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Trade Impacts of Soviet Reform: A Heckscher-Ohlin-Vanek Approach

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Abstract
The Heckscher-Ohlin-Vanek (HOV) equations used in this paper provide a feasible method for projecting longer-run trade patterns of the Former Soviet Union, one that does not depend on elasticities or the optimality of existing resource use. The authors contrast forecasted and actual trade patterns and compare their results with those of other studies.

Keywords
Policy, International Trade, Models and assessment tools

Disciplines
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Executive Summary

The economic transformation currently underway in the Former Soviet Union (FSU) will allow prices to dictate how resources are allocated, and will eventually ensure that these resources are utilized as efficiently as in market economies. In this paper, we measure the resource base of the FSU and then assume U.S. efficiency levels to predict how FSU trade patterns will evolve. We do this for the economy as a whole and in greater detail for the agriculture sector.

The results suggest that existing patterns of resource use in the FSU are suboptimal. For example, cotton and short-season varieties of corn and soybeans are grown on land better suited to other uses. The results also show an enormous increase in small grain production and the emergence of the FSU as a dominant exporter of small grains, forest products, and (non-soybean) oilseeds. Beef imports remain at approximately current levels, while net trade projections for pork and poultry are sensitive to model assumptions. Overall, the results suggest that agriculture, light engineering, and resource extraction will be the industries upon which future growth in the economies of the region will be based.

The procedure we use has much to recommend it in that the results are not dependent on existing resource patterns, relative prices, or trade patterns. However, the results do depend on the rather stringent assumptions that underlie the Hecksural-Ohlin-Vanek equations. In common with all economic forecasts, the specific results presented here should be treated with caution.

Trade Impacts of Soviet Reform: A Heckscher-Ohlin-Vanek Approach

Introduction

If the ongoing reforms in the Former Soviet Union (FSU) succeed, there will be an associated increase in trade in both industrial and agricultural goods. Under central planning, trade patterns of the FSU were determined by the Ministry of Foreign Trade. Imports were viewed as a way of covering internal shortages, and exports were a means of payment. Under this policy, there was no guarantee that existing resources were used in their most productive manner. Thus, attempts to project trade patterns after the economic reform based on present FSU production patterns, would likely be seriously biased. For example, land used elsewhere in the world for wheat may have been allocated to corn or cotton.[1] This bias would become evident if, after liberalization, land for growing corn was utilized for wheat production, even though the relative producer prices of corn and wheat remained unchanged.

A second problem with projecting changes in the trade pattern of the FSU is the quality and consistency of the data. Prior to the reform, the Soviet government used a different measurement system than the West. For example, meat consumption was calculated using a greater proportion of the animal's liveweight than in the United States. Also, there were years when apparently, for political reasons, little data were published. With the break-up of the USSR, responsibility for data collection has been dispersed with the result that inconsistencies may have been introduced into data for recent years. A high-quality, consistent, time-series of data for the FSU may be some time in coming. Unfortunately, the more recent data and those most suspect, are exactly those necessary for econometrically studying the consequences of the reforms for trade.

The Heckscher-Ohlin-Vanek (HOV) equations used in this article provide a feasible method for projecting longer-run trade patterns of the FSU that does not depend on elasticities, or the optimality of existing resource use. The HOV model requires data on the resource base of the FSU and a projection of the efficiency with which these resources will be transformed into outputs.

We do not know the input/output coefficients that will exist in the FSU after liberalization, but we do know them for the United States, an economy with a similar resource base. Therefore, U.S. input/output coefficients for 1967 (taken from Bowen, Leamer, and Sveikauskas) were superimposed on the FSU resource flows.[2] Thus, the projections assume the resource flows of the FSU are used with the same efficiency as in the United States in 1967.

The economy-wide results depend on assumptions made about the size and quality of both human capital and capital. This is true because available data on capital stocks must be converted from roubles to dollars, and because we are unsure about the development of the entrepreneurial skills that are implicitly assumed in the HOV approach. The problem encountered with measuring capital and human capital resources is unfortunate because the quality of the remaining data is quite good. This is true because these data were needed for economic planning. To overcome problems with the labor and capital data, two sensitivity analyses are provided. The first re-estimates the HOV model, but focusses exclusively on the agricultural sector. The advantage of this approach is that it does not depend on the quality of the capital and labor data because capital and labor tie the agricultural sector to the overall economy. By eliminating the other sectors of the economy, we eliminate the need for this link. A second advantage is that more recent (1991) input/output coefficients can be obtained for the U.S. agricultural sector than those used in the more aggregate analysis.

