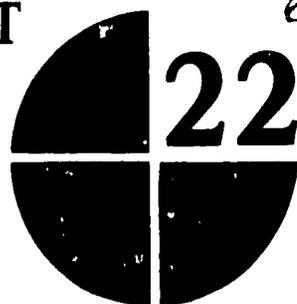


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RESEARCH REPORT



**ESTIMATES OF SOVIET
GRAIN IMPORTS IN 1980-85:
ALTERNATIVE APPROACHES**

Padma Desai

February 1981

**INTERNATIONAL
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POLICY
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FOREWORD

Research at the International Food Policy Research Institute (IFPRI) and corroborating analysis from other institutions indicate that imports of food by Third World countries will increase rapidly in the next few decades. Concurrently, it is probable that production will fluctuate more in the next few decades than in the past. These two sets of forces prompted IFPRI researchers to investigate the problems of assuring food supplies to low-income countries and to the low-income people of those countries. Factors bearing on these problems include global trends in food supply and demand, developed country price policies, international stockholding of wheat, trade, and food aid and other forms of foreign assistance. It became evident that actions by the Soviet Union were of particular importance to these food security issues. The large amount of grain the Soviet Union produces, consumes, and trades plus the large fluctuations in its agricultural production make it difficult to predict how the world will be affected. But they make that prediction more important to make.

Padma Desai has undertaken to estimate future imports of grain by the Soviet Union

and the probable fluctuations of those imports. Because of the difficulties and uncertainties in this task, she has tried several methods. This research report presents detailed results for three of them and a set of judgments that cut across all the data and analysis. The analysis confirms that the Soviet Union is likely to be a major element in the world grain market during the next several years and that the fluctuations in imports will probably be large. This may create problems for Third World importers, particularly if poor crop years in the Soviet Union coincide with poor crop years in Third World countries. The problems demand that attention continue to be paid to international agreements and to the trade, food aid, and domestic policies needed to solve them.

John W. Mellor

Washington, D.C.
February 1981

PREFACE

The Soviet Union imported increasing amounts of grain during the 1970s. These grain imports were not large in relation to Soviet grain output, but they were massive in relation to world grain trade. Furthermore, they fluctuated significantly from year to year. If future imports are not forecast in advance they can disrupt world trade with serious consequences for grain-surplus and grain-deficit countries.

It is therefore of utmost importance that future Soviet grain imports be estimated soundly. Accordingly, this study predicts Soviet grain imports during 1980-85 using three different methods. The approach is uncomplicated compared to the methods usually used for prediction by economists. Its simplicity is dictated primarily by the limited availability, and at times the total absence, of necessary information. Perhaps this limitation is no more serious than the limitations economists usually face when investigating the Soviet economy. In any case, complex procedures such as a detailed multivariate model for predicting Soviet grain imports are deliberately avoided here. It is hoped that the partial regression approach will nevertheless provide a sound base for predicting these imports.

The first draft of this manuscript was

completed at the beginning of 1978. The research effort underlying the preliminary results, especially those relating to the production function estimates, was partially supported by the National Science Foundation Grant No. SOC 77-07254. The project has since been financed by the International Food Policy Research Institute (IFPRI). I would like to thank Balabir Singh Sihag for assisting me with the initial formulations and estimations and Ricardo Martin for refining them with his computational skills and analytical insights. I am also grateful to Gunvant Desai, John Mellor, Leonardo Paulino, Alberto Valdés, all of IFPRI, for their suggestions aimed at defining the general scope of the study, and to Barbara Severin, Karl E. Wädekin, and David Schoonover for their extensive comments on details of Soviet agricultural data, policies, and practices. I have also profited from the detailed reaction of D. Gale Johnson to the first draft of the manuscript and the numerous occasions on which T. N. Srinivasan and Lance Taylor contributed generously with their suggestions about methodological details. It is needless to emphasize that the author alone is responsible for the final results presented here and the judgments which they incorporate.

1

SUMMARY

Sometime in the 1960s the leaders of the Soviet Union decided to increase their people's consumption of meat and dairy products and to keep that increase steady by not slaughtering livestock when harvests failed. This new policy required grain imports. Consequently, Soviet grain imports increased dramatically in the 1970s, with marked effects on international grain markets. These effects may be no less marked in the 1980s.

This report uses three methods to estimate Soviet grain imports between 1980/81 and 1985/86. In the first two, grain deficits (or surpluses) and imports are calculated by taking the difference between grain availability and grain use. The third method estimates imports directly from a linear specification.

Grain use (except for exports and inventory accumulation) for the first two methods is estimated as the combination of the amount of grain consumed by people and industry and the amount used as seed and feed. A percentage for waste is subtracted from output, 5 percent for years when production is below average, 10 percent for years when it is average, and 12.5 percent for years when it is above average. The amount used as seed is extrapolated to 1985/86 from the linear trend of seed use between 1955/56 and 1978/79. It is assumed that people and industry will continue to consume 50 million tons of grain. Feedgrain use is determined by a linear trend with a dummy variable used, beginning in 1971, to account for the policy decision to increase consumption of meat and dairy products without livestock slaughter. The feedgrain estimates are consistent with a 3 percent rise of meat output annually.

The first method uses a linear projection of past trends to predict grain output. The second method uses production function estimates with Western data on the value of gross agricultural output. That data is chosen because it is methodologically sound and easy to interpret.

Weather causes wide fluctuations in Soviet grain output and must be taken into account in projecting grain output. Therefore

three sets of forecasts are made for each method. One set assumes that the weather and grain output are average. Another assumes that the weather is bad, causing below-average output. A third assumes that the weather is good, causing above-average output.

The forecasts made for the first method account for the effect of weather with a 60 percent confidence interval around the trend. The lower estimates are characterized as below average and the upper, as above average. The trend estimates are average outputs. Also, 14.6 million tons are subtracted from the output estimate of the below-average year. This compensates for the asymmetrical effect of the weather; bad weather affects output more than good weather does. The forecasts made for the second method define a year's output as average, above average, or below average by the number of grain-growing regions that can be classified in terms of the Koppen weather classification as deserts and steppes in that year. These numbers are chosen so that about 25 percent of the years between 1960 and 1975 have above-average output and 25 percent have below-average output. The year with average output is given a dummy variable of 0; the year with below-average or above-average output is given a dummy variable of 1. The forecasts of output resulting from the first method are used for the third.

It is assumed for all three methods that Soviet agriculture will experience three average years, one below-average year, and one above-average year between 1981 and 1985. Their sequence is ignored. Soviet agriculture experienced these kinds of years in the same proportions between 1955 and 1980. There is no assurance that these proportions will be seen in the next five years, but a better way of predicting the fluctuations of output caused by weather has yet to be devised.

In estimating grain demand for addition to inventories, it is noted that Soviet grain output dropped 60 million tons in 1979. Recent estimates from the U.S. Department

of Agriculture (USDA) indicate that livestock continue to be slaughtered despite the 28 million tons of grain imported in 1979/80. These figures indicate that Soviet planners will start the 1980/81 agricultural year with their grain stocks largely depleted. It is therefore assumed that they will plan to build up those stocks by importing 5 million tons of grain in each consumption year. It is also assumed that they will export 2 million tons of grain each year to allied countries.

The average estimates of grain imports for the years between 1981/82 and 1985/86, resulting from the three methods utilized here, range from 15 to 18 million tons annually. If the Soviet Union imports 30 million tons in 1980/81 after the bad harvest in 1980, then the average estimates for 1980/81 to 1985/86 increase to 18-20 million tons. This is significantly greater than the 16 million tons of grain imported annually between 1971/72 and 1979/80. This is a central conclusion of considerable importance.

