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The Former Soviet Union and The World Wheat Economy

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Abstract

The impacts of the former Soviet Union (FSU) leaving the world wheat market as a consistent net importer are investigated using a modified version of a spatial trade equilibrium model. A price differential proxy transfer matrix is employed, along with price transmission elasticity assumptions, to capture trade interventions in the world wheat market. Long-run elasticity parameters are assumed in examining the potential impact of the FSU becoming self-sufficient by the turn of the century. Short-run elasticity parameters are used to examine the year-to-year role of the region on world trade and prices following Bigman's stochastic trade hypothesis.

Key Words: *Former Soviet Union, Spatial Trade Models, World Wheat Market Trends and Stability.*

The Former Soviet Union And The World Wheat Economy

Introduction

Wheat imports, which typically accounted for half of the former Soviet Union's (FSU's) grain imports in the 70s and 80s, peaked in 1984 at approximately 25% of global wheat trade. The world food economy is confronted with a new era following the collapse of central planning and single-party communism in the former Soviet Republics. The purpose of this paper is to examine the potential role of the FSU in the world wheat market by the turn of the century.

The remainder of this paper is organized into five sections. In the first section, arguments that the former Soviet Republics may cease or reverse their role as a continuous deficit region are briefly summarized. The second section describes the construction of a "price differential proxy" (PDP) quadratic trade model, which more fully accounts for export subsidies and other trade-distorting policies than predecessor spatial trade models. This model is employed in the next two sections of the paper (a) to evaluate scenarios where the former Soviet Union discontinues as a long-term net purchaser and draw implications on world wheat trade and prices, and (b) to analyze the effects of random fluctuations in wheat production in the FSU on the world wheat market. The results reported in the third section show that if the FSU achieves self-sufficiency, the simulated impact on average price levels is significant; however, whether prices actually will trend downward seems unlikely in light of projected world production, income, and population trends to the turn of the century. The results of a stochastic simulation in the fourth section suggest that the former Soviet region will play an important role in the year-to-year behavior of the world wheat economy, even if long-term self-sufficiency is achieved. Contrary to conventional wisdom, this role is argued to be stabilizing rather than destabilizing over time. Concluding remarks and implications are presented in the final section.

Economic Transition and Former Soviet Wheat Trade

Raup, a long-time observer of Soviet agriculture, has noted on several occasions that the Soviets should be able to eliminate their need for imports. More recently, he has speculated that this is "well within their grasp, and it could come relatively quickly ... by the latter years of the 1990s" (p 24). Studies by U.S. Department of Agriculture (USDA) researchers (Cook, Leifert, and Koopman; Sheffield; Koopman) suggest that under full privatization, marketization, and liberalization of agriculture, the former Soviet Union could approach self-sufficiency or even become a net exporter of grain, and particularly wheat. Other analysts are joining the chorus that the former Soviet Union could eventually discontinue its presence as a major buyer in the world wheat market (e.g., Avery; Brooks).

Johnson has noted that when and to what extent the former Soviet Republics, as a region, will reverse their role as a major grain importer is highly speculative. It is now apparent to analysts that it is impractical to expect the transition to a market-oriented economy to occur overnight. Prices and quantities were far from their likely equilibrium values in the old regimes (Hewett 1989). Changing from a planned economy with heavily subsidized consumer prices and irrational input and output prices has proven to be a daunting undertaking. Reform programs have had limited positive impact, partly because of a deeply engrained distrust of markets and partly because the basic superstructure of highly bureaucratized and monopolized systems remains entrenched. Where the old bureaucratic system of economic management is being dismantled, a lack of progression toward operational market mechanisms continues to be pervasive. The fallout includes "near universal corruption" (Foster) that goes well beyond the frustrations and inconvenience of encounters with red tape. A number of observers of Soviet agriculture have noted that after several decades as wage earners, farm workers lack managerial and entrepreneurial traditions (e.g., see Guth). Macroeconomic price discipline has been delayed, with alarming inflationary repercussions. Social and political instability continues in the former Soviet Republics. Viability of the economy will require fashioning of institutional arrangements (Bromley).

With no historical precedent upon which to draw except the Eastern European experience, economists have been overwhelmed in offering solutions to politicians who will dominate the process that restructures socialism into market-driven economies. Political leaders in the former centrally planned economies aspire to achieve capitalism's efficiencies without abandoning other goals long espoused by socialists. Whether one takes the Schumpeterian perspective (Murrel), i.e., stressing innovation over security when contrasting capitalist and Soviet-type economies, or the perspective of equity versus efficiency (Hewett 1988), politicians clearly face a challenge in converting these economies to market-oriented, Western-type economies. Russia has made more progress in developing markets and private property than any other member of the Commonwealth of Independent States. Nevertheless, in spite of Yeltsin's endorsement and relative success in achieving rapid price and economic reform, the outcome of the December 1993 elections (Vanous) and other recent developments cannot be regarded as promising for future reforms. Pressures to backtrack almost inevitably will slow the transition. Alexander Nikonov, an eminent Russian agricultural economist, has stated it will take almost a decade to travel the road of transition. This may be an optimistic estimate.