The second alternative presented is a summary of subjective estimates on the same issue provided by several noted experts. These opinions do not have the same grounding in economic theory as the HOV work—a feature that can be both a constraint and an opportunity. In this regard, we (and implicitly other authors quoted) agree with Just and Rausser (p. 78) who argue that "Sufficient data for objectivity are generally not available until the pressing issues of public significance have drifted into the history books."

All three procedures used point to the same conclusion. The FSU has an enormous capacity to expand production of wheat and barley. It also wastes large quantities of feedgrains. If market reforms succeed, land that is currently in soybean, corn, and cotton production will be used to grow small grain crops. Also, harvestable yields will increase while consumption falls. If all of this occurs, an important customer for U.S. grain exports will become a major competitor.

The Heckscher-Ohlin-Vanek Equations

In the theory supporting the HOV, a country's trade patterns are determined mostly by comparative advantage in the production of certain commodities. In a two-country, two-factor world, the commodity version of the earlier Heckscher-Ohlin (HO) theorem shows that the source of comparative advantage is relative factor abundance. That is, a country will export the commodity which uses relatively more intensively the factor in relative abundance. Rigorous empirical testing of the HO theorem intensified after Leontief questioned its validity. Vanek restated the HO theorem to focus on the factor services embodied in the goods traded rather than all products. This allowed an expansion of the model to n goods, and the "factor content" version of the HO theorem, the HOV theorem. Leamer (1980) used the HOV approach to resolve the Leontief paradox. Subsequently, the generalized HOV theorem has become the basis of most empirical work on competitiveness in international trade.

The HOV model has been conveniently summarized by Leamer (1984) and others. These related equations give a unique relationship among the trade vector, matrix of factor intensities, and excess factor abundance for a particular country. The HOV equations rely on key assumptions which are summarized here.

1. Technological knowledge is the same in all countries, and production exhibits constant returns to scale.
2. There is perfect competition in both the factor and commodity markets and factors are fully utilized.
3. All individuals have identical and homothetic preferences and they face the same price vector.

To derive the HOV equations, define for a particular country

Q_i = output of commodity i, where i = 1,...,m.

P_i = price of commodity i, where i = 1,...,m.

V_i = endowment for factor i, where i = 1,...,n.

W_i = reward of factor i, where i = 1,...,n.

A_{ij} = total (direct and indirect) amount of factor i required to produce a unit of commodity j.

C_i = amount of good i consumed, where i = 1,...,m.

By the full employment condition (Assumption 2) we have

$$\sum_{j=1}^{m} A_{ij}Q_j = V_i \qquad i = 1,...,n \tag{1}$$

and by the zero profit condition (Assumption 2) we have

$$\sum_{i=1}^{n} W_i A_{ij} = P_j \qquad j = 1,...,m. \tag{2}$$

Define V^w and Q^w as world factor endowment and output vectors, respectively. By linearity of Equation (1), and the assumption that the factor price equalization theorem holds, we get

$$\sum_{j=1}^{m} A_{ij}Q_j^w = V_i^w \qquad i = 1,...,n. \tag{3}$$

Assumption 3 implies that each country consumes commodities in the same proportion. This is given as

$$C_j = sQ_j^w, \tag{4}$$

where s is the country's consumption share of world output.

Suppose there is balanced trade; then the value of consumption equals the value of production,

$$\sum_{j=1}^{m} P_jQ_j = \sum_{j=1}^{m} P_jC_j = \sum_{j=1}^{m} sP_jQ_j^w. \tag{5}$$

Hence the consumption share, s, is

$$s = \frac{\sum_{j=1}^{m} P_j Q_j}{\sum_{j=1}^{m} P_j Q_j^w} = \frac{Y}{Y^w}. \tag{6}$$

Define T_j, the net trade value of commodity j, as production minus consumption of commodity j. Then $T_j > (<) 0$ implies the country is a net exporter (importer) of commodity j. T_j is then written as

$$T_j = Q_j - C_j. \tag{7}$$

By replacing C_j by sQ_j^w in Equation (4) and multiplying through by ΣA_{ij}, we get the following equality

$$\sum_{j=1}^{m} A_{ij} T_j = \sum_{j=1}^{m} A_{ij} Q_j - s \sum_{j=1}^{m} A_{ij} Q_j^w \qquad i = 1,\ldots,n. \tag{8}$$

Using Equations (1) and (3), Equation (8) can be simplified to

$$\sum_{j=1}^{m} A_{ij} T_j = V_i - sV_i^w \qquad i = 1,\ldots,n. \tag{9}$$

Suppose m = n, and the matrix A is nonsingular, then we get

$$T_j = \sum_{j=1}^{m} A_{ji}^{-1} (V_i - sV_i^w) \qquad i = 1,\ldots,n. \tag{10}$$

Equations (9) and (10) are the HOV equations. These equations are a set of relationships among factor intensities A, trade T, and excess factor supplies ($V - sV^w$).

