668.22
57	Fats and oil	13.39	310.50	-297.11
	TOTAL	274.03	1850.73	-1576.70
	11. TEXTILE AND LEADER PRODUCTS			
51	Raw material for textile ind	1687.46	1782.53	-95.07
52	Furs	115.36	8.40	106.97
530	Leather	128.53	3.45	125.08
59	Leather clothing	0.00	231.81	-231.81
90	Cotton fabric	412.84	385.78	27.07
91	Clothes	55.85	4953.67	-4897.82
93	Shoes	30.46	2150.10	-2119.64
	TOTAL	2430.51	9515.73	-7085.22
	12. LABOR INTENSIVE PRODUCTS			
92	Habedeshery goods	8.64	645.09	-636.45
94	Kitchen ware	60.29	142.96	-82.67
950	Furniture	62.96	843.60	-780.64
97	Household equipment	834.04	797.48	36.56
	TOTAL	965.93	2429.12	-1463.19

Table B.4. (continued)

CODE	Aggregates and Commodities	Export	Import	Net Export
	13. CHEMICAL PRODUCTS			
30	Chemical products	1961.56	3235.29	-1273.73
31	Dyes, Vanishes	127.25	985.88	-858.64
348	Chemical insecticides	63.18	609.04	-545.85
960	Medicine	156.55	2886.65	-2730.11
964	Sanitary and hygienic goods	0.00	398.34	-398.34
965	Soap and perfume	47.73	1567.77	-1520.04
967	Vitamins	31.37	0.93	30.44
	TOTAL	2387.64	9683.91	-7296.27
	14. PRIMARY MACHINERY			
100	Metal cutting machine tools	536.51	3039.43	-2502.92
105	Equipment for metal processing	6.87	283.23	-276.35
120	Mining equipment	446.72	908.69	-461.96
121	Crushing and ore enriching	171.01	83.02	87.98
123	Metallurgic equipment	509.70	1263.61	-753.91
127	Equipment for oil refinery	0.00	195.81	-195.81
128	Drilling equipment	666.21	994.99	-328.78
13	Lifting equipment	245.35	2150.68	-1905.33
143	Tobacco processing equipment	0.00	12.11	-12.11
144	Equipment for textile industry	352.74	1280.91	-928.17
145	Equipment for sewing industry	0.00	528.78	-528.78
146	Equipment for leather industry	0.00	287.29	-287.29
151	Equipment for timber and paper	63.13	604.77	-541.64
152	Woodworking equipment	9.92	28.49	-18.57
153	Equipment for construction ind	94.33	268.15	-173.82
154	Road construction equipment	513.54	559.80	-46.27
155	Pumping equipment	165.04	343.89	-178.85
156	Communal Service/in store equip	13.34	223.10	-209.76
157	Printing equipment	24.05	311.88	-287.83
159	Other industry equipment	86.09	2038.01	-1951.92
167	Pipelines	86.95	591.18	-504.22
40	Construction materials	154.60	1142.54	-987.94
	TOTAL	4146.10	17140.37	-12994.27
	15. SECONDARY MACHINERY			
110	Energy equipment	2586.80	739.15	1847.60
111	Electrical equipment	316.01	1536.38	-1220.37
112	Electrode production	2.19	95.89	-93.70
113	Cables and wires	53.48	294.37	-240.89
140	Food processing equipment	136.88	1378.13	-1241.26

Table B.4. (continued)

CODE	Aggregates and Commodities	Export	Import	Net Export
142	Cooling/air conditioning equip	40.56	321.96	-281.40
170	Measuring and lab equipment	243.58	1105.36	-861.78
173	Ball Bearing	175.91	148.11	27.80
174	Mechanical tools	92.57	113.59	-21.02
176	Hardalloys	24.65	40.39	-15.74
177	Computers	153.08	3272.27	-3119.18
180	Tractor and garbage equipment	1036.76	111.35	925.41
181	Agric machinery and equipment	456.15	1600.00	-1143.85
190	Railroad transportation equip	560.98	2086.82	-1525.85
191	Heavy trucks	1880.84	3108.59	-1227.75
192	Ships/supporting equipment	192.93	2629.17	-2436.25
193	Air transportation equipment	1616.67	0.00	1616.67
195	Cars, motorcycles	1866.07	515.12	1350.95
	TOTAL	11436.11	19096.65	-7660.54
	16. CAPITAL INTENSIVE			
162	Agric/fore indus (build equip)	252.37	0.00	252.37
164	Scientific, sports facilities	0.00	451.57	-451.57
166	Hydro technical equip ind	191.28	0.00	191.28
172	Medical equipment	29.43	723.18	-693.76
150	Equipment for chemical industr	269.49	2021.36	-1751.87
33	Movie and photo films	16.13	175.36	-159.23
98	Audio/visual equipments	410.31	211.23	199.08
	TOTAL	1168.99	3582.71	-2413.72
	GRAND TOTAL	80162.12	87296.48	-7134.36

Source: Soviet Foreign Trade Statistical Yearbook (Vneshniaya Torgovla, SSSR) - 1989, pp. 22-48.

[a]In million U.S. dollars. Converted to U.S. dollars using PPP exchange rate.