# Agricultural Output and Productivity in the Former Soviet Republics

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**Abstract**

The paper reviews agricultural development in the fifteen former Soviet republics over the period 1965-1997. Production functions are estimated and productivity differences and changes calculated. Large differences were found in terms of productivity and growth between the republics. The differences grew after 1990 reflecting variation in reform policies.

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## Introduction and Summary

This paper is an examination, in two parts, of productivity and changes in agriculture in the 15 new independent states that up to 1991 constituted the republics of the Soviet Union. The first part presents what may be called a conventional production function analysis for the Soviet period before 1990. The second part deals with the post-Soviet period of transition, 1991-98, covering both the collapse associated with the dissolution of the USSR and the recovery that has begun to emerge. The report is preliminary in several ways. First, transition is still an on-going process, and it is safe to expect that accumulated information and experience will change, in the coming years, the lessons of its analysis. Second, information on the former Soviet economies is often more problematic than on agricultural sectors of other countries, but the available data may be expected to improve as studies accumulate. Last but not least, we have not exhausted the analysis, even within the current state on knowledge. We plan to continue and return with expanded reports.

Although the pre-1991 economic literature usually treated Soviet agriculture as a single monolithic entity[1], the agricultural sectors in the 15 republics differed significantly due to natural, social, and political factors. Because of these differences, labor productivity—output per worker—in the best performing republic was 2.5 times higher than in the agriculturally least productive republic. As wide as this gap may seem, it was much smaller than the corresponding

[1]An exception is McConnell Brooks, but she was interested in comparing agriculture in the Soviet republics to areas with similar climates outside USSR, while we are mainly examining the differences between the republics.

gap between agricultural productivity in non-Soviet countries. While productivity was comparatively low, input use in the Soviet republics was on a par with agriculture in the industrialized countries, but again technical change was smaller.

After 1991 agricultural production collapsed in all 15 new independent states, probably both because of reduction in demand as real incomes fell and because of the disruptions in support services that accompanied the elimination of central controls. The collapse was so dramatic that agricultural production did not recover to its pre-1990 levels even six or seven years later. The reduction in output was accompanied by declines in the use of factors of production. The utilization of most purchased inputs decreased; labor left agriculture in some of the republics, while in others, particularly the Muslim countries of Central Asia, agricultural employment increased. Decreasing output and changing input utilization affected efficiency. Some countries improved the efficiency of agricultural production, while in others efficiency deteriorated during transition. Paucity of data precludes a systematic statistical analysis of the transition period, but visual examination suggests that policies—land individualization, structural changes in services and institutions—and the performance of the non-agricultural sectors have strongly affected recovery and efficiency gains (or losses) in agriculture.

## The Soviet Period

*Agriculture in the Soviet Union*

The world's Industrial Revolution was accompanied by a no less dramatic agricultural revolution—food is now in abundant supply and we eat more and better than our forefathers did (Fogel). The Soviet Union inherited from the Czarist Empire a farm sector that produced, before World War I, enough food for domestic consumption and for export. Production expanded under

the Soviet regime, but nature, impatience, and human blunders combined to prevent agriculture from developing at the rate necessary to satisfy the needs of an economy that was pursuing rapid industrialization and urbanization.

Large parts of the former Soviet Union— the vast tundra and coniferous forests of northern Russia and Siberia—are not fit for agriculture. Farming is therefore practiced in a relatively small part of the former USSR: in its European regions, in the narrow belt stretching across all of southern Siberia, in Transcaucasia, and in Central Asia. However, with few exceptions, farming conditions are not favorable even in these food-producing parts. Most of the grain-growing areas of Russia and Ukraine are colder than many farming regions in the world. Further east and south, Central Asia is a dry desert. Despite their huge area, the grain-producing regions of the Soviet Union are mostly located in a narrow climate zone and are similarly affected by changes in weather. This similarity is the principal explanation for the comparatively large yield variations and food-supply fluctuations that characterized Soviet agriculture.

Three times shortage of food reached famine proportions in the Soviet Union: in 1918-21 in the wake of the revolution and war communism, in 1932-33 at the height of collectivization, and in 1946-47 in the aftermath of World War II. Many perished in each instance. The Soviet regime, particularly under Stalin, reacted with coercion to the inability of the farm sector to supply the growing urban population with adequate amounts of food. Farm products were forcibly procured from the farmers and, under the stress, miracle cures were embraced: collectivization, economies of scale, Lysenko's biology, and even an attempt to change the climate.

Many reforms in agriculture were attempted after Stalin—higher producer prices, heavy investment, cultivation of virgin lands, consolidation of collective farms, food imports—but the

basic structure was not changed, shortages prevailed, productivity was judged low, and the problem of agriculture remained a central national issue. Later it was even suggested (Johnson) that inflated food subsidies were one of the major causes for the dissolution of the Soviet Union in 1991.