The empirical validity of equations (9) and (10) has been extensively researched. The most comprehensive work is by Leamer (1984). Leamer used a reduced form version of

Equation (10) to conduct analysis, in which he concluded among other things that "the simple linear model explains a large amount of the variability of net exports across countries." (p. 187) Other papers that have examined the empirical validity of the HOV model include Maskus, Brecher and Choudhri and Harkness.

Of particular relevance to the present analysis is the projection of GNP (Equation 6) via equation (5). The work cited earlier was undertaken to determine if the HOV equations adequately explained existing trade patterns, i.e., the answer (including GNP) was known in advance. There is a unique value of s that equates the value of exports and imports in Equation (10). In solving for this value, we calculate the income level of the FSU expressed as a percentage of world income. The intuition is as follows. The resource endowment V_i expressed through the inverse of the factor intensity matrix A provides a measure of production. Then assumptions 1 and 3 (identical technologies and homothetic preferences) allow us to calculate the income level that equates the total value of consumption with the total value of production.

Data for the Economy-Wide Model

Ten commodity aggregates, exactly those formed by Leamer (1984), were used in the first phase of our analysis. These aggregates are divided into three main categories: primary products (two aggregates), agricultural products (four aggregates), and manufactured products (four aggregates). Leamer's commodity aggregates were formed using the Standard International Trade Classification (SITC) codes, while the input/output tables, used for calculating the technology matrix, were according to Standard Industrial Classification (SIC) codes. Thus, the SIC codes in the input/output table were aggregated to represent Leamer's SITC aggregates.

The ten factor aggregates were grouped into four main categories: capital, labor, land, and natural resources. The three labor categories were taken from those defined at the one-digit level of the International Standard Classifications of Occupations (ISCO). The skilled professional category was from ISCO group 0/1/2, the skilled nonprofessional category was from ISCO group 3/4/5, and unskilled category was from ISCO group 6/7/8/9. The three land definitions were from the United Nations Food and Agricultural Organization (UNFAO). Natural resources were included in three categories derived from the 367-order U.S. input-output table for 1967; from I/O sectors 5.00-10.00. Crude oil was from I/0 sector 8.00, coal was from I/O sector 7.00, and other minerals were from I/0 sectors 5.00-6.02, 9.00, and 10.00. The commodity and factor aggregates are summarized in Table 1. FSU[3] data for capital, labor, and land were collected from the official *Soviet Statistical Yearbook (SSY)* (*Narodnoye Khoziaistvo* 1990). The data in *SSY* were aggregated to conform to the United Nations' classifications.

The capital measure for the FSU depends on the roubles per dollar exchange rate. If we had used the 1994 exchange rate of several hundred roubles per dollar, it would have reduced the 1989 estimate of capital stock to essentially a zero level. Our sense is that in the period for which this study is valid, the countries of the FSU will, by international aid or through internal generation, have acquired a level of capital commensurate with its resource base. Therefore, we use the 1989 market economy exchange rate of 2.5 roubles per dollar reported in the 1990 Plan Report. This rate was determined by interdepartmental auction and should approximate the market value of the rouble for the base year. For comparison Liefert, Koopman, and Cook, in a study with similar objectives to ours, used shadow exchange rates between 1.91 and 2.5 roubles to the dollar. This exchange rate is sufficient to allow Soviet industry to develop and specialize; however, this growth occurs within an environment in which capital is scarce. This makes sense given the enormous resource potential in the FSU, coupled with the political and economic uncertainty that will continue to limit investment inflows into the region for some time.

The data for the rest of the world were taken from a group of 50 countries, selected to reasonably reflect the actual world aggregate. One criterion for selection was having a market economy. The countries used and data collected are available (see Hayes, Kumi, and Johnson). Data on natural resources were taken from U.S. Central Intelligence Agency's (CIA's) *Handbook of Economics Statistics* and the Bureau of Mines' *Mineral Yearbook*. The procedures by which these data were derived and aggregated are also explained in Hayes, Kumi, and Johnson.