Timing is one speculative dimension of the former Soviet Union's future role in the world wheat economy, and the extent that its wheat deficit is reduced or reversed is the other dimension that invites speculation. Agricultural land in the former Soviet Union is relatively abundant, even if poor soils and weather conditions are taken into account [Organization for Economic Cooperation and Development (OECD) 1991, p. 98]. Imperial Russia was one of the world's major surplus grain producers, before becoming a casualty of the First World War, and further evolving into revolution and civil war. Grain shipped through Odessa and other Black Sea ports constituted about half of Russia's total export revenue towards the end of the nineteenth century.

To extrapolate a return to export status a century later, just because the Marxist centrally planned economy has collapsed, may be too simplistic. In Czarist times, the sale of grain apparently took some 15% or more of total Russian production in spite of considerable hunger at home (Charques). Russia's land tenure and agricultural procurement system possibly was nearly as export biased in the twilight of Czarist Russia as it was under Stalin in order to finance foreign investment and credits to support industrialization, and to subsidize the military schemes of a totalitarian ruling regime. The Soviet Union's poor agricultural performance and large imports of grains in the last two decades were due as much to over-stimulated demand from price and income policies and other policy errors as to systemic failure of agricultural production and distribution (Johnson and Brooks). Simply replacing socialized agriculture with privatized agriculture will not assure success of the region's wheat economy, especially if accompanied by poor financial/price management and policies. Moreover, as current events attest, policies of intervention in market-oriented economies can bias trade toward exports or imports.

Many scenarios for former Soviet participation in the world wheat economy by the turn of the century could emerge from the preceding observations. If and as the former Soviet Union progresses through a transition to an open-market economy, modeling to endogenize the procedure will be very difficult. Econometric estimation of excess demand and supply parameters was problematic under the centrally planned regime, and in light of the abrupt structural changes occurring, it is unlikely that estimation will yield useful behavioral patterns of trade parameters for the new regimes within the near future. Assumptions of exogenous shifts of income or production would be difficult to justify even if we had a structural model for incorporating these assumptions to project future trade needs or prospects. The magnitude of price response as reflected in domestic demand and supply parameters will be purely conjectural. Even price transmission elasticity values will be purely speculative. An exercise assuming unitary price transmission (no market intervention), or zero (total insulation of domestic prices from world price movements), or some other arbitrarily assumed value is the only tool we have available until the transition process unfolds sufficiently to reveal how government programs allow international market and price forces to affect domestic price determination.

If the researcher simply makes plausible assumptions about the future trade status of the region, this will be no more arbitrary than assuming changes in parameter values or exogenous variable values to determine potential impacts of the transition. Past Soviet grain imports were possible because government officials possessed a pool of foreign exchange reserves accrued from energy exports, and later a credit capacity that appeared sustainable. Now that hard currency reserves are depleted, imports of additional grain will depend on concessional terms offered by exporters. In the short to intermediate term, the FSU, as a region, could continue to be a net wheat importer if compensatory export credit guarantees and subsidies are available from Western governments to finance those purchases (Sheffield). However, we can conservatively speculate, based on the assumption that rather large concessional injections supporting imports are discontinued by the year 2000, that the region will either approach or be constrained to self-sufficiency. Imports of grain are already down considerably, explained by foreign exchange constraints and reduced use of grain in a much contracted livestock sector. The analysis that follows is developed under the assumption that the former Soviet Republics, as a region, will have exited the world grain market as a continuous net importer by the year 2000.

Base Model Specification and Description

The model from which simulations are reported in this paper is a quadratic programming spatial equilibrium trade model. Spatial trade models analyzing patterns and trends in the world wheat market, initially applied in the late 1960s, have continued to be used extensively (e.g., see Schmitz; Anania and McCalla; Anania, Bohman, and Carter; USDA/ERS; Holland and Sharples). The model contains 194 countries, protectorates, and regions incorporated into exporting regions consisting of Australia, Argentina, the European Economic Community, and six U.S. and two Canadian export ports, plus the FSU and 22 other world importing regions. Refer to table 1 for an aggregated listing of participating trading regions. Column one presents regional groupings that are aggregated from the model grouping to conserve space.[1] Equilibrium prices and trade flows are generated by maximizing a net social payoff objective function, or its equivalent, net benefits of trade (Takayama and Judge).