*The Fifteen Republics*

Of the fifteen former Soviet republics, eight are northern, located in the temperate planes (the Baltics and the core republics; see Table 1) and seven are southern, located in Transcaucasia and Central Asia. As the data in Table 1 show, the two groups differ in more than just location and climate.

Typically, the northern populations had low rates of growth, less than 1% per year, while the southern populations grew much faster, with yearly rates exceeding 2% in the Muslim republics of Central Asia (Table 1). The republics also differed in income. In the late 1980s, on the eve of transition, GNP per capita in the northern republics was twice as high as in their southern counterparts. The northern republics fell in the World Bank's group of Higher Middle income countries, while the southern republics were at the level of the Lower Middle income countries. There was considerable inequality among the Soviet republics, and yet all of them fell in the Middle Income group. The income differences among the Soviet republics were thus substantially smaller than the differences among non-Soviet countries, ranging from Low to High Income economies. This attribute of the Soviet system, namely that the dispersion of the 15 republics was less than the dispersion of countries outside the USSR, will recur again and again as we continue our review.

In terms of labor allocation in the 1980s, only Russia could be considered an industrial country, with less than 14% of the labor force in agriculture. In the other countries, agriculture

had higher shares in employment, with the highest in the southern republics (Moldova, the southernmost member of the northern group, had 37% of labor in agriculture).

The republics differed also in the nature of their agriculture. The northern republics had relatively high shares of livestock in agricultural product and no irrigation to speak of (except Moldova). The southern republics had less livestock and, located as they were in a relatively dry climate, most of their arable land was irrigated.

*Productivity in the Soviet Republics*

The period of our analysis, dictated by the availability of data, covers the years 1965-1990. Productivity differences between the republics and changes over time were estimated in the framework of a Cobb-Douglas production function. The variables in the analysis are reported in Table 2 (in the Appendix we comment on the data and their sources.). Labor productivity—output per agricultural worker—was highest in the Baltics and lowest in Central Asia. Land endowments were highest in Kazakhstan and Russia, the principal grain-producing republics. In the southern republics, the land-to-labor ratio was comparatively low, but most of the area was irrigated. The Baltics had the highest capital-to-labor ratio (measured by horsepower of machines) and more livestock per worker than any of the republics, except the sheep-herding Kyrgyzstan. It seems that fertilizers were allocated in Soviet agriculture according to the principle of comparative advantage: the more intensively cultivated areas, among them the Baltic republics and the irrigated lands of Central Asia, received more fertilizers than the extensively cultivated grain-producing planes.

Although the Soviet republics differed substantially in labor productivity, these differences were smaller than among non-Soviet countries. Table 3 reports productivity and factor allocation in the Hayami and Ruttan sample (see Appendix for comments). Output per

agricultural worker (here measured in wheat units) was almost four times higher in the industrialized countries than in Latin America. The differences between the newly settled countries and Asian agriculture were even greater.[2] Inputs were measured in Tables 2 and 3 in essentially the same units. It is perhaps surprising to find that intensity of all factors—land, machinery, livestock, and fertilizers—in the Soviet republics was on a par with industrialized countries in the Hayami and Ruttan sample. The frequently reported poor labor productivity in the Soviet Union may have been a reflection of inefficient use of other inputs, machinery in particular (Johnson and McConnell Brooks, Medvedev).

As is typical of less-developed countries, agricultural labor in Central Asia was still growing (in absolute values) over the period 1965-1990 (not in the table), while in the European republics it was decreasing. Both demography and general economic conditions were responsible for the differences in trends in agricultural labor. The Central Asian republics had comparatively high birth rates and faster increases of the labor force. Combined with relatively smaller manufacturing and service sectors (as reflected by higher shares of labor in agriculture in Table 1), they lacked the ability to create employment opportunities for the growing numbers of workers.

*Production Functions and Technology*

The estimated production function is of the Cobb-Douglas type with republic and time dummies added in some of the regressions. Because of space limitations, we do not report in detail the estimated technology—the contribution of the factors of production—and show only

[2] McConnell Brooks reports that the average output per worker measured in wheat units for the 15 Soviet republics was less than one-tenth of the corresponding average for 11 American states and 3 Canadian provinces with comparable climates.

the two regressions that constitute the basis for Table 4 (see the notes to the table). The table itself reports republic and time effects. All estimates are for the 26-year period 1965-90.

In family farming, output per agricultural worker is a good indicator of family income. In Soviet agriculture, output was created both in large-scale collective farms and in small household plots akin to family farms. Family disposable income therefore was not always a simple function of output. Still, income was related to output, even if in a roundabout way. We therefore focused our attention on output per agricultural worker, and the regressions for Table 4 were estimated at the per-worker level. They were estimated separately for the northern and the southern republics. The specification in the two groups differed in that irrigation was included as a separate variable only in the regression for the southern republics, where the land variable was accordingly the residual dry land.