Results Using the Economy-Wide Data

Table 2 compares world and FSU factor endowments (columns 1 and 2), and measures of factor abundance (columns 3 and 4). The s value used in column 3 is that required to balance trade and equals 0.17. This means that had the FSU used its resource endowment with the same efficiency as that calculated for the United States in 1967, it would have had a GNP of $2,525 billion. For comparison, the equivalent U.S. value for 1989 was $4,219 billion. Appendix Table 1 gives further detail on the relative size of the FSU factor endowment compared to those of the 50 countries representing the rest of the world. The last column of Table 2 shows the FSU excess factor endowment ($V - sV^w$) expressed as a percentage of world factor endowment V^w. These values indicate the likely impact of liberalization of the FSU on world markets. For example, the capital inflow required to achieve the trade pattern later discussed represents about 14 percent of world capital stock.

Likewise, the crude oil available for export (either as oil or embedded in other goods) represents 15 percent of total world production in 1989.

The results for labor indicate that the FSU has a relative abundance of skilled labor and is relatively deficient in semi-skilled and unskilled labor. Many of the entries in the skilled labor category represent the enormous "managerial" class of the FSU. It is not obvious, however, that these individuals will be able to transfer managerial skills to the private sector.

Table 3 compares the economy-wide projections from the HOV model (Equation 10) with actual trade data for 1989. Results indicate that the FSU would export far less petroleum, and export cereals and light engineering (machinery). These values make sense given the data used. On paper, the FSU is capital scarce and has a surplus of high-quality labor. Other countries, such as Japan and South Korea, in a similar position, have used export-oriented light industry to develop.

It is not clear, however, whether the entrepreneurial talents that propelled East Asian countries will emerge in the FSU. If the managerial classes that operated the economy before market reform can adapt, then one would expect export-led growth in the light industrial sector. In the event that skilled labor does not adapt easily to the more competitive economy, the FSU will not reach the potential GNP and export levels indicated in Table 1. Given the problematical nature of assumptions which underlie the HOV model, all one can conclude with confidence is that given the resource endowment, policies for export of raw materials, cereals, and light industrial exports, will be more successful than those relying on capital or labor-intensive products.

The aggregate HOV analysis indicates that the FSU will become a large net exporter of cereals. To the extent that this is true, the United States and other agricultural exporters will see an important customer become an important competitor.

The aggregate HOV results tell us little about what type of grain will be exported. Also, the results depend on measures of capital stock and labor quality that are at best problematical. To develop more detail from the HOV analysis, estimates of the factor-intensity matrix and factor availability that are consistent with those used in previous literature are required. Also, it is important for all sectors to be equally disaggregated, i.e., the factor disaggregation required to provide more detail in the agricultural sector must be consistent with the factor requirements of other sectors. This disaggregated HOV model would have prohibitive data requirements. If, however, one is prepared to accept the assumption that agriculture is separable from the rest of the economy, then application of the HOV analysis for agriculture with available data is tractable.

Post Reform Agricultural Trade

This section reports on an attempt to model the agricultural sector of the FSU as if it were the only sector in the economy. There are advantages to this approach. First, the quality of the two main factors that link agriculture and the rest of the economy—labor and capital—cannot be measured accurately. Second, the analysis reported is independent of the work presented earlier, i.e., new measures of factor availability and factor intensity are used.

This agriculture-specific analysis is a test of the robustness of the earlier results on cereal exports. Third, the disaggregation for agriculture allows more detail on quality of land used. In particular, we have introduced crude measures of climatic conditions. The obvious disadvantage is that we are conducting an essentially partial equilibrium analysis using a general equilibrium model.

In this section, we replace the HOV predictions of labor, fertilizer, and capital use in agriculture with their actual 1989 values. Thus the results implicitly assume that the FSU uses 1989 inputs with 1989 U.S. efficiency levels.

Data on land quality and climatic condition are not available for some of the 50 countries that represented the rest of the world in the aggregate analysis. Consequently, we modified the HOV model so that accurate data on only two countries—the United States and FSU—are required.

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

Assume that

$$\frac{C^s}{C^u} = \frac{Y^s - B^s}{Y^u - B^u}, \tag{11}$$

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 (11) we get

$$C^s = gC^u, \tag{12}$$

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

Then, define the Soviet trade pattern as

$$T^s = Q^s - C^s. \tag{13}$$

Using Equation (12) and the fact that $Q = A^{-1}V$, equation (13) can be rewritten as

$$T^s = A^{-1}V^s - g(A^{-1}V^u - T^u). \tag{14}$$

Simplifying Equation (14) we have

$$T^s = A^{-1}(V^s - gV^u) + gT^u. \tag{15}$$

Equation (15) generates trade patterns predictions that are identical to the HOV model in Equation (10), as long as U.S. trade data conform to the HOV model. To illustrate this result, assume that the U.S. trading pattern, T^u, have been derived using the HOV equations. Then Equation (15) becomes

$$T^s = A^{-1}(V^s - gV^u) + g[A^{-1}(V^u - kV_w)], \tag{16}$$

where V_w is the world factor endowment vector and k is the U.S. consumption share of world output, $(Y^u - B^u)/Y_w$.