Excess demand ($P_j = \lambda_j - \omega_j Q_j$) and supply ($P_i = \mu_i + \eta_i Q_i$) functions, specified as quantity domain equations, were incorporated into an objective function to maximize net social payoff (Z):

(1) $$Z = \sum_{j=1}^{23} \int_{0}^{Q_j} \left(\lambda_j - \omega_j Q\right) dQ - \sum_{i=1}^{11} \int_{0}^{Q_i} \left(\mu_i + \eta_i Q\right) dQ - \sum_{i}^{11} \sum_{j}^{23} T_{ij} X_{ij}$$

subject to

(1a) $Q_j = \sum_{i=1}^{11} X_{ij}, \quad j = 1, ..., 23$

(1b) $Q_i = \sum_{j=1}^{23} X_{ij}, \quad i = 1, ..., 11$

(1c) $P_j \geq 0$ and $P_i \geq 0, \quad j = 1, ..., 23, \; i = 1, ..., 11$

(1d) $X_{ij} \geq 0, \quad i = 1, ..., 11, \quad j = 1, ..., 23$

(1e) $P_j - P_i \leq T_{ij}, \quad i = 1, ..., 11, \quad j = 1, ..., 23$

(1f) $X_{ij}(P_j - P_i - T_{ij}) = 0$

where

$Q_j = \sum_{i=1}^{n} X_{ij}$ is the sum of shipments to importer j from exporter i;

$Q_i = \sum_{j=1}^{m} X_{ij}$ is the sum of shipments from exporter i to importer j;

i represents export regions or ports, $i = 1, ..., 11$ ($i = 1, ..., 8$ represents U.S. and Canadian ports, and $i = 9, ..., 11$ represents other export regions);

j represents import countries or regions, $j = 1, ..., 23$;

P_i represents the price of wheat at export ports i;

P_j represents the price of wheat at import ports j;

X_{ij} represents wheat trade flows from export ports to import ports;

T_{ij} represents net transfer costs per unit from export ports to import ports; and

Z as defined earlier, is net social payoff.

Constraint equations (1a) and (1b) were introduced to meet import demand and export supply conditions in importing and exporting regions or countries, respectively. Constraint (1c) stipulates that import and export prices at equilibrium are positive. Constraint (1d) states that quantity outflows of wheat from export regions or inflows to import regions are greater than or equal to zero.

Conditions (1e) and (1f) state that the price differential (P_j - P_i) between two trading regions must be less than or equal to the transfer costs (T_{ij}) between the regions. If the trade flow between the two regions is positive, the price differential will equal transfer costs. On the other hand, if the price differential is less than transfer costs, no trade will occur between the regions. In a world with no trade interventions, T_{ij} would consist of transportation costs (τ_{ij}) exclusively. When tariff and tariff equivalents of nontariff import restrictions (π_{ij}) along with export subsidies (σ_{ij}) are included, T_{ij} expands from a transportation cost matrix to a generalized transfer matrix, where $T_{ij} = \tau_{ij} + \pi_{ij} - \sigma_{ij}$ (Takayama and Judge, chapter 10).

We consider both cases in selecting the empirical model below, and introduce a price differential proxy (PDP) version, which approximates the combined effects of transportation costs and tariff and subsidies. We found that the PDP generalized transfer version tracts actual trade and price patterns better than spatial solutions using estimated transportation costs exclusively. This addresses one of the fundamental issues regarding the plausibility of spatial trade modeling simulation results. Price transmission elasticity assumptions incorporated into trade elasticity parameters partially account for government intervention and trade distortion in spatial trade models, but the wedge driven between import and export prices usually ignores tariffs and subsidies.

Proxy transfer values used in the PDP model version were estimated from origin to destination by taking the difference in average prices ($\overline{p}_j - \overline{p}_i$) between importing regions j and exporting regions i for the period 1986-90. Implicit export and import prices were calculated from trade value and quantity data from various issues of the *FAO Trade Yearbook*, published by the United Nations, Food and Agricultural Organization. Annual (1971-1991) export quantity and price data for designated port areas in the U.S. were obtained from the USDA's *Grain and Feed Market News*. Parameters of excess supply and excess demand functions were estimated from historical trade and price data (1986-90), and trade elasticities. Ocean shipping rates in the traditional model version, as contrasted with the PDP modified spatial model, were estimated using a procedure outlined in Jones et al.

Two sets of elasticity assumptions are employed to analyze two different trade issues concerning the FSU. The issue of the FSU's long-run impacts on the level of future world prices logically calls for long-run elasticity response, but the effect of annual variability in FSU wheat production on world prices and trade is more appropriately viewed as a short-run issue. Additionally, the range of results can be compared to observe the sensitivity of elasticity parameter assumptions.

Long-run trade elasticities are derived from domestic demand and supply elasticity parameters and price transmission assumptions reported in Tyers and Anderson. Short-run trade elasticity parameters were taken from USDA/ERS. There are two distinct approaches to estimation of excess demand and supply elasticities: direct econometric estimation and synthetic estimation methods. Long-run trade elasticity parameters were calculated from domestic supply, demand, and price transmission elasticity parameters estimated econometrically by Tyers and Anderson. In our study, these elasticity estimates were weighted by base period price and quantity data. The long-run elasticity estimates do not include stock elasticity coefficients, since stocks are assumed constant over time.