The republic effects in the regressions are reported in Table 4 for the northern republics relative to Russia and for the southern republics relative to Georgia. In the Soviet era, all the northern republics (except Kazakhstan) were more productive than Russia. This was particularly true of Moldova, a republic endowed with fertile soil and warm weather. Among the southern republics, Georgia was the most productive, with Turkmenistan and Uzbekistan the least productive. In a pooled regression of all 15 republics, Georgia's coefficient was 25.8% lower than Russia's. This indicates a large difference in agricultural productivity between the northern and the southern republics.

Three columns in Table 4 present growth accounting by Solow's method for the 26-year period 1965-90. Take Lithuania as an example. Agricultural output grew over the 26-year period by 1.51% per year and technical change was 0.03% per year. The growth of the conventional inputs (labor and those in the regression) was thus 1.48% per year, accounting for 98% of the

growth in agricultural output. The contribution of the conventional inputs to output was generally close to 100%, and for many republics—those with negative technical change—it was higher than 100%. Comparison to Table 3 shows that, in terms of the components of growth accounting, the Soviet republics behaved like the less-developed countries. They were far from the performance of agriculture in the newly settled and industrialized countries.

To summarize the discussion of the Soviet period, we note that substantial differences were found between the northern and the southern republics and, in particular, between their agricultural sectors. But, as a rule, these differences were smaller than the gaps in corresponding magnitudes between countries in the non-Soviet world. We also found that technological change in agriculture in the Soviet republics was small or even negative.

## The Post-Soviet Period

This part describes the developments in agriculture in the 15 former Soviet republics in the post-Soviet period and attempts to explain the changes that have occurred. One of the questions that we ask is, to what extent specific features observed in the Soviet era can also be identified as affecting agriculture in the transition countries after 1991.

### *Production and Efficiency*

The dissolution of the USSR in 1991 was naturally followed by an economic upheaval from which the former Soviet republics (by now independent states) have yet to recover. In Estonia, the per-capita GNP in 1997 was 21% lower than in the three last years of the Soviet era (Table 5, column 1); the corresponding magnitude for Moldova was 71%.

Agricultural production also collapsed. Column 2 in Table 5 reports the immediate change in agriculture between 1989 and 1992, when central planning ceased to function in the

former USSR[3]. Output fell dramatically, more so in the northern countries than in the southern, although there were exception in each group: Kazakhstan among the northern countries recorded growth of agricultural output and in Georgia, a southerner, output fell by more than 40% (in part due to the vicious civil war that raged in the country at that time). Output changes were accompanied by labor movements. Agricultural employment grew in all countries but three (column 3). People evidently returned to the land when the urban economy became uncertain, as land reform policies, wherever implemented, afforded access to subsistence farming. The returning workers contributed to production and mitigated the agricultural decline.

Armenia is a striking example. The country suffered a devastating earthquake in 1988, which destroyed much of its industry and infrastructure. The Nagorno-Karabakh conflict with Azerbaijan triggered a regional blockade that disrupted critical imports of energy and other inputs. The non-agricultural sectors were in total disarray in the early 1990s, and labor migrated to rural areas. The government responded to the growth of the rural labor force by implementing a swift and irrevocable land reform, which involved redistribution of most of the arable land from collective farms to individuals. As a result agricultural employment in Armenia increased by 75% between 1989 and 1992 while output declined by just 7% – less than in any other southern country (except Turkmenistan).

As output dropped and employment increased, labor productivity—output per worker—declined, in Armenia and elsewhere. The declines in output in the initial period 1990-92 were so large that labor productivity declined even in countries where labor was leaving agriculture (Estonia, for example): production fell proportionately more than the number of workers.

[3]Two-point comparisons of production in agriculture may be inaccurate because of weather variation, but at this stage our analysis does not allow for output fluctuations.

The second period examined in Table 5, 1992-97, was to be a period of recovery. However, agricultural output continued to decline (column 4), except in Georgia, where the political situation stabilized after the civil war. Still, even if a real recovery cannot be identified, a mitigation of the deteriorating trend is discernible: in Estonia, Lithuania, and Belarus labor exit from agriculture exceeded the decline in output (column 5) and labor productivity improved. As the changes were not uniform, the dispersion of performance in agriculture increased markedly. Even disregarding Estonia as a possible outlier, the coefficient of variation of labor productivity increased between 1990 (not in the table) and 1998 by more than 60%.

Labor movement and productivity are important indicators of changes in welfare, but labor is just one of the factors of production. The use of other factors also decreased, particularly the use of fertilizers, livestock, and machinery (agricultural land was naturally less affected). Column 6 reports our calculation of the change in the quantity index of a composite basket of all inputs from 1992 to 1997. The inputs are those listed in Table 2, and to calculate the index we weighted the changes in each input by the corresponding production function coefficients (as shown in the notes to Table 4). Estonia and Kazakhstan reduced input use by more than 40%. The northern countries in general reduced input use more than the southern countries, where input use actually increased in Turkmenistan and Uzbekistan—mostly due to the increased labor employment in these two Muslim countries with fast growing populations.