Equation (16) can be simplified to

$$T^s = A^{-1}(V^s - gkV_w). \tag{17}$$

Note that gk is the Soviet consumption share of world output defined by s in Equation (10). Thus, Equation (17) is identical to the HOV equations, given in Equation (10).

Since the model considers the agricultural sector as the whole economy, C^u and C^s are considered U.S. and Soviet agricultural consumption, respectively. The ratio g is defined as the Soviet agricultural consumption share of U.S. agricultural consumption and can be calculated endogenously using the balanced trade assumption, or exogenously using 1989 data on quantities consumed in both countries.

Data for the Agricultural Model

The nine commodity aggregates for the agricultural trade model were wheat, barley, corn, other grains (sorghum, oats, rye, and rice), soybeans, other oilseeds (sunflower seeds and rapeseed), cotton, beef, and pork/chicken. The factors were capital, skilled labor, unskilled labor, land I, land II, land III, fertilizer, chemicals, and energy.

Data for capital were the amount of capital used in the agricultural sector in 1989. Soviet skilled labor was the part of the agricultural work force with university or college degrees. Arable land was divided in the three categories based on temperature and precipitation. The endowment of fertilizer was the amount used in the production of agricultural commodities in 1989.

The data for chemicals were the amounts of pesticides used in the agricultural sector in 1989. Energy was taken as the value of fuel and electricity used in the agricultural sector in 1989.

Most of these Soviet data were from the *SSY* and *Soviet Agricultural Yearbook.* The U.S. data were from USDA's *Agricultural Statistics, Agricultural Resources,* and the U.N.'s

Fertilizer Yearbook. 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.* The data for the remaining inputs are calculated using information from the *U.S. Average Cost of Production for Major Field Crops.* The data for the agricultural model are discussed in more detail in the Appendix.

Results from the Agricultural Model

Table 4 shows the results where trade is balanced by endogenously altering g and Table 5 shows the results where this restriction is lifted. In the case where we forced a trade balance, corn and cotton were imported as were soybeans and meats. When we removed the trade balance restriction, only soybeans and meat were imported and the USSR ran up an enormous trade surplus. In particular, exports of wheat, barley, other grains, and other oilseeds were quite large.

The intuition behind the results in Tables 4 and 5 is that the FSU has a large land base relative to its population. This is particularly true for land quality I which is like the Northern Plains of the United States. For example, the FSU has 109,800 thousand hectares in land category I compared with 60,600 in the United States (see Appendix Table 5). Currently some of this wheat-type land is being used for short-season corn and soybeans in the FSU, or not being used to its productive potential. When we assume that this land can yield as much as its equivalent in the United States or Canada, it allows the FSU to produce more wheat and barley than the United States. Much of this increased production is then exported.

The results in Table 4 depend crucially on the balanced trade assumption. Here we have implicitly modeled the FSU as if agriculture were the only economic activity. The large resource base of the FSU would, under these circumstances, allow it to import large quantities of commodities with the monies earned on agricultural exports. The imported commodities include corn, soybeans, and cotton. The imported corn and soybeans are then used to produce meat for domestic consumption.

The balanced trade assumption is obviously unrealistic when applied to a sector of the economy. In this case, it allows the agricultural sector to consume the entire value of agricultural production. In reality, other sectors of the economy would likely not run trade deficits, financed by the agricultural surplus.

When we drop the balanced trade assumption in Table 5, the FSU becomes an exporter of corn and, to a relatively minor extent, of cotton. Agriculture runs a very high trade balance, thereby allowing imports in other sectors of the economy. Again these values should not be taken as accurate predictions of how trade will evolve. It is unlikely, for example, that a country would simultaneously import corn and export barley. This result is due more to the law of one price assumption (i.e., no transportation costs) than the superiority of corn and soybeans in animal rations. Also, the technology matrix for the United States does not incorporate the large post-harvest loss for grains (20 to 40 percent) estimated by various specialists on Soviet agriculture (Brooks et al; Johnson 1990). The results do, however, indicate that the current pattern of importing wheat and exporting cotton is likely to change. The results may also imply that corn production will fall at the expense of small grains.