The short-run trade elasticities cited above were derived synthetically, with the important qualification that these judgmental estimates were compiled by a panel of academic and government trade economists who incorporated prior econometric estimates where they were available and were judged to satisfy reasonable statistical and theoretical criteria. Details of how the elasticities were selected are reported in the USDA/ERS trade embargo study, and also in Abbott and in Abbott and Paarlberg. These short-run elasticities incorporated price transmission elasticity and stock adjustment assumptions.[2] Based on the above parameter assumptions weighted for the base period 1986-90, excess demand faced by the U.S. is inelastic (-0.80) in the short run, and elastic (-4.08) in the long run.

Comparisons of trade and price simulations with actual values in the base model solutions are summarized in table 1 for long- and short-run elasticity assumptions, respectively.[3] Columns two and five (denoted "Actual") list historical average trade and price data for the base period 1986-90, which can be compared to simulated values using the price differential proxy transfer matrix (PDP) in columns three and six, and the transportation matrix (TRANS) in columns four and seven. Most spatial programming models have been solved using a transportation cost matrix, even though the literature recognized early on the conceptual ability to incorporate a generalized transfer matrix which adds import tariffs and deducts export subsidies in addition to transportation costs. The problem has been the daunting task of incorporating data into the model for tariff and tariff equivalents and subsidies. The technique described above (taking actual historical data on price differences between exporting and importing regions as a proxy for tariffs and subsidies) is a relatively straightforward method of estimating approximate average values for trade intervention parameters that are known to play a very prominent role in agricultural trade and prices. Cursory inspection of table 1 reveals that simulated trade and prices employing the generalized PDP transfer model approximate actual values notably better than simulations employing a simple transport cost matrix.

Where available, information can be substituted into the transfer matrix pertaining to the occurrence of trade barriers that are not generally proportionately or globally applicable, but that apply uniquely to a specific trade flow between two countries. For example, in our model, an arbitrarily large transfer cost is inserted between shipments from U.S. Pacific Northwest origins (Columbia River and Puget Sound export ports) to China. This is done to take into account a quarantine imposed by China, since 1973, on shipments from these ports because of concern by China's plant and quarantine authorities about possible dwarf bunt infestation in shipments from this region.

Overall goodness of fit between simulated and historical trade and prices is summarized as mean absolute deviation (MAD) coefficients for five alternative model formulations in table 2. It can be seen from this table that the model utilizing a PDP matrix more accurately tracts world trade and prices in both long-run and short-run model versions. In the long-run version of the model, the error associated with estimation of the base period's import quantities has been reduced by 77% by exchanging the simple transport cost version with a price differential proxy matrix version. The error associated with estimation of export quantities was reduced by 48%, and that associated with the model's ability to capture actual import and export prices was reduced by approximately 76%. In the model's short-run version, the error associated with estimation of the base period's import quantities has been reduced by 25% by exchanging the simple transport cost version with a price differential proxy matrix. The error associated with estimation of export quantities was reduced by 30%, and that associated with the model's ability to capture actual import and export prices was reduced by 49%.

All model versions reported in this paper disaggregated Canadian and U.S. exports regionally, as opposed to the traditional procedure of specifying shipments through U.S. Gulf ports as representative of all U.S. exports, or as one port for all Canadian exports. Export supply functions for six U.S. port regions (Gulf, Atlantic, Great Lakes, Puget Sound, Columbia River, and California) and two Canadian port regions (East and West) were directly estimated by regressing regional export shipments on port price, hinterland wheat production, and proxy variables that capture port and hinterland infrastructural developments. Disaggregating shipping regions in Canada and the U.S. was motivated by the need to reduce the error associated with ignoring substantial intraregional cost differences of shipping from different port regions to overseas markets. The disaggregated port model reduces error, as compared to a single or aggregated port specified model, by 30% for export prices, 29% for import prices, 23% for export volume, and 39% for import volume.

The base model selected for construction and comparison of simulations below employs the PDP transfer matrix solution because of its conceptual and empirical advantages. Referring back to table 1, total imports simulated for the FSU in the long-run version of the model is 17.992 million metric tons (mmt), accounting for 18.8% of world total imports. Total imports simulated for the FSU in the short-run version of the model is 17.844 mmt, accounting for 19.0%

of world total imports. Actual average market share for the period 1986-90 was 18.5%, or 17.132 mmt.

Year 2000 Projection

The significance of the Soviet role in world trade in the base period can be seen by running a scenario without its presence, i.e., FSU is self-sufficient (see table 3). In the model with long-run trade elasticity assumptions, world trade volume drops from 95.557 mmt to 87.745 mmt, approximately 8%, and the trade weighted export price falls from $147.30 per ton to $131.10 per ton, or approximately 8%.

Table 3 also presents the results of solutions which project the volume of wheat trade flows and prices at the turn of the next century. The purpose of the projections is to give some perspective on the implications of Soviet withdrawal as a consistent year-to-year importer in the context of the dynamics of the world wheat market. These cases basically contrast the projection of a protectionist scenario (Crisis-2000) with two scenarios that assume enactment of the Uruguay Round and continuation of dynamic economic trends in Asia (Growth-2000 and Shift-2000).