The residual difference between the growth of output and the growth of inputs is generally attributed to technical change; in other words, it represents efficiency improvements (column 7). The term efficiency is used here with some reservation. In many cases, prices rose drastically following deregulation and producers could not afford to use purchased inputs at the previous levels. In other cases, feed, fertilizers, or spare parts may have been simply unavailable

in any price. Thus, not all changes in input use reflected rational economic calculations. Indeed, we should not expect to have optimal input combinations under conditions of rapid transition. Still, a smaller decrease of output, relative to inputs, indicates improved efficiency and productivity. We see from column 7 that, in the northern countries, efficiency generally improved—primarily due to reduced use of inputs, not gains in output (Latvia and Kazakhstan are the only exceptions that show decrease in efficiency). Among the southern countries, efficiency improved by 22% and 32% in Armenia and Georgia, respectively, the two countries that resolutely switched from large-scale collective agriculture to small-scale individual farming. Efficiency deteriorated in Central Asia, at least partly due to the fast population growth that created a need to absorb labor in agriculture.

*Food Supply*

Agricultural production declined markedly after the disintegration of the USSR both in countries where efficiency decreased and in countries that enjoyed improvements in agricultural productivity. It has often been said (e.g., Csaki and Fock) that domestic production was replaced by imported food. In Table 6 (column 1) we have attempted to evaluate the ratio of import surplus to agricultural output for the five-year period 1992-96. As column 1 shows, only Estonia and Belarus had import surpluses that could cover a significant part of the reduction in output between 1989 and 1997. However, even in Estonia, the country with the highest import surplus ratio, output fell over this period by 52%, while import surplus was only 37% of the lower, post-1991 output. In the other countries, import surplus was much smaller; Moldova, Kazakhstan, and Uzbekistan even recorded export surpluses.

If these estimates are correct, food supply must have actually declined in the 15 former Soviet republics. As indicated in the introduction, the qualification "if," while appropriate in any

empirical analysis, applies here more than elsewhere. The transformation of the Soviet Union into 15 new independent states changed their economies and price structures significantly. Consequently, consumers may have enjoyed in recent years a wider variety and better quality of goods than in the past even if, by conventional accounting, food supply was reduced (Kostova Huffman and Johnson). However, a reduction of basic food supply is indicated also by another set of data. Column 2 presents the average caloric intake for 1992-96 from FAO food balances. Twelve of the 15 former Soviet republics had caloric intakes of less than 3000 calories per capita per day in the post-1990 period, and the average for the former USSR was 2660 calories per capita per day. A decade earlier, the average intake for the Soviet Union was 3203 calories per capita per day. By these numbers, food supply indeed must have decreased substantially in the former Soviet republics.

According to the same FAO food balances, the caloric intake in 1992-96 was 3202 calories per capita per day for the developed countries and 2601 calories for the developing countries (the 15 former Soviet republics are in neither of these groups). By column 2, food intake in the northern republics was between the values for the developing and the developed countries, while the population in the southern republics ate less than the average of the world's developing economies.

*Economic Environment and Factors Affecting Recovery*

We turn now to examine the economic environment and the factors that could have affected agricultural development in the 15 former Soviet republics. Data limitations preclude a systematic statistical analysis and we will have to rely on comparisons of numbers. The immediate effects of the traumatic changes in 1990-91 are recorded in columns 1, 2, and 3 of Table 5; the following years, 1992-97, form a period when recovery, or at least mitigation of the

initial decline, could be expected to have taken place (this period is reflected by the rest of the columns in Table 5).

The first question we ask is whether the recovery was affected by the productivity of agriculture in the Soviet republics before 1991. Except for Armenia and Georgia, which dramatically shifted to individual agriculture while recovering from natural disaster and war devastation, the southern republics registered reduction in efficiency (column 7 in Table 5). The more productive agricultural sectors in the northern countries recovered more than the relatively less efficient ones.

Our estimates, reported in Table 4 for the northern and the southern countries separately, indicated marked differences in agricultural productivity across the republics in the Soviet period. Republic coefficients from a pooled regression utilizing data for both the northern and the southern countries are presented in column 8 of Table 5. Productivity in the southern republics was estimated to be substantially lower than in the northern ones. Comparing to column 7 in the table, we see that, in general, countries that showed relatively high performance in the pre-1990 era (as judged by the republic dummies) registered efficiency improvements after 1992 (the Baltics). The under-performers from the pre-1990 period (Central Asian countries) registered continued efficiency declines after 1992; while the core republics retained their middle-of-the-road position in terms of performance and efficiency after 1992. As indicated, above and also below, Georgia and Armenia were special cases.