A Comparison with Other Studies

It is interesting to compare our post liberalization FSU trade projections with others who have addressed the same issue. Liefert, Koopman, and Cook used a spatial model (SWOPSIN) and projected a decline in net grain imports from 28 million tons to 1.5 million tons. They also projected that the FSU would become a net exporter of wheat and increase its soybean imports. In addition, cotton production falls due to a reduction in planted area after liberalization. Johnson (1992) argued, as do we, that one cannot "project future trading patterns from analysis of the revealed comparative advantage of particular commodities under the socialized system." (p. 6) He used market insight and a description of existing inefficiencies to argue that "the shift in trade position for grain implied by the effects of system change is a very large one, from perhaps 35 to 40 million tons of imports to about one-half that large a volume of exports." (p. 10)

Anderson argued that because agriculture can respond more rapidly to export opportunities, it will lead the economic development of the former centrally planned economies in the medium term. Later, industrial exports will overshadow agriculture. Anderson's analysis is richer than ours in that it offers a time frame. In his model, both agricultural and industrial exports lead the economy at different time periods, with agricultural exports declining as incomes rise under industrialization. Our analysis shows that FSU resources are large enough to allow it to consume at U.S. or European levels and continue to export agricultural products. Anderson made projections for all of the centrally planned economies and consequently used more aggregated data. Land resources, for example, were measured in hectares of arable land, plus permanent crops and pastures per capita. Also, he made the assumption that U.S. or EC level yields will not be reached unless governments subsidize prices. When Russia is broken out separably, his results, even in the long-run, agree with ours, i.e., Russia exports both grain and energy.

Tyers (1992) used a very comprehensive model. The Tyers-Anderson model of international trade was used to simultaneously evaluate both CAP reform and the ongoing reforms in the FSU. His FSU-specific results "yield net cereal exports and, in the medium-term, net livestock product imports. It would permanently reduce (world) average grain prices by at least 20 percent and until technology improvements that are in place, raise international meat and dairy product prices slightly." (p. 26) All of these studies used different modeling techniques and data. Yet all agreed that the FSU (or Russia) will export grains. In other respects, the results differ from ours, but they differ in ways that can be traced to underlying assumptions or data.[4]

Our method requires the least subjective input, a feature that can be viewed as both a strength and a weakness. Our results are perhaps the most objective in that they flow directly from available data and well-established theory. But, the assumptions required can produce counter-intuitive results, such as the simultaneous export of barley and import of corn. The strength of the studies mentioned earlier is that their authors have extensive knowledge of the FSU and its agriculture. Their results are - quite reasonably - based on this expertise. That our study is in agreement with the others is supportive of their more subjective methods and results.

Conclusion

This article evaluated the likely trade patterns of the FSU under the assumption that U.S. production efficiency levels are achieved. Data problems and possible resource misallocations make it difficult to justify an elasticities-based model. Instead, we rely on measures of the resource base as of 1989 and a trade model that projects trade patterns independently of existing or historical patterns of trade and production.

The analysis is conducted separately for the entire economy and for the agricultural sector. The results derived can only indicate the likely future pattern of trade if the economy of the FSU is liberalized. One result that occurs with some consistency is that the FSU will become a major net exporter of small cereal grains. A second conclusion from the more aggregate analysis is that the FSU will become a net importer of tropical agricultural products and a major exporter of temperate agricultural commodities.

Appendix

The Agricultural Model

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

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 the associated values were taken from *Soviet Statistical Yearbook* (*SSY*). The remainder of the work force in the agricultural sector was considered unskilled labor.

The arable land category was considered the most important in the Soviet factor endowment, so more emphasis was placed on the associated data derivation. Arable land was 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 were used. Data were 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 were calculated. Classifications of 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. Appendix Table 1 gives the average normal monthly temperature from April to October, and total normal annual precipitation for the 32 Soviet weather stations. These data for average temperatures in Appendix Table 1 were divided into three categories: high, medium, and low, while precipitation data were divided into high and low. If the average temperature is denoted as temp, then, high $\equiv$ temp $\geq$ 18°C, medium $\equiv$ 14°C $\leq$ temp $<$ 18°C and low $\equiv$ temp $<$ 14. Precipitation was divided so that cities with annual precipitation greater than 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 economic regions of the USSR.[7] Data for arable land in each of the economic regions were calculated using information from the CIA's *USSR Agricultural Atlas* and Lydolph (1979). Appendix Table 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 Appendix Tables 1 and 2. The division of arable land into the three different categories is summarized in Appendix Table 3.