At the average price of grain suggested by a World Bank study—\$220 per ton—the annual foreign exchange cost of such grain imports will be between \$4.0 and \$4.4 billion. If the annual growth of Soviet hard currency export earnings decreases from about 15 percent in 1980 to 10 percent in 1985, this import bill will constitute 20-22 percent of the projected hard currency merchandise

earnings in 1981 and settle at 13-14 percent of these earnings in 1985. Debt payment also requires hard currency, and it could increase from almost 27 percent in 1981 to 31 percent of such earnings in 1985. Yet Soviet planners could still spend 51-56 percent of their hard currency earnings on imports of machinery from the West. It seems that the hard currency costs of food imports will be manageable.

In view of the significantly larger estimates of Soviet grain imports in this study, and the dominant role of the U.S. as a grain supplier in the world market, it appears that the prospects of the current U.S.-U.S.S.R. agreement being renewed in the future are good. In fact, the minimum amount that the Soviet Union is required to purchase without consultation under this agreement is likely to be increased from 6 million tons to 8-10 million tons.

Although the estimated average grain import requirements for 1980/81 to 1985/86 are larger than the amounts imported in the 1970s, Soviet imports need not disrupt world grain trade or prevent developing countries from buying the grain they need. But Soviet imports should be planned for. The effects of unplanned Soviet grain imports, bought to offset a domestic harvest failure, would be especially disruptive. This study estimates that such imports could reach 30 million tons in a single year.

2

INTRODUCTION

It is well known that Soviet imports of grain, including wheat, have become large in recent years. While gross Soviet grain imports averaged about 2 million tons each year between 1966/67 and 1970/71, they reached a record 23 million tons in 1972/73. This represented 13 percent of comparable Soviet grain output.¹ In that year, Soviet wheat imports, approximately 16 million tons, were so massive that they dislocated the world wheat market and led to a depletion of the world's reserves of wheat. The USDA estimated recently that the Soviet Union imported as much as 28 million tons of grain in the marketing year ending June 30, 1980.²

It is also known that while in the past grain was imported largely to offset crop failures, it will now be imported, especially in the near future, for a different reason: the Soviet decision to increase the production and consumption of meat and dairy products will require that feedgrains be imported. If such imports are significant and variable, they will be a continuing problem for the Soviet planners, since financing them would create demands on Soviet hard currency earnings that would conflict with technology imports needed from the West.³ They would also be a problem for the major grain suppliers, among them the United States, because Soviet requirements, if massive and unpredictable, could make it hard to keep prices stable. Finally, these imports could disrupt foreign sources of grain for grain-deficit developing countries if a Soviet grain harvest failed.

The aim of this report is to predict Soviet grain imports during the years 1980-85. In Chapter 3 total grain imports are predicted using the simple method of taking the difference between total supplies and requirements, with the major components of the

two categories predicted from simple regressions. In Chapter 4 this methodology is modified in one respect. Soviet production of grain is estimated not from past trends, but by fitting a simple Cobb-Douglas production function with constant returns to scale to alternative sets of data. Finally, in Chapter 5, the imports of grain are predicted using import demand functions where the explanatory variables are domestic production of grain, price per ton of imported grain, a time trend, and, from 1971, a dummy variable representing the policy decision to import grain to keep inventories of livestock steady.

The large fluctuations in Soviet grain output caused by the weather make it necessary to forecast grain output and imports by defining below-average harvests associated with unfavorable weather and above-average harvests associated with favorable weather. Accordingly, three sets of output forecasts are made in this report. A forecast with a 60 percent confidence interval is made in Chapter 3. Suitably defined dummy variables for weather are incorporated into the production functions of Chapter 4. Finally, in Chapter 5 the 60 percent confidence-interval outputs are used to derive the corresponding average, below-average, and above-average imports from the import demand equation.

Underlying all three sets of estimates is the assumption that the Soviet Union will experience three average years, one below-average year, and one above-average year during 1981-85 (the sequence of this weather pattern is ignored). The estimates in Chapters 3 and 4 also contain the assumptions that Soviet grain stocks on July 1, 1980 will be so depleted that imports of 30 million tons of grain will be required beginning July 1, 1980 to build grain reserves, that the Soviets will

¹ All tons in this report are metric tons. The data, unless otherwise stated, are from the U.S. Department of Agriculture. The years, unless otherwise noted, are grain-use or marketing years. They extend from July 1 of one year to June 30 of the next.

² U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture Circular—Grains*, FG-22-80 (Washington, D.C.: USDA, 1980), p. 2.

³ Gross Soviet medium-term and long-term indebtedness is currently reported to be about \$17 billion.

export 2 million tons of grain annually during 1981-85, and that the estimated feedgrain requirement will support an average annual increase in meat output of 3 percent. For the estimates in Chapters 3 and 5 it was assumed that the Soviets will need

to import an extra 14.6 million tons of grain in each below-average year because, as has been observed, bad weather affects output much more than good weather does. The arguments and analysis supporting these assumptions are given in the next chapter.

3

GRAIN IMPORTS ESTIMATED AS THE DIFFERENCE BETWEEN TOTAL SUPPLIES AND REQUIREMENTS

The most striking feature of Soviet domestic production is its volatile fluctuation from year to year. In contrast, of the components of use, seed use has risen steadily, industrial and food uses of grain have stabilized in recent years, waste is variable but averages 10 percent of output, and feed use has risen rapidly.⁴

In the following analysis, Soviet deficits of grain are estimated initially as the difference between output and the requirements for feedgrains, seed, and industrial and personal consumption. Separate estimates of waste are also included. Variations in predicted weather patterns are considered. Then, the resulting deficits are augmented by estimated export requirements. Finally, changes in Soviet grain reserves are considered, resulting in estimates of Soviet imports between 1980/81 and 1985/86.⁵

Predicting Output of Grain

First, it is important to have plausible fore-

casts of the domestic production of grain on the supply side and of feedgrain and seed use on the requirements side if the resulting import estimates are to be reasonable.

Grain output can be predicted from the trend of past output or of past yield using either a linear or a log trend. In this chapter, future output of grain is predicted on the basis of the following equation. This equation incorporates the linear trend of output from 1955/56 to 1978/79 in Table 1 because, of all the four alternatives, it gives the least estimated variance of predicted outputs:⁶

$$(\text{Grain output})_t = 155.8320 + 4.7009t \quad (1) \\ (3.8601) \quad (7.7856)$$

$$R^2 = 0.9203, \text{ D.W.} = 2.83, \text{ S.E.R.} = 20.4758$$

In all equations of this report, R^2 is the correlation coefficient, D.W. is the Durbin-Watson statistic, and S.E.R. is the standard error of the regression. Values in parentheses are t-values of the estimates. In this chapter

⁴ The sources, methodology, and limitations of the data used for the estimates in this chapter are discussed at length in the notes to Table 1.

Commenting on its estimates of the waste component, the USDA reports: "The 10 percent waste factor appears to be reasonably accurate over time, but in individual years waste is estimated to vary from a low of about 5 percent (largely normal losses in dry years when there is no excess moisture and foreign matter) to a high of 15 percent or somewhat more (years when there is a lot of precipitation during harvesting and excess moisture and foreign matter would add 10 percent or more to normal losses). For details, see U.S. Department of Agriculture, Economic Research Service, *U.S.S.R. Agricultural Situation: Review of 1974 and Outlook for 1975* (Foreign Agricultural Economic Report No. 102 (Washington, D.C.: USDA, 1975), p. 7.

Karl Eugen Wädekin refers to the observations of a Soviet authority, who implies that an accurate adjustment would reduce Soviet yield and production estimates by at least 20 percent. For details, see Roy Laird and Betty Laird, "The Widening Soviet Grain Crop and Prospects for 1980 and 1990," in Roy Laird, Joseph Hajda, and Betty Laird, eds., *The Future of Agriculture in the Soviet Union and Eastern Europe* (Boulder, Colo.: Westview Press, 1977), p. 32.