Each of the 15 new independent states modified to a different extent the economic structure of collective agriculture inherited from the Soviet Union. Columns 3 and 4 in Table 6 report the percentage of agricultural land in individual use and the share of individual agricultural production for 1997. Estonia, Lithuania, Armenia, and Georgia individualized land

use and showed efficiency gains (privatization did not help Latvia, though). Southern countries that have not implemented significant land individualization register the largest reductions in efficiency. Another indicator is the World Bank's ECA policy and institutional reform index in column 5 of Table 6 (Csaki and Fock). This is a weighted average of scores on a scale of 1 to 10 for policies that affect the economic environment of agriculture, including trade and price liberalization, land reform, privatization of services and supplies, development of rural finance and public institutions. The northern countries, especially the Baltics, received comparatively high scores; the southern countries scored lower. The index is highly correlated with efficiency gains in column 7 of Table 5. Thus, implemented policies affected recovery.

As we have seen, efficiency and recovery involve both production and utilization of inputs. A major input is labor. Modern agriculture in the industrialized countries is characterized by exit of labor and intensification of the use of machines and purchased inputs. Agriculture in the former Soviet republics contracted essentially in all its dimensions; arable land was the only variable that did not decline (and even here we find an exception: Kazakhstan "decommissioned" large areas of marginal productivity, reducing its arable land resources by about 20% since 1992). We cannot explain all the changes, but we may attempt to shed some light on labor exit. For labor to leave agriculture remuneration elsewhere must be higher and there need be jobs in other sectors. Remuneration is indicated in column 6 of Table 6 as the ratio of value added per worker in the non-agricultural sectors of the economy to value added in agriculture. In the Baltic states, Russia, and Kazakhstan income outside agriculture was substantially higher than in agriculture; in the other countries, agriculture provided close or even better income opportunities. The share of non-agricultural sectors in GDP (column 7 in Table 6) may serve as a proxy for the probability to find employment in town. This share is higher in the northern countries than in the

southern ones. Labor exited from agriculture (columns 2, 4 in Table 5) wherever it was motivated by higher relative income and by availability of employment opportunities.

These observations raise a question to which we have already made reference in passing. As indicated in column 1 of Table 5, income fell drastically in all 15 countries, and the reduction of income probably reflects economic upheavals. One would expect such changes, particularly if abrupt, to be accompanied by significant increases in unemployment. Yet the World Bank's World Development Indicators show only single digit rates of unemployment (or even less) in the 15 former Soviet republics. It is therefore impossible to incorporate unemployment and its effects in the analysis, but we have to qualify the discussion by noting that unemployment and under-employment are hard to measure in transition economies and their absence from the official records does not mean that they do not exist.

## Appendix

The data for the productivity analysis of the 15 Soviet republics (Tables 2 and 4) were collected from USSR statistical yearbooks for various years, supplemented, where necessary, by statistical yearbooks of the different republics. The data for the analysis reported in Table 3 are from Hayami and Ruttan, extended to cover all agricultural labor (male and female) and the year 1990 using information from ILO and FAO.

The variables for the 15 Soviet republics (Tables 2 and 4) were defined and constructed as in Hayami and Ruttan with three major modifications: labor is both male and female workers; land is arable (pastures are not included); livestock does not include draft animals. In the southern Soviet republics, irrigated land and dry land were taken as separate variables.

The groups of Hayami and Ruttan countries in Table 3 are defined as follows:

Newly settled: United States, Canada, Australia, New Zealand;

Industrialized: United Kingdom, Switzerland, Sweden, Spain, Norway, The Netherlands, Italy, Ireland, Denmark, Finland, France, Germany (Federal Republic), Greece, Belgium, Austria, Israel, Japan.

Latin America: Venezuela, Paraguay, Peru, Argentine, Mexico, Brazil, Chile, Colombia;

Egypt+: Egypt, Libya, Mauritius;

Asia: Sri Lanka, Philippines, Pakistan, India, Bangladesh;

Others: South Africa, Turkey, Yugoslavia, Portugal, Syria.

## References


Biton, David, *Productive Efficiency and the Agricultural Labor Market in International Comparisons*, MSc thesis, The Hebrew University, Rehovot, Israel (Hebrew), 1998.

Csaki, Csaba and Achim Fock, *The Agrarian Economies of Central and Eastern Europe and the Commonwealth of Independent States, An Update on Status and Progress—1998*, The World Bank, 1999.

FAO, Food and Agriculture Organization of the United Nations, www.fao.org.

Fogel, Robert W., "Catching Up with the Economy," *American Economic Review*, 89(1999):1-21.

Goskomstat SNG, *Statistical Data of the Commonwealth of Independent States 1999*, CD ROM 4/1999, Moscow, 2000.

Goskomstat SSSR, *Statistical Yearbook of the USSR*, Moscow, various years up to 1990.

Hayami, Yujiro, and Vernon Ruttan, *Agricultural Development*, Johns Hopkins, 1985.

ILO, International Labour Organization, *Economically Active Population 1950-2010*, on diskettes.