Soviet fertilizer endowment was the amount of nitrogen, phosphate, and potash used in the production of agricultural commodities as reported in *SSY*. These figures are compatible with the Soviet fertilizer production figures in the *U.N. Fertilizer Yearbook*. These figures were converted into values using the U.S. fertilizer prices from the *U.N. Fertilizer Yearbook*.

Endowment for Soviet chemicals was the amount of pesticides and herbicides used in the agricultural sector in 1989. This value is given in the *SSY*, in percent of active ingredients of each type of chemical. These figures were again converted to value terms using U.S. herbicide prices from the USDA's *Agricultural Resources*.

Soviet endowment for energy was taken as the value of fuel and electricity used in the agricultural sector. The data for Soviet agricultural consumption of fuel and electricity were from *Soviet Agricultural Yearbook* (Sel'skoe Khoziaistvo, SSSR). These figures were converted to value terms using U.S. electricity prices from in the USDA's *Agricultural Statistics*. Data for Soviet factor endowments for agriculture are given in Appendix Table 5.

U.S. Factor Endowments

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

Appendix Table 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 used from each USDA region,[8] except for the Mountain region for 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 United States 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 from the USDA's *Agricultural Resources*. Data for the amount of arable land for each state were from *Agricultural Statistics*.

The other U.S. resources data were from two other sources. U.S. fertilizer endowment was the production of nitrogen, phosphate, and potash fertilizers. These 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 from the USDA's *Agricultural Resources*. Energy was the sum of oil and electricity used in agriculture. Data for U.S. factor endowments for agriculture are supplied in Appendix Table 5.

Technology Matrix

To calculate the data for the technology matrix, an assumption was made that crops were produced on land for which climatic conditions were 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 selected crops were available from several other sources. For example, information on ideal weather conditions for growing corn were 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 were from USDA's *Crop Production*. Data required to calculate land needed to produce a unit of meat were from *Livestock Enterprise Budgets for Iowa*. The data for the amount required to produce a unit of an agricultural crop were from a five year

(1986-90) U.S. average yield of the crops. The data on 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 get hectares per $1000 of output. For the 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 for meat production were taken directly from the *Livestock Enterprise Budgets for Iowa.*

The data for the remaining inputs were 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.[9]

Data for the amount of capital required to produce a unit of commodity were the sum of capital replacement, operating capital, and other nonland capital. Data for skilled and unskilled labor were amounts of unpaid labor and hired labor, respectively. The justification is that most of the unpaid labor was required for the operation of machinery and other technical equipment, which needed considerable skill. The data for fertilizer and chemicals were from similar categories in the *U.S. Cost of Production* (*COP*) data. Data for energy were from fuel, lubrication, and electricity category also from the *COP* data.

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Footnotes

1. One indication that resources were used inefficiently is a recent calculation that "if all the raw materials that Russia produces were sold abroad, the country would earn twice as much as its present total GNP. Yet, raw materials output is included in GNP" (*The Economist*, December 4, 1992 survey).
2. We use 1967 U.S. economy-wide input/output coefficients for the aggregate HOV model because they are the only ones available. We use 1991 coefficients for the agriculture-specific HOV model. The HOV procedure we use provides a static equilibrium structure and does not tell us how long it will take to reach the new equilibrium. The results we present are a point estimate of what trade patterns will be once 1967 or 1991 U.S. efficiency levels are reached. If one is prepared to guess when these efficiency levels will occur, then it is possible to interpolate between the current and predicted trade pattern to arrive at a rate of change.
3. The data used were for 1989. This is before the break-up of the Soviet Union. Hence the use of the name Former Soviet Union refers to the 15 republics as of 1989.
4. Another useful study on the economic conditions required for the transition is that by Brooks et al. 1991.
5. We express our sincere appreciation to Professor Harry Bowen, New York University, for providing us with the U.S. total input requirements.
6. These prices were from Bowen, Leamer, and Sveikauskas and multiplied by the ratio of the 1986 and 1967 U.S. implicit GDP deflators. This is because the prices were given in

1967 dollars while the factor endowments were not. The implicit GDP deflator was derived from World Bank's *World Tables*.

7. Moldavian SSR is included in this number.

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

9. The wage rate of $6/hour was taken from "Estimated Cost of Crop Production in Iowa - 1992," November 1991, by Iowa State University Extension.