The problem of what discount to apply to Soviet bunker weight output data has been discussed often. For an early study of the problem, see D. Gale Johnson, "Agricultural Production," in *Economic Trends in the Soviet Union*, ed. Abram Bergson and Simon Kuznets (Cambridge, Mass.: Harvard University Press, 1963), pp. 212-213. For one of the earliest exercises in applying such a discount, see Arcadius Kahan, "Soviet Statistics of Agricultural Output," in *Soviet Agriculture and Peasant Affairs*, ed. Roy Laird (Lawrence, Kans.: University of Kansas Press, 1963), pp. 145-150.

⁵ Bond and Levine have used a slightly different method to predict Soviet grain imports. See Appendix I.

⁶ The standard statistical criteria, such as R^2 (between 0.70 and 0.78) and the D.W. statistic (between 1.8 and 2.0), were hardly distinguishable in the four regressions. The regression equation used was chosen because it minimizes the variance of predicted outputs. Also, it was estimated from output data from earlier USDA reports before the output figures of Table 1 from the latest USDA report were available. The USDA continuously updates its estimates of Table 1. The estimates of equations (1), (2), and (3) might indicate a discrepancy from the results that could be obtained from the fully updated figures of Table 1.

Table 1—Total supply and estimated use of grain, 1955/56-1980/81

Year	Domestic Production ^a	Trade			Availability ^c	Use						Stock Change ^e
		Imports	Exports	Net Trade ^b		Seeds ^d	Industrial ^f	Food ^g	Dockage Waste ^h	Feed ⁱ	Total ^j	
(million metric tons)												
1955-56	105.7			-1.9	102	19	3	45	10	26	102	-1
1956-57	125.0	0.9	5.4	-4.5	120	18	3	42	12	33	108	+12
1957-58	102.6	1.5	6.2	-4.7	98	18	3	43	10	34	109	-11
1958-59	134.7	1.7	7.7	-6.0	129	18	3	43	13	39	117	+12
1959-60	119.5	1.0	6.8	-5.8	114	16	3	43	12	40	116	-2
1960-61	125.5	0.8	7.0	-6.2	119	20	3	42	13	41	118	+1
1961-62	130.8	0.8	8.4	-7.6	123	21	3	44	13	45	126	-3
1962-63	140.2	0.6	8.3	-7.7	133	23	2	48	14	43	130	+2
1963-64	107.5	10.4	4.7	+5.7	113	23	2	47	5	32	110	+3
1964-65	152.1	2.6	4.3	-1.7	150	22	3	45	17	44	130	+20
1965-66	121.1	9.0	5.3	+3.7	125	24	3	44	12	56	139	-14
1966-67	171.2	3.9	5.3	-1.4	170	24	3	44	14	60	144	+26
1967-68	147.9	2.3	6.4	-4.1	144	24	3	44	12	64	146	-2
1968-69	169.5	1.2	7.4	-6.2	163	25	3	44	17	72	160	+3
1969-70	162.4	1.8	7.6	-5.8	157	23	3	45	23	83	177	-20
1970-71	186.8	1.3	8.5	-7.2	180	25	3	45	22	92	188	-8
1971-72	181.2	8.3	6.9	+1.4	183	27	3	45	13	93	181	+2
1972-73	168.2	22.8	1.8	-21.0	189	26	3	45	15	98	187	+2
1973-74	222.5	11.3	6.1	-5.2	228	27	3	45	33	105	214	+14
1974-75	195.7	5.7	5.3	+0.4	196	28	3	45	23	107	206	-10
1975-76	140.1	26.1	0.7	-25.4	166	28	3	45	14	89	180	-14
1976-77	223.8	11.0	3.3	-7.7	232	29	3	45	31	112	221	+11
1977-78	195.7	18.9	2.3	-16.8	213	28	4	45	29	120	228	-16
1978-79	237.0	15.6	2.8	-12.8	250	28	4	46	28	125	231	+19
1979-80	179.0	30.5	0.8	-29.7	208	28	4	46	22	126	226	-18
1980-81	189.0		0.0			30	4	46	10	127	217	

Sources: The data for 1955-56 are rounded figures from U.S. Department of Agriculture, Economic Research Service, *Prospects for Agricultural Trade with the U.S.S.R.*, ERS-Foreign 356 (Washington, D.C.: USDA, 1974), p. 30. The data for 1956-57-1979-80 are from U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *U.S.S.R. Agricultural Situation, Review of 1979 and Outlook for 1980*, Supplement 1 to WAS 21 (Washington, D.C.: USDA, 1980), p. 22. The figure for domestic production in 1980-81 is the latest estimate cited in Soviet sources. The other figures for 1980-81 are derived using the methodologies discussed in the text.

Notes: Each year begins on July 1. For 1978-79 the estimates of trade, availability, use, and stock change are preliminary. All the figures for 1979-80 are USDA forecasts. The domestic production figure for 1980-81 is also preliminary. In some years the stock change estimates do not equal the difference between availability and use because of rounded figures in the original source.

^a The domestic production figures are all from Soviet sources. They are bunker weight figures, that is, they include moisture, trash, and waste in storage and transportation. Output includes the spring and autumn harvests. The USDA assumes that the grain output of a given year would begin to be available from July 1. Accordingly, it derives the components of use using the output of a year running from July 1 to June 30.

^b Positive net trade implies that imports exceed exports.

^c Total availability is the sum of domestic production and net trade.

^d The seed estimate is intended to be used for the next year's plantings. It is noted in U.S. Department of Agriculture, Economic Research Service (ERS), *U.S.S.R. Agricultural Situation, Review of 1974 and Outlook for 1975*, Foreign Agricultural Economic Report No. 102 (Washington, D.C.: USDA, 1975), p. 7, that: "The seed use estimates . . . are based on information on seeding rates, or seeding norms for the various grains, and occasionally a published seed-use figure. The changes in seed use largely reflect changes in grain acreage and some reseeded in years when winter kill is abnormally heavy." Also note this comment from U.S. Central Intelligence Agency (CIA), *The Soviet Grain Balance, 1960-73*, A(ER)75-78 (Washington, D.C.: CIA, 1975), p. 12: "The (seeding) norms seem high compared with Western practice—in Canada the rate for spring wheat is 1.0 centner per hectare while in the United States the average is 0.9 centner." However, the same CIA report cites evidence suggesting that Soviet farms meet or exceed the norms. And it notes that the year-to-year fluctuations in seed requirements caused by winter kill range from nearly zero to 11 million hectares.

^e The estimates of industrial use imply that "one to two percent of the grain crop is used by industry to make alcohol, beer, starch, and syrup" (CIA, *Soviet Grain Balance*, p. 11).

^f The amount of grain used for food is derived by multiplying per capita consumption (presumably of the flour in bread) by the population and converting the resulting estimates to the equivalent of whole grains on the basis of a specified milling rate of grain into flour. For details see ERS, *U.S.S.R. Review of 1974 and Outlook for 1975*, p. 7.

The CIA uses flour production data rather than consumption statistics to estimate the amount of grain used for food. It also notes that much more flour is produced than is consumed and exported. The discrepancy seems to be accounted for by some industrial use of flour, by large losses in transport and storage, and by inadequate reporting of consumption. For details see CIA, *Soviet Grain Balance*, p. 11.

^g As noted in the text, the USDA calculates waste by subtracting 10 percent from production in normal years, 5 percent in dry years (when there is no loss caused by excess moisture and foreign matter), and 15 percent in wet years (when excess moisture and foreign matter are abnormal).

^h "Estimates of grain used for feed are based on statements by Soviet officials concerning feed use of grain, data on feed production and use contained in Soviet statistical handbooks, and information on feeding rates and feeding efficiency relative to livestock numbers and the output of livestock products." (ERS, *U.S.S.R. Review of 1974 and Outlook for 1975*, p. 7).

By contrast, the CIA estimates the amount of grain used as feed from official Soviet data on the quantity of concentrates fed. Such an estimate certainly overstates the amount of grain fed to livestock because the official data on concentrates are based on production data and are not given in terms of standardized weight. Therefore, the data contain excess moisture, trash and dirt with no nutritional value, and weed seeds and grain admixture which may have some feed value.