Johnson, D. Gale and Karen McConnell Brooks, *Prospects for Soviet Agriculture in the 1980s*, Indiana University Press, 1983.

Johnson, D. Gale, "Why is It So Difficult to Replace a Failed Economic System: The Former USSR," in: Antle, John M. and Daniel A. Sumner (eds.), *The Economics of Agriculture, Vol. 1, Selected Papers of D. Gale Johnson*, Chicago, 1996.

Kostova Huffman, Sonya and Stanley R. Johnson, "Impact of Economic Reform in Poland; Incidence and Welfare Changes within a Consistent framework," Staff paper 331, Department of Economics, Iowa State University, 1999.

Kriss, Alon, *Agricultural Productivity in the Former Soviet Republics*, MSc thesis, The Hebrew University, Rehovot, Israel (Hebrew), 1994.

McConnell Brooks, Karen, "Productivity in the Soviet Agriculture," in: Johnson and McConnell Brooks, 1983.

Medevedev, Zhores A., *Soviet Agriculture*, Norton, 1987.

Solow, Robert M., "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, 39(1957): 312-20.

World Bank, *World Development Report 1996*, Oxford, 1996.

World Bank, *World Development Indicators 1999*, CD ROM, Washington, DC, 1999.

**Table 1. Country Profiles of the Fifteen Soviet Republics in the Pre-Transition Period**

| | Population, millions | Population growth rate, % per year | GNP per capita, 1995 US$ | Share of agriculture in labor, % | Share of livestock in ag product, % | Irrigated land, % of arable land |
|---|---|---|---|---|---|---|
| | 1980 | 1980-90 | 1987-90 | 1980-88 | 1980-1989 | 1989 |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| *Baltics* | | | | | | |
| Estonia | 1.5 | 0.77 | 4646 | 17 | 69 | 1 |
| Latvia | 2.5 | 0.62 | 4582 | 16 | 70 | 1 |
| Lithuania | 3.4 | 0.92 | 2902 | 25 | 67 | 2 |
| *Core* | | | | | | |
| Russia | 138.3 | 0.68 | 3827 | 14 | 61 | 5 |
| Belarus | 9.6 | 0.64 | 2637 | 24 | 57 | 2 |
| Moldova | 4.0 | 0.90 | 2200 | 37 | 36 | 17 |
| Ukraine | 50.0 | 0.37 | 3389 | 21 | 54 | 8 |
| Kazakhstan | 14.8 | 1.19 | 2161 | 23 | 59 | 6 |
| *Transcaucasia* | | | | | | |
| Armenia | 3.1 | 1.35 | 2168 | 20 | 51 | 61 |
| Georgia | 5.1 | 0.77 | 2295 | 28 | 32 | 58 |
| Azerbaijan | 6.1 | 1.55 | 1564 | 33 | 32 | 87 |
| *Central Asia* | | | | | | |
| Kyrgyzstan | 3.6 | 1.97 | 1397 | 32 | 57 | 74 |
| Tajikistan | 3.9 | 3.01 | 1033 | 43 | 32 | 86 |
| Turkmenistan | 2.8 | 2.51 | 2001 | 40 | 34 | 105 |
| Uzbekistan | 15.8 | 2.58 | 1310 | 38 | 33 | 93 |

Source: GNP per capita from World Bank Word Development Indicators database (1999 edition). All other data from USSR statistical yearbooks (Goskomstat SSSR).

**Table 2. Indicators of Agriculture in the Pre-Transition Period (1980-85 averages)**

| | Output, '000 1983 rubles/worker | Arable land, ha/worker | Irrigated land, ha/worker | Farm machinery, hp/worker | Livestock, standard head/worker | Fertilizers, kg per ha arable land |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| *Baltics* | | | | | | |
| Estonia | 12.5 | 7.3 | 0.1 | 38.4 | 7.0 | 247 |
| Latvia | 10.3 | 6.7 | 0.1 | 38.0 | 6.5 | 238 |
| Lithuania | 11.1 | 6.6 | 0.1 | 35.4 | 7.0 | 235 |
| *Core* | | | | | | |
| Russia | 8.1 | 12.0 | 0.5 | 28.7 | 6.6 | 79 |
| Belarus | 8.8 | 5.0 | 0.1 | 20.9 | 5.8 | 266 |
| Moldova | 6.0 | 2.5 | 0.3 | 14.7 | 2.5 | 197 |
| Ukraine | 7.9 | 6.0 | 0.3 | 18.6 | 5.1 | 126 |
| Kazakhstan | 7.7 | 20.7 | 1.2 | 35.7 | 9.0 | 22 |
| *Transcaucasia* | | | | | | |
| Armenia | 6.1 | 2.3 | 1.3 | 10.8 | 5.6 | 191 |
| Georgia | 5.2 | 1.2 | 0.7 | 5.4 | 3.4 | 280 |
| Azerbaijan | 6.2 | 2.2 | 2.0 | 9.0 | 4.6 | 195 |
| *Central Asia* | | | | | | |
| Kyrgyzstan | 5.7 | 3.1 | 2.3 | 14.0 | 7.2 | 182 |
| Tajikistan | 5.4 | 1.8 | 1.5 | 10.6 | 4.0 | 273 |
| Turkmenistan | 5.3 | 2.6 | 2.5 | 12.7 | 3.9 | 243 |
| Uzbekistan | 5.1 | 2.1 | 1.9 | 11.6 | 2.7 | 283 |

Source: USSR statistical yearbooks (Goskomstat SSSR) and calculations by Kriss.