Table 1. Summary of commodity and factor aggregates

Factor Aggregate Name and Number	Commodity Aggregate Name and Number
A. Capital	A. Primary products
1. Capital	1. Petroleum products
	2. Raw materials
B. Labor	
2. Skilled professional	B. Agricultural products
3. Skilled nonprofessional	3. Forest products
4. Unskilled	4. Tropical agriculture
	5. Animal products
C. Land	6. Cereals, etc.
5. Arable land	
6. Pasture land	C. Manufactured products
7. Forest land	7. Labor intensive
	8. Capital intensive
D. Natural Resources	9. Machinery
8. Crude oil	10. Chemicals
9. Coal	
10. Other minerals	

Table 2. World and Soviet factor endowments, Soviet factor abundance supply, and Rank

Factor Aggregate	Factor	V^w	V	$V - sV^w$	Relative Abundance
a. Capital (billion U.S. dollars)					
	1. Capital	15,849.86	509.60	-2,247.57	-14.18
b. Labor (million persons)					
	2. Skilled	154.11	37.83	11.02	7.15
	3. Semi-skilled	177.83	26.97	-21.37	-7.69
	4. Unskilled	597.15	72.45	-31.42	-5.26
c. Land (billion U.S. dollars)					
	5. Arable	450.60	96.40	18.02	4.00
	6. Pasture	512.63	109.21	20.04	3.91
	7. Forest	50.10	15.70	6.98	13.94
d. Natural Resources (billion U.S. dollars)					
	8. Crude oil	340.70	110.50	51.23	15.04
	9. Coal	147.62	38.92	13.23	8.97
	10. Minerals	342.59	51.25	-8.34	-2.43

Note: V is the USSR endowment.
V^w is the world endowment.
s is the FSU consumption share of world production.
Rank = $(V - sV^w)\ V^w * 100$

SOURCE: See Hayes, Kumi, and Johnson.

Table 3. Soviet post-reform net trade vector, calculated using the HOV equations, and official Soviet trade data for 1989

	Net Trade[a]	
Commodity Aggregate	HOV Prediction	Soviet Data[b]
a. Primary Products		
1. Petroleum products	6,586.20	38,072.12
2. Raw materials	12,780.63	1,125.93
b. Agricultural Products		
3. Forest products	3,560.34	2,072.68
4. Tropical agricultural products	-15,546.10	-1,650.78
5. Animal products	260.28	793.78
6. Cereals, etc.	13,526.01	-4,782.97
c. Manufactured Products		
7. Labor intensive	-19,054.57	-7,085.22
8. Capital intensive	-5,052.29	-1,463.19
9. Machinery	56,763.24	-7,296.27
10. Chemicals	-53,823.84	-12,994.27
Trade Balance	0	-7,134.36

[a] In million U.S. dollars.
[b] SOURCE: Soviet *Foreign Trade Statistical Yearbook.*

Table 4. Post-reform Soviet agricultural trade patterns calculated using modified HOV and Soviet trade data and the balanced trade assumption

Commodity Aggregates	HOV Results	Soviet Data[a]
	(million U.S. dollars)	
Wheat	6,446.61	-2,108.50
Barley	3,900.46	-426.40
Corn	-5,291.93	2,221.10
Other Grains	4,597.94	-237.00
Soybeans	-4,237.46	-256.10
Other Oilseeds	1,964.13	75.70
Cotton	-3,346.62	1,320.90
Beef	-612.52	-819.00
Pork/Chicken	3,641.75	-284.70
Trade Balance	0	-4,956.20

[a]SOURCE: Zeimetz, Kathryn, *USSR Agricultural Trade* (August 1991).

Table 5. Post-reform Soviet agricultural trade patterns calculated using modified HOV and Soviet trade data

Commodity Aggregates	HOV Results	Soviet Data
	(million U.S. dollars)	
Wheat	8,879.34	-2,108.50
Barley	2,404.33	-426.40
Corn	839.89	-2,221.10
Other Grains	2,973.94	-237.00
Soybeans	-261.89	-256.10
Other Oilseeds	1,396.20	75.70
Cotton	102.65	1,320.90
Beef	-946.64	-819.00
Pork/Chicken	-1,630.99	-284.70
Trade Balance	13,756.84	-4,956.20

[a]SOURCE: Zeimetz, Kathryn, *USSR Agricultural Trade*, (August 1991).

Appendix Table 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	375.9
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.
SOURCE: Hayes, Kumi, and Johnson.

Appendix Table 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.

Appendix Table 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.

Appendix Table 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.

Appendix Table 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.

Appendix Table 5. 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.