The projection scenarios are based upon population and income growth rates assumed in the 1992 OECD study, *Long-Term Prospects for the World Economy.* The Growth-2000 scenario is run assuming a global annual income growth rate of 3.6% and an annual global population growth rate of 1.5% through the turn of the century. The Shift-2000 scenario assumes the same world population growth rate, but a gross domestic product growth rate of 3.4%. This scenario is run to capture continued shift in economic activities from the Atlantic to the Pacific basin. It also brings out another feature of trade modeling (spatial or otherwise), namely that regional elasticity parameter assumptions are important. While the Shift scenario assumes a lower overall rate of world income growth, its impact on wheat prices is more bullish than the Growth scenario because of differences in regional growth assumptions (and income elasticities). The Crisis-2000 scenario assumes the world experiences a lower annual income growth rate of

2.6%, and the same population growth rate as in the Growth-2000 scenario. Projected growth rates averaging 2.3% for world wheat production (World Bank) were assumed in all scenarios. Given the leveling out of growth beginning around 1984, this would seem to be a fairly optimistic assumption.

The import tariff and export subsidy reductions required in the recent Uruguay Round agreement were implemented through the PDP matrix by reducing or expanding the price wedge between importer and exporter. Export subsidy reductions increased the price wedge whereas import tariff reductions reduced the price wedge. The adjustments to reflect Uruguay Round agreement provisions were calculated on the basis of tariff and subsidy reduction commitments by GATT members, as reported in Premakumar et al.

In the context of the dynamics of world population, income, and wheat production growth trends in the projections above, the impact of FSU self-sufficiency looks much less dramatic than earlier, when the simulated impact was viewed in the base period. Regardless of the scenario, world trade is projected to increase in volume by the year 2000 compared to the base period average. World prices are also projected to increase, except in the Crisis-2000 case, which assumes an anemic world gross domestic product (GDP) annual growth rate of 2.6%. Indeed, even in the Crisis scenario, an assumption of a slightly lower growth trend in world wheat production would result in a price increase in spite of the FSU becoming self-sufficient.

Needless to say, these scenarios do not begin to exhaust all possible occurrences that could unfold by the turn of the century, but our judgment is that they set plausible boundaries on possible developments. Finally, the above projections are all based upon assumed long-term trends, but major economic or climatic disruptions in any given period could dramatically influence wheat trade and prices within these parameters. For example, a serious food crisis because of drought occurring simultaneously in the former Soviet Union, the United States, and China could cause prices to rise dramatically. Addressing this type of issue requires explicitly considering stochastic disturbances in supply, which is the focus of the next section with emphasis upon the FSU.

Stochastic Disturbances in FSU Wheat Production

The focus of the discussion so far has been on the impact of the FSU discontinuing its role as a consistent net importer in the world wheat market. However, even assuming long-term self-sufficiency, the region still may play a significant role in the world wheat market by buying wheat in years of crop shortfalls and selling in years of bumper crops. Because the grain belt in the former Soviet Union is located in the high northern latitudes, winters are long and summers are short.

In particular, winterkill in long, severe winters can be a factor contributing to annual crop variations. In addition, short growing seasons enhance the penalty of delays in planting and harvesting, and therefore augment year-to-year variations caused by weather phenomena such as winterkill, drought, flood, and adverse conditions at the time of harvest. In this section, a stochastic simulation analysis is employed to examine the projected effects of stochastic wheat supply in the FSU on world price and trade flow variability.

Following Bigman, we postulate a stylized model to examine the impact of wheat production instability in the FSU on the world market. Consider a model with linear supply and demand functions defined for each region or country $i = 1, ..., n$ as

(2) $$S_i = a_i + b_i P_{it} + u_{it}$$

(3) $$D_i = c_i - d_i P_{it}$$

where S is supply; D is demand; P is price; a, b, c, and d are positive coefficients; and u is stochastic supply disturbances. The stochastic term is assumed to be distributed with mean zero and variance σ^2. We assume that consumers' tastes and preferences are stable, and domestic demand is not subject to random fluctuations. The stochastic disturbance vector $[u_1, u_2, ..., u_n]$ is distributed with mean $[\mu_1, \mu_2, ..., \mu_n]$ and variance $[\sigma_1^2, \sigma_2^2, ..., \sigma_n^2]$. All covariance terms are assumed zero, implying that supply shifts in different countries are governed by independent forces. The linearity and additive risk assumptions simplify determination of market equilibrium in a multi-region world, because they generate linear excess demand/supply equations. For convenience of presentation in this section, region 1 is assumed to be the former Soviet Union. Excess supply/demand for region i is given by

$$X_i = S_i - D_i = a_i + b_i P_{it} + u_{it} - c_i + d_i P_{it} \tag{4}$$

As shown by Bigman, the degree of price variability in a region experiencing stochastic production shifts is reduced as a result of trade. Trade acts as a buffer program that helps to stabilize prices in the FSU in our application. The issue we address is how stochastic supply in the FSU affects the world wheat market.