**Table 3. Agriculture in the Hayami and Ruttan Sample**

| | Newly settled | Industrial-ized | Latin America | Egypt + | Asia | Other |
|---|---|---|---|---|---|---|
| **Output and inputs, 1979-81 averages** | | | | | | |
| Output (wheat units/worker) | 180.5 | 53.4 | 14.1 | 2.9 | 2.7 | 17.4 |
| Arable Land (hectares/worker) | 78.7 | 7.9 | 4.9 | 1.4 | 0.6 | 7.5 |
| Capital (horsepower/worker) | 91.6 | 28.8 | 1.27 | 0.13 | 3.12 | 5.94 |
| Livestock (head/worker) | 48.8 | 10.5 | 9.4 | 0.6 | 1.4 | 6.0 |
| Fertilizers (kg per hectare) | 80.1 | 219.1 | 38.9 | 128.0 | 24.4 | 52.6 |
| **Growth accounting, 1960-90** | | | | | | |
| Output (% per year) | 1.96 | 1.84 | 3.04 | 2.44 | 2.78 | 2.84 |
| Technical Change (% per year) | 1.01 | 1.18 | -0.59 | -0.61 | -2.53 | 0.02 |
| Conventional inputs (share in %) | 48 | 36 | 120 | 125 | 191 | 99 |

Source: Biton.

**Table 4. Productivity Differences and Growth for the Fifteen Soviet Republics, 1965-90**

| | Republic dummies, % | Growth accounting | | |
|---|---|---|---|---|
| | | Output, % per year | Technical change, % per year | Share of conventional inputs, % |
| | 1 | 2 | 3 | 4 |
| *Northern republics* | | | | |
| Lithuania | 37.4 | 1.51 | 0.03 | 98.0 |
| Latvia | 25.2 | 1.32 | -0.14 | 110.6 |
| Estonia | 39.0 | 1.38 | -0.24 | 117.4 |
| Russia | 0.0 | 1.63 | 0.12 | 92.6 |
| Ukraine | 28.4 | 1.67 | 0.31 | 77.8 |
| Belarus | 30.8 | 1.93 | -0.06 | 103.1 |
| Moldova | 65.9 | 1.71 | -0.12 | 107.0 |
| Kazakhstan | -23.8 | 2.98 | 0.87 | 70.8 |
| *Southern republics* | | | | |
| Georgia | 0.0 | 2.01 | -0.08 | 104.0 |
| Azerbaijan | -32.5 | 3.71 | -0.84 | 122.6 |
| Armenia | -17.6 | 0.84 | -0.16 | 119.0 |
| Uzbekistan | -49.2 | 3.87 | -0.23 | 105.9 |
| Kyrgyzstan | -39.0 | 2.88 | -0.40 | 113.9 |
| Tajikistan | -35.9 | 3.19 | -0.58 | 118.2 |
| Turkmenistan | -55.5 | 5.24 | 0.07 | 98.7 |

Source: Kriss and authors' calculations.

Notes: The production functions were estimated using per-worker data with republic dummies (an asterisk indicates estimates significantly different from zero).
Northern republics: Output=-0.796*+0.257*xLand+0.453*xLivestock+0.043xCapital+0.143*xFertilizers ($R^2$=0.962).
Southern republics: Output= -1.650*-0.001xLand+0.211*xIrrigation*+0.104xLivestock+0.113xCapital+ 0.379*xFertilizers* ($R^2$=0.766).