ⁱ The amount of grain used is the sum of the amounts of grain used for seed, industrial uses, food, and feed, and of the amount lost as waste.

^j The estimates of stock change are derived by subtracting the total amount of grain used from availability. Commenting on the reliability of these estimates, the USDA states: "It bears repeating that the stock data are subject to a wide range of error because each of the annual changes is a residual subject to cumulative errors of estimating other uses" (ERS, *U.S.S.R. Review of 1974 and Outlook for 1975*, p. 7).

only, the variable t runs from 55 to 78.

These grain output estimates are calculated with a 60 percent confidence interval because the extreme weather-induced variability of annual output (indicated by the estimated standard error of 20.5 million tons in equation [1]) renders point estimates meaningless. The lower estimates are characterized as below average and the upper, as above average. The intermediate trend estimates are average outputs.

Why has the narrow 60 percent confidence interval been selected? Obviously, the customary range of 90-95 percent would make it almost certain that actual outputs of the past and future are covered by the range regardless of weather fluctuations. The corresponding output ranges would then make it possible to make such statements as: actual imports (corresponding to below-average grain output) and additions to grain reserves plus exports (corresponding to above-average grain output) would be anything up to the estimated amounts. Such statements do not help provide a good indication of Soviet grain imports in the near future.

By contrast, a 60 percent confidence interval will provide estimates of Soviet grain imports or domestic stock accumulation possibilities that can be interpreted as: chances are 60 percent (almost two in three) that the actual imports (or additions to stocks plus exports) will not exceed the stated estimates. Ten of the 26 observations from between 1955/56 and 1980/81 are outside the limits set by the 60 percent confidence interval. Of these, five (1963/64, 1965/66, 1975/76, 1979/80, and 1980/81) are outside the lower range of the interval, and five (1956/57, 1958/59, 1973/74, 1976/77, and 1978/79) are outside the upper range. Two of these, 1956/57 and 1958/59, are almost on the boundary. Indeed an investigation of the distribution of observations indicates that, whereas the above-average observations are close to the upper boundary of the 60 percent range (with two out of five almost on the boundary), the below-average

observations are far from the lower boundary of the 60 percent confidence interval.

This pattern reveals the asymmetric impact that extremes of weather have on output. This means that if a wider confidence interval is selected (such as 70 percent), the output might be overstated if the weather is better than average. On the other hand, in settling for the 60 percent confidence interval, the estimates of output could be overstated if the weather is worse than average.⁷

These below-average and above-average grain output estimates (see Table 2) suggest that with a 60 percent confidence interval, Soviet grain output can vary as much as 38-40 million tons in a given year.

How do the estimated outputs compare with actual Soviet performance and targets of grain outputs? Actual average output between 1976/77 and 1980/81 was 204.9 million tons (Table 1). The estimated average annual output is 210.8 million tons. However, since the weather pattern during the period is known, 1976/77 and 1978/79 can be classified as above-average years, 1979/80 and 1980/81 as below-average years, and 1977/78 as an average year. If 14.6 million tons are subtracted from the output of each of the two below-average years to allow for the asymmetrical impact of bad weather,⁸ annual output during the Tenth Five-Year Plan (1976-80) would be 204.7 million tons (Table 2),⁹ close to the actual average output of 204.9 million tons.

Finally, the estimated average output during 1981/82-1985/86 is 234.3 million tons. This indicates that the Soviets may fall short of their preliminary target (238-243 million tons) by 4-9 million tons. Undoubtedly, the Soviet planners will revise this target.

Estimating Feedgrain Requirements

Output in the near future can be predicted with confidence intervals assigned on the

⁷ In order to counteract this possibility, an estimate was made of the average size of the output shortfall that can be attributed to the weather asymmetry. It is incorporated in the import estimates of a below-average year. The phenomenon of weather asymmetry and the method of quantifying its effects are discussed below.

⁸ This figure is derived later in this chapter.

⁹ As far as the amount of grain produced is concerned, the calendar year and the USDA consumption year (from July 1 to June 30) are interchangeable.

Table 2—Estimated output and use of grain, 1976/77-1985/86

Year	Output ^d			Use	
	Average ^b	Below Average ^c	Above Average ^c	Feed ^d	Seed ^e
(million metric tons)					
1976/77			219.0 ^f		
1977/78	206.1 ^f				
1978/79			226.4 ^f		
1979/80		198.0 ^f			
1980/81		201.0 ^f		126.5	30.3
1981/82	224.9	205.5	244.4	130.3	30.8
1982/83	229.6	210.0	249.3	134.0	31.3
1983/84	234.3	214.5	254.2	137.7	31.8
1984/85	239.0	219.0	259.2	141.4	32.3
1985/86	243.7	223.4	264.1	145.1	32.8

^a The estimates of output are derived using equation (1).

^b Average outputs are derived from the linear trend of output (from 1955/56 to 1978/79) stated in equation (1).

^c Below-average and above-average outputs are the lower and upper estimates of the 60 percent confidence interval around the trend.

^d The estimates of the amount used as feed are derived using equation (2).

^e The estimates of the amount used as seed are derived using equation (3).

^f On the basis of the available weather information, 1976/77 and 1978/79 are classified as above-average, 1979/80 and 1980/81 as below-average, and 1977/78 as average years. These output figures minus 14.6 million tons annually for the two below-average years when averaged over the five years from 1976/77 to 1980/81 will give an annual output figure of 204.7 million tons. The actual output during the five years was 204.9 million tons.

basis of past performance, but a prediction of feedgrain requirements from past patterns must take account of the Soviet decision to increase consumption of meat and dairy products. This decision implies not only that production of meat and dairy products must be increased but that the Soviets must maintain output of these products at a specified level without slaughtering cattle after every crop failure.

Furthermore, the past pattern of grain use for animal feed may have reflected shortages of fodder and high-protein feed or prescribed norms of feed. There is no guarantee that these elements will not change.

It is not possible to introduce refinements in the forecasts of feed use that can handle these complications successfully. Nonetheless, reasonable projections of feedgrain use can be made with a careful extrapolation of recent trends, cross-checked with alternative estimates of feedgrain use

derived explicitly from production targets for meat and dairy products.

Accordingly, equation (2) is used to predict feedgrain use. In this equation, feedgrain use between 1955/56 and 1978/79 (Table 1) is regressed on time and a simple dummy variable of 1 beginning from 1971.¹⁰ The dummy variable incorporates the policy decision evident in 1971 to increase production of meat and dairy products without slaughtering livestock.¹¹

$$\begin{aligned}
 (\text{Feedgrain use})_t = & \\
 & -181.2340 + 10.7148 (\text{dummy}) \\
 & (7.7256) \quad (1.9500) \\
 & +3.7134t \quad (2) \\
 & (9.9234)
 \end{aligned}$$

$R^2 = 0.9661$, D.W. = 1.18, SER = 7.31.

The resulting estimates of feedgrain use from 1980/81 to 1985/86 are presented in

¹⁰ Annual meat production could have been used instead of time as an explanatory variable in this relationship. If that were done, the SER of the regression would have jumped up 27 percent. Predictions of feedgrain requirements using this procedure would cause more problems than those using time as an explanatory variable because annual targets of meat production for 1980-85 are not available and would have to be forecast.

¹¹ One of the earliest references to the timing of this policy was made in D. Gale Johnson, *The Soviet Impact on World Grain Trade* (Washington, D.C.: British-North American Committee, 1977), p. 20.