A stochastic simulation procedure is used to analyze the impacts of FSU wheat instability. The stochastic simulation procedure is based on the large-sample theory that the distribution of a sample approaches that of the true population as the sample size increases. Stochastic simulation is used to analyze the behavior of the endogenous variables in response to random shocks. For example, production fluctuations are due to random shocks generated by weather vagaries, pests, and disease.[4] These production fluctuations cause inherent instability in the market, and the stochastic simulation approach is an appropriate technique to study the effects of these instabilities on other endogenous variables. McCarthy has provided the methodology for undertaking stochastic simulations, which is briefly discussed next.

Consider the following definition of pseudo-structural disturbances:

$$V = \frac{1}{\sqrt{T}} rU \tag{5}$$

where V is a $1 \times M$ matrix of pseudo-structural disturbances; r is a $1 \times T$ vector of random numbers, normally distributed with zero means and unit variances; U is any $T \times M$ matrix of disturbances from T observations of M true structural equations, and has $M \times M$ covariance matrix $\Sigma = T^{-1}EU'U$. Since r is standard normal, and is independent of U, the covariance matrix of V is given by

$$\Sigma_v = EV'V = \frac{1}{T}[EU'U]I = \Sigma. \tag{6}$$

Substitution of estimated sample residuals, $\hat{U}$, for U yields the disturbance vector and its covariance matrix:

(7) $$\hat{V} = \frac{1}{\sqrt{T}} r\hat{U}$$

(8) $$\hat{\Sigma}_V = \frac{1}{T} E\hat{U}'\hat{U} = \hat{\Sigma}.$$

In empirical application, however, $\hat{\Sigma}$ is estimated first, and $\hat{V}$ is computed using r as follows (see Chowdhury and Heady). Define

(9) $$\hat{V} = Hr$$

such that

(10) $$E(Hrr'H) = HE(rr')H' = HH' = \hat{\Sigma}.$$

Since Σ is a symmetric positive definite matrix, Cholesky decomposition can be applied to obtain a unique lower triangular matrix H. From equations (6) and (10), it is clear that $\hat{V}$ in (9) is equal to V in (5).

Next, we explain how $\hat{V}$ is computed in this study. A trend equation for production is estimated using

(11) $$S_i = \alpha_i T + U_i \quad (i = \text{FSU, ROW})$$

where S_i is wheat production in country i, T is time trend (1960-90), α_i is the coefficient, and U_i is the stochastic disturbance. The estimated residual is

(12) $$\hat{U}_i = S_i - \hat{\alpha}_i T.$$

The estimated variance of the residuals is denoted as $\hat{\sigma}_i^2$ The computed residual is

(13) $$\hat{V}_i = r\hat{\sigma}_i.$$

Once $\hat{V}_i$ is computed, it is substituted into the trend production equation to generate a random production function:

(14) $$\hat{S}_i = \hat{\alpha}_i T + \hat{V}_i.$$

By repeating this process, thirty random production values are generated for the FSU and the other trading regions (ROW) for the year 2000. Columns 2 and 3 in table 4 present the projected baseline 2000 nonstochastic production levels and coefficients of variation of production computed from the thirty stochastic values for the FSU and ROW, respectively. The coefficient of variation of 0.134 in production in the former Soviet Union exceeds that of the rest of the world (0.053). While these summary statistical values emphasize the volatility of FSU production due to stochastic weather disturbances relative to ROW wheat production, the coefficient of variation for total world production (not shown in table 4) including the FSU is 0.041. To the extent that year-to-year weather variations in the FSU are independent of ROW weather variations, production in that region is not necessarily destabilizing to world wheat production.

Assuming the former Soviet Union were to become essentially self-sufficient in the long run, the region can still play an important role in world wheat trade by importing in certain years and exporting in other years, as shortfall and bumper crops occur from season to season due to variations in weather conditions. Production values generated from the thirty stochastic production values are incorporated into the spatial equilibrium model to generate the values of other endogenous variables.

Table 4, column 4, shows scenarios where the FSU is assumed to be normally self-sufficient, but a substantial volume of trade is generated due to random disturbances in supply. Two values of FSU price transmission are assumed. Under a "restricted trade" scenario, the coefficient of price transmission elasticity is assumed to be 0.32, which assumes the same level of trade intervention as that under the old Soviet trade regime in the 1986-90 base simulations. FSU trade ranges from a net export high of 25.5 mmt to an extreme of 22.5 mmt in imports over the thirty simulations. Assuming an unrestricted trade price transmission elasticity coefficient value of unity increases the range of trade to a net export high of 37.7 mmt and a net import extreme of 27.9 mmt. Clearly, even if the FSU achieves long-term self-sufficiency by the turn of the century, the world wheat economy will still be scrutinizing wheat market conditions in the FSU each year. But to suggest the FSU will remain pivotal in world wheat trade is not necessarily the same as saying the region will be destabilizing over time, as demonstrated by the results in columns 5 and 6 of table 4.