**Table 5. Changes in Per-Capita Incomes and in Agriculture in the Post-Soviet Period (in percent)**

| | GNP/cap 1987-90 to 1997 | Ag output 1989-92 | Ag labor 1989-92 | Ag output 1992-97 | Ag labor 1992-97 | Use of all inputs 1992-97 | Efficiency 1992-97 | Republic dummies 1965-90 |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| *Baltics* | | | | | | | | |
| Estonia | -20.6 | -32.1 | -19.3 | -28.9 | -47.7 | -43.1 | 14.2 | 28.7 |
| Latvia | -38.6 | -29.4 | 10.0 | -45.3 | 0.2 | -39.2 | -6.1 | 11.1 |
| Lithuania | -30.6 | -34.8 | 17.2 | -6.1 | -14.9 | -24.4 | 18.3 | 20.0 |
| *Core* | | | | | | | | |
| Russia | -41.6 | -16.7 | 3.2 | -24.7 | -12.5 | -32.1 | 7.4 | 0.0 |
| Belarus | -22.4 | -20.9 | -6.2 | -17.7 | -20.6 | -20.5 | 2.9 | 11.2 |
| Moldova | -70.9 | -34.8 | 4.6 | -16.8 | -6.8 | -19.3 | 2.4 | -5.0 |
| Ukraine | -57.2 | -22.8 | 2.4 | -26.6 | 1.2 | -29.2 | 2.5 | 4.6 |
| Kazakhstan | -40.9 | 6.8 | 15.5 | -47.5 | -16.4 | -42.3 | -5.2 | -3.3 |
| *Transcaucasia* | | | | | | | | |
| Armenia | -58.7 | -7.3 | 74.9 | -1.5 | 13.8 | -24.4 | 22.9 | -22.1 |
| Georgia | -70.0 | -40.2 | -2.6 | 24.0 | 87.1 | -8.8 | 32.9 | -25.8 |
| Azerbaijan | -68.5 | -24.0 | 11.2 | -33.4 | -14.2 | -29.6 | -3.9 | -18.1 |
| *Central Asia* | | | | | | | | |
| Kyrgyzstan | -41.5 | -14.5 | 21.3 | -6.8 | 13.7 | -5.2 | -1.7 | -15.5 |
| Tajikistan | -69.1 | -27.0 | 12.5 | -28.8 | 24.1 | -17.3 | -11.5 | -14.4 |
| Turkmenistan | -67.9 | -5.9 | 11.7 | -22.2 | 10.8 | 7.2 | -29.4 | -16.7 |
| Uzbekistan | -25.8 | -1.6 | 24.3 | -4.5 | -2.7 | 6.2 | -10.7 | -18.8 |

Sources: column 1, World Bank's World Development Indicators database; columns 2-5, Goskomstat SNG and official country statistics for the Baltics; column 6, authors' calculation using the sources of columns 2-5 and FAO; column 7, authors' calculations; column 8, Kriss.

Note: Efficiency calculated as the difference between column 4 and column 6 (changes in agricultural output and input use between 1992-97). Republic dummies are relative to Russia, based on a pooled regression of 15 republics.

**Table 6. Characteristics of the Former Soviet Republics in the Post-Soviet Period**

| | Food supply | | Policy reforms | | | Non-agricultural sector | |
|---|---|---|---|---|---|---|---|
| | Import surplus in % of ag output | Calories per capita per year | Share of individual farms 1997, % | | ECA Policy Index | Per-worker value added, non-ag in % of ag | Share of non-ag sectors in GDP |
| | 1992-96 | 1992-96 | Land | Production | 1997 | 1994-96 | 1994-96 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *Baltics* | | | | | | | |
| Estonia | 37 | 2705 | 63 | n.a. | 7.8 | 171 | 92 |
| Latvia | 7 | 2962 | 95 | n.a. | 7.6 | 142 | 90 |
| Lithuania | -3 | 2950 | 67 | n.a. | 7.0 | 132 | 88 |
| *Core* | | | | | | | |
| Russia | 24 | 2913 | 11 | 55 | 6.0 | 172 | 93 |
| Belarus | 10 | 3177 | 16 | 45 | 1.6 | 94 | 83 |
| Moldova | -21 | 2925 | 27 | 51 | 5.8 | 87 | 69 |
| Ukraine | 6 | 3044 | 17 | 53 | 5.4 | 101 | 83 |
| Kazakhstan | -3 | 3155 | 20 | 38 | 5.8 | 170 | 87 |
| *Transcaucasia* | | | | | | | |
| Armenia | 6 | 1930 | 32 | 98 | 7.4 | 23 | 58 |
| Georgia | 8 | 2152 | 24 | 76 | 6.2 | 52 | 64 |
| Azerbaijan | 11 | 2151 | 9 | 63 | 5.0 | 129 | 76 |
| *Central Asia* | | | | | | | |
| Kyrgyzstan | 1 | 2358 | 23 | 59 | 5.8 | 49 | 55 |
| Tajikistan | n.a. | 2274 | 7 | 39 | 3.8 | n.a. | n.a. |
| Turkmenistan | n.a. | 2547 | 0.3 | 30 | 1.8 | n.a. | n.a. |
| Uzbekistan | -5 | 2646 | 4 | 52 | 2.2 | 103 | 69 |

Sources: columns 1-2, FAO and authors' calculations; columns 3-4, Goskomstat SNG and official country statistics for the Baltics; column 5, Csaki and Fock; columns 6-7, World Bank's World Development Indicators database and authors' calculations.

Note: The import surplus ratio in column 1 was calculated by dividing import surplus in dollars (FAO) by agricultural output (value added in agriculture from World Bank's World Development Indicators database multiplied by 1.67, reflecting the assumption that value added was 60% of output).