Table 2 along with estimates of other categories of grain use. These suggest that the use of grain for feed will increase from 126.5 million tons in 1980/81 to 145.1 million tons in 1985/86. The official estimate of the feedgrain requirement in 1980 is about 125.0 million tons.¹²

Estimates of Feedgrain Use and Production Targets for Livestock Products

The estimates of feedgrain use derived by using equation (2) may now be cross-checked against those that can be obtained by using the projected targets of meat and dairy products. The relevant calculations are presented in Table 3. An average increase of 3 percent in meat production over actual production in 1980 is assumed. The feedgrain requirement is then computed by multiplying the actual and targeted amounts of meat and dairy products produced by the coefficient of feedgrain requirement per unit. The U.S. Central Intelligence Agency (CIA) estimates of "... grain for maintenance of horses as draft animals plus grain required to accommodate inventory increases of other livestock"¹³ are finally added to the resulting estimates. These figures, however, fall short of the predicted estimates of feedgrains using equation (2) by about 11 million tons in 1970. This shortfall increases to 29 million tons in 1985. It must be explained.

The gap occurs despite the application of rising feed norms so that they do not

constitute an explanation. According to David Schoonover, the gap can be attributed, in part, to the absence of pulses from the grain feed coefficient and their presence in the estimates of feedgrain use in Table 1. The importance of this discrepancy can be measured by the amount of pulses produced: 7.6 million tons in 1970 and 3.5 million tons in 1975.¹⁴ All of this, excluding allocations for seed, would be used to feed animals.

Another reason for the gap, according to Schoonover, is that some of the feedgrains used in a given USDA consumption year are accounted for by the livestock products of the next calendar year. The reconstructed estimates in Table 3 do not account for this lag because they are calendar year estimates. With feedgrain use increasing, and assuming that a certain fraction of feedgrain use stated in a consumption year results in livestock output in the next calendar year,¹⁵ the estimates of feedgrain use that incorporate these lags (Table 1) would be increasingly higher than the estimates of Table 3.

These comments ensure that the two sets of estimates are comparable. The estimates of feedgrain use of Table 2 will therefore be interpreted as supporting an average annual increase in meat output of 3 percent during 1980-85. Such a performance of meat output would be compatible with a 3 percent average annual increase of per capita real personal disposable income during 1980-85,¹⁶ and an income elasticity of demand for meat of 1¹⁷ if imports of meat and population growth were negligible. With Soviet population growing about 0.8 percent annually, such a growth of meat output will

¹² This figure is cited in David M. Schoonover, "Soviet Agriculture and Grain Trade in the 1976-80 Plan," a paper presented at the Corporate Sponsor Seminar, Russian Research Center, Harvard University, Cambridge, Mass., February 1978, p. 17. The USDA estimates of feedgrain requirements in Table 1 are higher than the Soviet target figures because the Soviet figures are based on a calendar year, but the USDA figures are based on a consumption year that includes six months of the next calendar year.

It is possible that if the livestock slaughter of 1979 and early 1980 continues into late 1980 and later, the estimates of feedgrain requirements used in this paper would be somewhat large even if the time-lag problem did not exist.

¹³ U.S. Central Intelligence Agency, *USSR - Long Term Outlook for Grain Imports* (FR79-10057 U) (Washington, D.C.: CIA, 1979), p. 14.

¹⁴ U.S. Department of Agriculture, Economic Research Service, *USSR Agricultural Situation: Review of 1976 and Outlook for 1977* (Foreign Agricultural Economic Report No. 132) (Washington, D.C.: USDA, 1977), p. 2.

¹⁵ In CIA, *USSR - Long Term Outlook* this fraction is estimated to be one third.

¹⁶ *Ibid.*, p. 5.

¹⁷ D. Gale Johnson, "Soviet Agriculture and World Trade in Farm Products," in *Prospects for Agricultural Trade with the USSR*, ERS-Foreign 356 (Washington, D.C.: U.S. Department of Agriculture, 1974), p. 46.

Table 3—Feedgrain requirements, 1970, 1975, 1980, and 1985

Output/Requirement	1970	1975	1980	1985
	(million metric tons)			
Output of livestock products ^a				
Meat	12.3	15.0	15.1	17.4
Milk	83.0	90.8	90.7	98.0
Eggs	2.2	3.2	3.7	4.0
	(kilograms)			
Grain used as feed per kilogram of livestock product ^b				
Meat	3.5	3.5	3.6	3.7
Milk	0.3	0.3	0.3	0.3
Eggs	3.5	3.5	3.5	3.5
Feedgrain requirement for output of livestock products ^c	75.4	91.3	94.6	107.8
Feedgrain requirement to maintain livestock inventories	5.5	7.0	9.4	8.7
Total feedgrain requirement	80.9	98.3	104.0	116.5
Feedgrain requirement estimated from past trend of feedgrain use ^d	92.0	89.0	126.5	145.1
Difference between feedgrain requirements estimated from past trend and the total above	11.2	-9.3	22.5	28.6

Sources. The production data for 1970 and 1975 are from U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service (E.SCS), *USSR Agricultural Situation, Review of 1978 and Outlook for 1979*, Supplement 1 to WAS 18 (Washington, D.C.: USDA, 1979), p. 10; and U.S. Central Intelligence Agency (CIA), *USSR Long-Term Outlook for Grain Imports*, ER79-10057 (Washington, D.C.: CIA, 1979), p. 12. The output data for 1980 are from Soviet sources. The meat output target of 17.4 million tons in 1985 implies an average annual growth rate of 3 percent over 1980. The corresponding Soviet target is 17.0-17.5 million tons. The milk output of 98 million tons in 1985 is the average of the Soviet target of 97-99 million tons. The egg output target of 4 million tons in 1985 is from Soviet sources.

The estimates of egg output are converted from the number of eggs to tons at the rate of 18,182 eggs per ton (U.S. Department of Agriculture, Economic Research Service, *USSR Agricultural Situation, Review of 1974 and Outlook for 1975*, Foreign Agricultural Economic Report No. 102 [Washington, D.C.: USDA, 1975], p. 31).

The amounts of grain used as feed per kilogram of output are from E.SCS, *Alternative Futures for World Food in 1985*, vol. 1, *World GOI Model Analytical Report*, Foreign Agricultural Economic Report No. 146 (Washington, D.C.: USDA, 1978), pp. 93 and 131. The estimates of the amount of feedgrain required to maintain livestock inventories are from CIA, *USSR Long-Term Outlook*, p. 14.

^a The figures for 1970, 1975, and 1980 are actual outputs. The 1985 figures are Soviet output targets stated in the Eleventh Five-Year Plan (1981-85).

^b The feeding coefficients assume that the growth and fattening cycles of livestock are standardized. Feedgrain use figures derived from these coefficients, therefore, do not take into account premature slaughter of livestock, such as occurred in 1975. As a result, the feed use figures for 1975 derived from feedgrain norms are 9.3 million tons higher than the USDA estimates stated here from Table 1.

^c These figures are derived by multiplying output of livestock products by the feed norms.

^d These figures are calculated from equation (2).

imply continuing shortages. Moreover, as meat output during the Tenth Five-Year Plan (1975-80) hardly grew,¹⁸ fulfilling these targets would be an arduous task for the Soviet planners.¹⁹ Their fulfillment would necessitate large grain imports, as the estimates of this report indicate.

A final caveat must be inserted. These feedgrain use estimates may need adjustment because feeding rates change as feedgrain is substituted for roughages and protein feed or because the consumption of animal and dairy products changes as retail prices do. However, the projected feed requirements based on the past pattern do incorporate the increase in feeding rates that began about 1964/65: "... the average rates of grain fed per livestock production unit are estimated to have increased about two thirds from 1964/65 to 1974/75."²⁰ More to the point, "... Soviet plans on feed requirements imply that little increase in grain feeding rates is anticipated in the next few years."²¹

Moreover, potential price changes of meat and dairy products can be ignored for the short period under consideration.²² More specifically, retail price increases can be plausibly ruled out except as a measure of last resort, although they also would help alleviate another problem—the growing budgetary subsidization of meat and milk prices.²³

Estimating Seed Requirements

The linear trend of equation (3) is used to extrapolate seed use.²⁴ The trend is estimated from seed use data from 1955/56 to 1978/79 (Table 1).

$$\text{(Seed use)}_t = -9.1785 + 0.4934t \quad (3)$$

$$(4.5721) \quad (16.4310)$$

$$R^2 = 0.9899, \text{ D.W.} = 1.49, \text{ S.E.R.} = 1.0182.$$

The estimates of seed requirements based on this equation, presented in Table 2, increase steadily through 1985/86.