Column 5 of table 4 presents summary world price descriptive data resulting from a scenario of stochastic supply in the ROW and including the FSU in the world wheat economy. Column 6 presents similar descriptive data, but with the FSU excluded, to show the net effect of FSU stochastic production and trade on the world wheat economy. Contrary to conventional wisdom, the overall stochastic role of the former Soviet Republics, as reflected in the coefficients of variation of world prices, does not contribute to overall variability in world prices. Coefficients of 0.396 without Soviet stochastic trade, compared to 0.309 under the restricted trade assumption and 0.265 under the unrestricted trade scenario with former Soviet participation, suggest that the stochastic role of production in the FSU over time would tend to ameliorate price fluctuations due to stochastic fluctuations in the rest of the world.

Both coefficients should be taken as qualitative rather than quantitative indicators of stochastic influences on world trade and prices. The model exercise omits storage adjustments in the FSU that would buffer these variations somewhat. While stock adjustment elasticities were included in the Delphi trade elasticity estimates used in the spatial model for some participating trading regions, the FSU elasticity did not include stock adjustments. Other considerations also are omitted in the above intellectual exercise. Johnson and Brooks, and Desai have noted that much of the annual variability in Soviet production in the past could be attributed to policy and economic problems not associated with climate. During the transition, shortages or delays of inputs could enhance the degree of variability; conversely, successful transition to a more market-oriented agricultural sector could in time reduce the level of future variability.

The above results run counter to the common perception that the FSU aggravates rather than ameliorates world price variations. Examination of extreme values of prices in the stochastic simulation explains the perception that the former Soviet Republics, as a region, have contributed to volatility in world market prices. The prices varied from a low of $66.03 per ton to a high of $237.36 per ton, a range of $171.33 per ton. The range is even greater without

Soviet participation ($209.13 per ton). But a year in which domestic production in the former Soviet Union buffers large variations in ROW production is less likely to be remembered with the same clarity as a year such as 1972, when a severe shortfall in the Soviet Union corresponded with a below-average world crop (and increasing world demand).

Conclusions and Implications

This paper has examined the impacts of a possible withdrawal of Russia and Eurasia from the world wheat market by the turn of the century. In increasing numbers, trade analysts are predicting that the former Soviet Union will no longer be a significant net importer as price and market reforms suppress excess demand for wheat, and/or as hard currency financial pressures force an end to FSU purchases of wheat imports.

The breakup of the Soviet Union and the ongoing transition of the various former republics to market-oriented economies make it important, albeit difficult, to determine the future market role of the region in the global wheat economy. Through spatial trade modeling experiments, we have examined possible future scenarios in the world wheat economy that may occur if the former Soviet Union should evolve to a long-term self-sufficiency position by the turn of the century. The simulations demonstrate, as expected, that the evolution of the former Soviet Union to self-sufficiency in the world wheat market could have substantial effects on world trade/price levels and patterns. However, whether world prices will fall or increase in the next century depends on other economic policy parameters and trends, as demonstrated in the OECD Crisis-2000 and Shift-2000 simulations. Even assuming self-sufficiency, stochastic production variations in the region could on occasion throw the FSU into the world market as a large importer or exporter. While the image of the area as a major source of volatility will probably continue as the transition to a more market-oriented economy occurs, our simulations suggest that over time the region acts as a moderate buffer to production variations in the rest of the world because of production variation due to weather phenomena. Moreover, for the foreseeable future, the world market will continue to receive mixed signals as to whether the region is moving toward or beyond self-sufficiency; i.e., even at or near self-sufficiency, the region will likely import in certain years and export in others, much as India's precedent of the past several years.

At present, possible modeling exercises on scenarios in which the region becomes a long-term net exporter are too varied to constrain. But if Nikonov is correct in his assertion that the transition of the Soviet-type economies to market-oriented economies will be completed within a decade, it may be appropriate to look at these scenarios by the turn of the century.

Footnotes

[1]The disaggregated results are available to interested readers from the authors.

[2]Estimated excess demand and supply data and parameters are available from the senior author upon request.

[3]The model is a quadratic programming algorithm with linear constraints, solved using the General Algebraic Modeling System (GAMS/MINOS) software package.

[4]Production would capture the stochastic elements better than yield because stochastic elements in production contain variability in both the yield and acreage.

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Table 1. Actual (1986-90 average), Price Differential Proxy General Transfer (PDP), and Transportation (TRANS) Base Trade and Price Solutions

Country/	Trade (1,000 mt)			Price ($/mt)		
Regions	Actual	PDP	TRANS	Actual	PDP	TRANS
			Long-Run Elasticity Assumptions			
FSU	-17,132	-17,992	-12,646	124.3	120.3	145.1
ROWM[a]	-75,325	-77,565	-77,943	154.4	150.1	147.0
U.S. West[b]	11,893	11,241	11,103	142.1	138.0	126.7
U.S. East[c]	3,212	3,573	3,613	130.0	126.0	127.1
U.S. Gulf	19,278	17,262	16,668	137.3	133.5	124.5
Canada	18,504	15,580	13,882	164.8	159.6	130.0
ROWX[d]	49,104	47,901	45,323	155.7	151.9	131.5
			Short-Run Elasticity Assumptions			
FSU	-17,132	-17,844	-15,956	124.3	114.2	141.1
ROWM[a]	-75,325	-76,276	-76,416	154.9	145.1	143.0
U.S. West[b]	11,893	11,166	11,053	142.1	131.9	122.7
U.S. East[c]	3,212	3,389	3,492	130.0	119.9	123.1
U.S. Gulf	19,278	16,855	16,401	137.3	127.4	120.5

Note: Negative volume signs denote wheat imports.