Estimates of Grain Consumed by Industry and People and the Waste Discount

The pattern of grain use suggests that the remaining uses of grain can be estimated readily. The USDA estimates in Table 1 show that the amount of grain consumed by industry and people is steady. It has therefore been assumed that these amounts remain stable at 4 million tons for industry and 46 million tons for people, a total of 50 million tons. With population growing about 0.8 percent per year, such constant use of grain

¹⁸ In 1975 meat output was 14,968 million tons. In the latest official sources, meat output in 1980 is stated to be 15 million tons with a decline of 2 percent in 1980.

¹⁹ If the official prices of meat products are kept constant, the excess demand will manifest itself in queuing and an increase of meat prices in the open markets. Even if they are fulfilled, the output targets for 1985 (Table 3) imply that the output of meat will be 62 kilograms per capita, of milk, 350 kilograms per capita, and of eggs, 259.4 eggs per capita. In contrast, U.S. consumption per capita in 1972 was 114 kilograms of meat and meat products (184 percent of the 1985 Soviet output target) and 164 kilograms of milk and milk products (47 percent of the 1985 Soviet output target). Soviet consumption of milk exceeds U.S. consumption apparently because of the high proportion of butter in the Soviet diet. Also, Soviet meat output figures are on a slaughter-weight basis and are not comparable with the U.S. figures.

²⁰ Schoonover, "Soviet Agriculture and Trade," p. 17. This increase is associated with a decrease in the amounts of roughages and protein feeds supplied. It is not induced by relative price changes. When a dummy was incorporated to account for this rise in equation (2), the estimated coefficient was statistically not significant.

²¹ *Ibid.*

²² Official retail prices of livestock products were increased 50 percent in mid-1962. They have not been increased since.

²³ Schoonover, "Soviet Agriculture and Trade," p. 8. The policy of not changing the retail prices of food (except of imports such as coffee) was reaffirmed at the July 1978 Plenum by General Secretary Brezhnev. According to Soviet estimates, the subsidies for food products, about 22 billion rubles, made up 18 percent of gross agricultural output in 1977 (U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *U.S.S.R. Agricultural Situation, Review of 1978 and Outlook for 1979*, Supplement 1 to WAS 18 [Washington, D.C.: USDA, 1979], p. 25).

²⁴ When, in addition, land is included in this equation as an explanatory variable, the coefficient for land is statistically not significant.

for items like bread and vodka implies that the per capita consumption of grain for these items decreases slightly. Such a decrease is also implied by the USDA estimates of grain use for these categories in Table 1.

Finally, the discount for waste is assumed to be 5 percent for below-average, 10 percent for average, and 12.5 percent for above-average production. The maximum discount of 12.5 percent may be reconciled with the USDA practice as follows: the USDA discounts production 15 percent when too much precipitation causes abnormal amounts of moisture, weeds, and seeds to appear in harvested grain. However, adoption of the narrower 60 percent confidence interval rules out the occurrence of such abnormally moist weather. In fact, for the period 1955/56-1980/81, the discount rate of 12 to 15 percent is applied by the USDA only for three above-average years, 1973/74, 1976/77, and 1978/79. All of these were outside the 60 percent confidence interval. For the remaining above-average years, 1956/57 and 1958/59, which are just covered by the 60 percent confidence interval, the discount rate used by the USDA varies from 8 to 10 percent. In view of this, a discount rate of 12.5 percent for the above-average grain output estimates of Chapters 3 and 4 was chosen in this report.

Estimated Grain Deficits or Surpluses During 1980/81-1985/86 Without Weather Specification

Table 4 shows the estimates of grain deficits or surpluses based on the assumptions discussed above in this chapter (outlined in the notes to the table) and on the assumption that the U.S.S.R. will not change the size of its grain stocks or trade in grain. The deficit for 1980/81 is based on actual grain production and predicted use. The estimates for the other years are based on predicted production and use.

The estimates in Table 4 suggest many interesting possibilities. If grain output from

1981/82 to 1985/86 were average, the Soviet Union would still have a grain deficit of about 8.6 million tons per year. Below-average grain production would result in an annual deficit of as much as 15.8 million tons, but not more. Above-average output performance, similarly defined, would result in surpluses not greater than 2.9 million tons per year. The official estimate of output for 1980/81 of 189 million tons could mean that the deficit will be as much as 27.3 million tons. It will be less if livestock continues to be slaughtered. Since that possibility cannot be assessed confidently, it seems reasonable to accept an estimate of 25 million tons for the 1980/81 deficit.

Estimated Grain Deficits or Surpluses with Weather Specification and Export Possibilities

While these estimates are plausible, the occurrence of average, below-average, and above-average years should be defined precisely if the deficits and surpluses are to be estimated in relation to a probable weather pattern.

Predicting Future Weather and Output

Predicting the impact and occurrence of future weather with a precise sequence of average, below-average, and above-average years is impossible. Even defining the impact of past weather in terms of output falling outside the 60 percent confidence interval is not satisfactory. The complex structure of Soviet crops and climate makes the available weather information inadequate. Stephen Wheatcroft has discussed crop-weather response and the limitations of the standard approach which captures this response by relating crop yields over vast areas to monthly precipitation and mean air temperatures without regard to stages of plant physiology and phenology.²⁵ From this perspective, incorporating the impact of weather via the

²⁵ Stephen G. Wheatcroft, "The Significance of Climatic and Weather Change in Soviet Agriculture (With Particular Reference to the 1920s and 1930s)," Paper No. 11, Soviet Industrialization Project Series, Center for Russian and East European Studies, University of Birmingham, Birmingham, U.K., 1977, pp. 1-19. Evidently Russia was acknowledged to be a pioneer in the development of "the first comprehensive approach to the weather crop problem which extended over a large geographical area."

Table 4—Estimated grain deficits and surpluses, 1980/81-1985/86

Grain Output	Surplus or Deficit	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	Annual Average, 1981/82-1985/86
(million metric tons)								
Average	Deficit	...	-8.7	-8.7	-8.6	-8.6	-8.6	-8.6
Below average	Deficit	-27.3 ^a	-15.9	-15.8	-15.7	-15.7	-15.7	-15.8
Above average	Surplus	...	+2.7	+2.8	+2.9	+3.1	+3.2	+2.9

Notes: Below-average and above-average outputs are estimated as the lower and upper values of the 60 percent confidence interval of equation (1). This means that there is a 60 percent chance that in a below-average year actual grain output will not be less than the estimated lower value and that the deficits will not be more than the stated amount. Similarly, the chances are 60 percent that the grain output in an above-average year will not be more than the estimated upper value and that the surpluses will not be more than the stated amount.

The estimates of grain outputs and of feed and seed requirements are from Table 2. Grain use for human and industrial consumption is assumed to be a constant 50 million tons. Waste is estimated to be 5 percent for below-average output, 10 percent for average output, and 12.5 percent for above-average output.

The above estimates incorporate the assumption that existing grain stocks remain unchanged and that there are no grain imports or exports.

^a The estimated deficit for 1980/81 is based on the following estimates: output, 189 million tons; seed use, 30.3 million tons; human and industrial use of grain, 50 million tons; and feedgrain use, 126.5 million tons. Five percent of the 189 million tons is subtracted as waste. As the slaughtering of livestock may continue through 1980, the estimated feedgrain use is a little high.

60 percent confidence interval and dummy variables, as will be done in Chapter 4, does not seem to be altogether objectionable.

But handling the impact of past weather in the manner just described and making forecasts are two different things. The precise sequence of average, below-average, and above-average years during 1980-85 is also needed.

It is possible to go along with a report of the CIA that seemed to prefer a forecast of Soviet weather for 1978-80 based on a projection of the "harsh climate" of 1962-65:²⁶ "This was a dry period for the entire grain belt, with hot summers in the spring grain regions and cold winters in the winter regions."²⁷ This grim forecast is predicated on the assumption that the Northern Hemisphere began to warm up in 1975: "... rains

have returned to the Sahel and India, and rainfall has decreased in the Soviet grain belt."²⁸ During the late 1960s, in contrast, the Northern Hemisphere was cooling. This period was marked by changes such as the Sahelian drought, failures of the Indian monsoon, increasing polar ice, and increased rainfall in the Soviet grain belt. The CIA, therefore, regards the 1975 Soviet drought as an indication of the end of this favorable climatic trend and a return to the harsher conditions of the early 1960s. The CIA does not make a convincing case for this controversial view. But even if it were to be adopted, it would be consistent with a large number of alternative sequences of bad and good years during 1980-85. It would still leave no determinate, single number to adopt for that period.²⁹

²⁶ When discussing the impact of weather on output in the spring and fall of a given year, the calendar year and the USDA consumption year are interchangeable. Thus 1978-80 is the same as 1978/79 to 1980/81.

²⁷ U.S. Central Intelligence Agency, *USSR - The Impact of Recent Climate Change on Grain Production*, ER76-10577 U (Washington, D.C.: CIA, 1976), p. 23.

²⁸ *Ibid.*, p. 2.

²⁹ In Daniel I. Bond and Herbert S. Levine, "Energy and Grain in Soviet Hard Currency Trade," in U.S. Congress, Joint Economic Committee, *Soviet Economy in a Time of Change*, 2 vols. (Washington, D.C.: U.S. Government Printing Office, 1979), 2:261, the CIA forecast of weather was adopted to make grain import predictions for 1978-85, but the sequence of good and bad years of 1961-68 was essentially chosen arbitrarily as the sequence for 1978-85. CIA, *USSR - Long-Term Outlook* forecast Soviet grain imports for 1980 and 1985 assuming, alternatively, favorable and average weather for each year.

The problem of the sequence of the average, above-average, and below-average years can be avoided if the less difficult problem of their likely occurrence is solved by observing their frequency between 1955 and 1980. This is an inexact, rule-of-thumb procedure. It is adopted with many reservations.

Classifying the 26 years between 1955 and 1980 for that purpose as above average, below average, and average with a 60 percent confidence interval gives some evidence that the number of above-average and below-average years is about equal. As already indicated, a 60 percent confidence interval leaves five years clearly outside the lower range (below-average) and five years outside the upper range of the interval (above-average). The remaining 16 observations fall in the average range. Accordingly, the long-run weather pattern for the Soviet Union seems to be that three fifths of the years are average, and the remaining are almost equally divided between below-average and above-average years.

In this paper it will be assumed that the weather between 1981 and 1985 will be average, below average, and above average in the same proportion. That is, three years will be average, one year will be above average, and one year will be below average. This assumption is shaky. It is adopted only because a firmer one is not to be found.

Unfortunately, the sequence of these years cannot be predicted. A below-average year following an average year will affect output differently from a below-average year following an above-average or a below-average year. The omission of the impact of the sequence is a serious limitation of the calculations of this report. The calculations can, however, adjust for the deficit arising because a below-average year depletes stocks more than an above-average year adds to them. (This asymmetry is referred to above.)

Given this pattern of the effects of weather on production—three average, one below-average, and one above-average year during 1981-85—the annual average esti-

mates (Table 4) show a total deficit of as much as 38.7 million tons. It is assumed that for the above-average year exactly 2.9 million more tons of grain will be produced than used.

Furthermore, for the period 1955/56 to 1980-81, the total net deficit from the asymmetrical effects of below-average and above-average years is about 72.8 million tons.³⁰ When distributed among the five below-average years, this estimate yields an average net deficit caused by weather asymmetry of about 14.6 million tons. With the addition of this amount to the deficit of the below-average year during 1981-85, the total deficit would be as much as 53.3 million tons.

Predicting Exports and Total Deficits Between 1981/82 and 1985/86

Export requirements must be added to this deficit. Soviet grain exports, mostly wheat, to Eastern Europe, Cuba, Vietnam, and elsewhere, beginning in 1956/57 (Table 1) declined from 6.6 million tons annually between 1956/57 and 1960/61 to 6.2 million tons annually between 1961/62 and 1965/66. They rose to an average 7 million tons between 1966/67 and 1970/71 when domestic grain output was less volatile—not a single year was below average or above average. Exports declined further to 4.2 million tons annually between 1971/72 and 1975/76. They averaged 2.3 million tons in the four years beginning in 1976/77.

Because exports declined from plan to plan in the past, it can be assumed that exports between 1981/82 and 1985/86 will average the recent level of 2 million tons, with the exact amount determined by the specific circumstances of a given year. The paramount consideration in Soviet grain trade policy and decisions will continue to be the need to import grain when domestic harvests fail so that livestock inventories can be maintained. This makes it unlikely that the Soviet Union will import grain in order to export it. The only recent exception

³⁰ The actual surplus of the five above-average years (1956, 1958, 1973, 1976, and 1978) is estimated by subtracting from the actual output the corresponding output of the upper 60 percent range; the actual deficit of the five below-average years (1963, 1965, 1975, 1979, and 1980) is estimated by subtracting actual output from the corresponding output of the lower 60 percent range. The net deficit, 72.8 million tons, is the difference between these two totals.

This asymmetry is brought out more clearly later in the estimated parameters of the weather dummies in the production functions. See Table 5.

was the Soviet decision to buy less than a million tons of rice from India and to ship it, presumably directly, to Vietnam. Moreover, the Soviet Union may decide not to supply grain to an ally when its harvest fails, especially when it fails as badly as the 1979 harvest did.³¹

The estimates, then, indicate a total deficit of up to 63.3 million tons between 1981/82 and 1985/86. Of this, 38.7 million tons represent the deficit of use over availability. A further 10 million tons are accounted for by export commitments during the five years and 14.6 million tons are attributable to the difference between the effects on output of the below-average and above-average years. As for 1980/81, the Soviet Union can be expected to import 25 million tons of grain, if no grain is exported and stocks are not changed. Whether such massive amounts can be found in the world grain markets is doubtful, but this question will be discussed later.

Estimating Changes in Grain Reserves and Imports

These deficits can be met by reducing stocks or by importing grain. A formidable problem arises when trying to determine how the Soviets use these alternatives to meet deficits: official information on the

current size of grain reserves is not available. In making these estimates, it is particularly important to know the size of the grain reserves on July 1, 1980. These and additions to the reserves can make up for grain shortages in the future.

However, a qualitative indication of current Soviet grain reserves can be discerned from the measures taken to combat the decline in grain output in 1979/80. Because the 1980/81 crop was also poor, the Soviet planners will probably use these measures even more earnestly.

About half of the decline during 1979/80 seems to have been offset by imports before July 1, 1980. An early estimate of the USDA indicated that, of the 35 million tons of wheat and feedgrains the Soviet Union was expected to buy between July 1, 1979 and June 30, 1980, approximately 30.5 million tons seemed to have been contracted for from all exporting countries, presumably for delivery by July 1, 1980, although some of this amount may not reach the Soviet Union until later.³²

Furthermore, indications are that a shortage of feedgrains remains, making some slaughter of livestock necessary.³³ This will, of course, reduce meat and milk output.³⁴ According to the latest official estimates, meat output declined by 2 percent in 1980.