[a] ROWM denotes rest of world importing regions (Eastern Europe, Other Western Europe, Mexico, Central America and Caribbean, Brazil, Venezuela, Other South America, China, Japan, Other East Asia, Indonesia, Thailand, Other Southeast Asia, Mid-East, Egypt, North Africa, Nigeria, West Central Africa, East Africa, and South Africa).

[b] US West denotes Puget Sound, Columbia River, and California.

[c] US East denotes Gulf, Atlantic, and Great Lakes.

[d] ROWX denotes rest of world exporting regions (E.U.-15, Australia/Oceania, Argentina).

Table 2. Mean Absolute Deviation (MAD) Coefficients of Alternative Base Models*

	Short-Run Price Differential Proxy Model	Short-Run Transportation Matrix Model	Long-Run Price Differential Proxy Model	Long-Run Transportation Matrix Model	Long-Run Port Price Differential Proxy Model
			Exports		
MAD of Price	10.13	19.72	4.03	16.38	5.76
MAD of Trade	661.27	943.64	667.45	1,275.64	868.80
			Imports		
MAD of Price	10.11	19.98	4.07	18.07	5.77
MAD of Trade	121.04	160.35	140.26	616.70	229.13

*The mean absolute deviation (MAD) of simulated values from historical values was calculated by the formula: MAD = $|X - \hat{X}|/n$, where X is the actual average price or trade quantity for 1986-90, $\hat{X}$ is the simulated price or trade quantity, and n is the number of shipment points (n = 23 for importing regions, and n = 11 for exporting regions except in the aggregated North American port model, where n = 5).

Table 3. Base Solution and Scenarios Assuming FSU Self-Sufficiency

Country/ Regions	Base 1986-90	FSU Self-Sufficiency Scenarios 1986-90	Growth-2000	Crisis-2000	Shift-2000
		Trade Quantity (1000 mt)			
FSU	-17,992	0	0	0	0
ROWM[a]	-77,565	-87,745	-129,079	-122,785	-137,941
U.S.	32,076	30,247	51,179	49,399	52,836
EU	31,027	29,042	38,391	38,608	40,896
Canada	15,580	14,627	18,519	17,097	19,461
ROWX[b]	16,874	13,829	20,990	17,681	24,748
Total trade	95,557	87,745	129,079	122,785	137,941
		Price ($/mt)			
FSU	120.2	--	--	--	--
ROWM[a]	150.3	133.6	159.7	134.0	175.5
U.S.	134.2	114.4	136.0	114.1	152.7
EU	167.1	150.4	156.5	149.4	173.2
Canada	159.6	159.6	167.1	142.1	183.7
ROWX[b]	124.0	107.8	131.5	106.5	147.5
World[c]	147.3	131.1	145.8	128.6	162.2

Note: Negative volume signs denote wheat imports.

[a] ROWM denotes rest of world importing regions (refer to table 1, footnote a, for full description).

[b] ROWX denotes rest of world exporting regions (refer to table 1, footnote d, for full description).

[c] World price is trade weighted FOB price.

Table 4. Random Supply Shocks and the Impact of the FSU on the World Wheat Market

Summary Statistics	FSU Production (1,000 mt)	ROW Production (1,000 mt)	FSU Stochastic Net Trade (1,000 mt)	Trade-Weighted World Price with FSU Stochastic Trade ($/mt FOB)	Trade-Weighted World Price without FSU Stochastic Trade ($/mt FOB)
Baseline 2000	95,476	558,946	0	--	167.59
Restricted Trade Scenario (FSU price transmission elasticity = 0.32)					
Range	50,211	117,321	48,032	171.33	209.13
Minimum	69,473	491,832	-22,532	66.03	51.29
Maximum	119,684	609,153	25,500	237.36	260.42
Coefficient of Variation	0.134	0.053	5.65	0.309	0.396
Unrestricted Trade Scenario (FSU price transmission elasticity = 1)					
Range	50,211	117,321	58,946	140.21	209.13
Minimum	69,473	491,832	-27,861	82.42	51.29
Maximum	119,684	609,153	37,674	220.75	260.42
Coefficient of Variation	0.134	0.053	1.922	0.265	0.396

Notes: Negative volume signs denote wheat imports. FSU = Former Soviet Union, ROW = Rest of World, and FOB = weighted price at export origins.