Finally, the Soviet Union, according to the USDA, managed to accumulate 19 million tons of grain (all wheat) during 1978/79 (Table 1).³⁵ While this may have provided

³¹ The decline in Soviet grain output in 1979, about 26 percent (60 million tons), coincided with declines in agricultural output in Czechoslovakia (4 percent) and Poland (2 percent). It is not surprising, therefore, that the USDA estimated aggregate Soviet exports in 1979/80 to be only 800,000 tons. The poor 1980 grain harvest, 189 million tons, makes it unlikely that the Soviet Union can contribute anything to Poland, which is estimated to need at least 8 million tons in 1980 (see the *Wall Street Journal*, November 10, 1980, p. 27).

³² For details, see the *New York Times*, April 10, 1980, pp. A1, D12. According to the USDA's latest estimate, the Soviets had imported 28 million tons of grain by July 1, 1980.

³³ A report in *Ekonomicheskaya Gazeta*, no. 29, 1980, gave the following account of livestock inventories on state and collective farms in the first half of 1980. The percentages in parentheses represent numbers in 1980 compared to numbers in the first half of 1979: cattle, 93.5 million head (101 percent), cows, 29.6 million head (101 percent); swine, 56 million head (98 percent), sheep and goats, 143.9 million head (98 percent), and poultry, 704 million head (102.6 percent). These figures suggest that all kinds of livestock were slaughtered, but proportionately more swine, sheep, and goats were, so that their numbers on state and collective farms declined.

³⁴ The same report in *Ekonomicheskaya Gazeta*, no. 29, 1980 said that production of meat on state and collective farms in the first half of 1980 was 99 percent of production in the first half of 1979. The total amount of milk produced was 96 percent of the amount produced in the first half of 1979. Furthermore, partial information on state and collective farm production in the first seven months of 1980 indicates that production declined in July but recovered some in August. Thus production of meat on state and collective farms in July 1980 was only 85 percent of the amount produced in July 1979, but production in August 1980 was 88 percent of the amount produced in August 1979. According to latest official estimates, meat output declined by 2 percent in 1980.

³⁵ For details, see Michael D. Zahn, "Soviet Livestock Feed in Perspective," in U.S. Congress, Joint Economic Committee, *Soviet Economy in a Time of Change*, 2 vols. (Washington, D.C.: U.S. Government Printing Office, 1979), 2:175.

some relief,³⁶ it is clear that the Soviet policymakers had to make extraordinary efforts (undoubtedly intensified by the U.S. grain embargo) to buy grain and slaughter livestock. The slaughtering is likely to continue.

Everything considered, it seems realistic to say that the Soviet Union began 1980/81 on July 1, 1980 with its grain reserves largely exhausted.³⁷ Therefore it can be assumed that the Soviet Union cannot rely on domestic grain reserves to meet any grain shortage, including the 25-million-ton shortage of 1980/81. All of the deficit will have to be filled by imports. This assumes away the crucial issue of the choice between stock depletion and grain imports.

Furthermore, the assumption that there were almost no grain reserves on July 1, 1980 (except those set aside for strategic-military considerations) leads to the assump-

tion that the Soviet Union will avoid a recurrence of the scramble for grain imports and the involuntary slaughter of livestock. It will probably decide instead to accumulate grain by importing 5 million tons of grain each year during the six years beginning July 1, 1980.

Given these assumptions, the total shortfall of grain to be filled by imports between 1980/81 and 1985/86 will be 30 million tons during 1980/81 and up to 88.3 million tons between 1981/82 and 1985/86, indicating average annual imports of up to 17.7 million tons during the Eleventh Five-Year Plan (1981-85). The financial implications, especially the hard currency cost of this amount of grain imports, and the question whether the Soviets will be able to get 30 million tons of grain in 1980/81 will be discussed in Chapter 6.

³⁶ The USDA has many reservations about the reliability of its estimates of stock change (see Table 1, note j).

Again, it is well known that in the Soviet Union wheat is used for animal feed. Between 1971/72 and 1975/76, wheat accounted for 35 percent of the grain used for feed. Also, beginning in 1972/73, Soviet feedgrain imports exceeded wheat imports. It is probable that this pattern will continue. For details, see *ibid.*, p. 166.

³⁷ Of course it can be assumed that the Soviet planners set aside some grain as a strategic stockpile. This stockpile is to meet grain requirements during military emergencies and is not used to meet shortages caused by harvest failures.

4

THE PROBLEMS AND POSSIBILITIES OF ESTIMATING SOVIET GRAIN OUTPUT USING THE RESULTS OF PRODUCTION FUNCTIONS

In Chapter 3, Soviet grain production was predicted using past trends. In this chapter, the possibility of predicting it using production function estimates is explored. For this approach an agricultural production function needs to be estimated. This is a major task in itself. But the approach must also forecast the amount of inputs the Soviets will put into agriculture so that the production function can be used to estimate future Soviet agricultural output. The task is made even more difficult because, although it requires predicting the output of grain alone, estimates are available only for inputs into all agriculture. Moreover, since weather is an important factor in determining production, Soviet weather must be forecast as well, a task that makes only "conditional" forecasts possible, as the earlier analysis showed. The method used to predict grain output in Chapter 3 above is far simpler, but the analysis below is important and provides a different perspective on forecasts of Soviet grain imports.³⁸

Specification and Estimation of the Production Function

The agricultural production function is defined as:

$$Q_t = A e^{\lambda t} K_t^{\alpha_1} \cdot M_t^{\alpha_2} \cdot R_t^{\alpha_3} \cdot L_t^{\alpha_4} \cdot e^{u_t} \quad (4)$$

where

$$A > 0, 0 \leq \alpha_i \leq 1,$$

and

$$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 1.$$

The dependent variable, Q_t , stands for agricultural output. Different estimates of it are used. These are the Western gross measure and the Western net measure, both in rubles, and the author's estimate of agricultural production in million metric tons based on Soviet official data. The Western gross measure and agricultural production in tons include such inputs from agriculture as feedgrains going into animal husbandry, but the Western net measure subtracts them. Furthermore, whereas the physical measure of output includes trash, waste, and moisture content, the Western estimates do not. Finally, the estimate of agricultural production in tons employed in production function estimation is put together from data in Soviet sources. In contrast, agricultural output is officially measured by its value and is derived by weighting the physical output of all items, presumably with constant prices.

The explanatory variables in equation (4) are capital stock (K) in agriculture given in Soviet sources, labor employed (M) in agriculture as estimated by Murray Feshbach, current inputs (R) in agriculture as estimated by Douglas Diamond, and area sown (L) during the agricultural year as given in Soviet sources. The data, their sources, and their limitations are given in Appendix 2, Tables 10 and 11.

In addition to capital stock, labor in man-hours, current inputs, and sown area, dummy variables are also included for weather, with each year in the period classified as average, above average, or below average on the basis of the number of grain-growing regions that can be classified in that year as

³⁸ To experts on Soviet agriculture, this "successful" estimation of an agricultural production function is important. The analysis also spotlights important deficiencies and suggests refinements.

deserts and steppes.³⁹ These classifications for the 27 growing regions of the U.S.S.R. are made in a recent report of the CIA for the 16-year period from 1960 to 1975 on the basis of the Koppen method of weather classification.⁴⁰ On the basis of this information, approximately 25 percent of the observations were assigned to the lower end of the distribution as above average and 25 percent were assigned to the upper end of the distribution as below average. The remaining observations were characterized as average. As a result, five years (1969, 1970, 1971, 1973, and 1974) with less than 3 regions classified as steppe and desert are called above average (one year had none), and four years (1960, 1962, 1963, and 1975) with more than 11 steppe and desert regions are called below average (one year had 16). Both these sets of years are then assigned dummy variables of 1. The remaining years (including the entire pre-1960 period) are assigned values of 0.

This simple specification of the weather variable was adopted after several other formulations of the weather index were experimented with. An estimation of the production functions without a weather variable was tried first. Then an attempt was made to formulate two weather variables, associated with actual temperatures during January, February, and March in the southern Ukraine and precipitation between July and October in the entire growing region.

Then an experiment was made using four dummy variables, one each for one standard deviation above mean temperature (HTEMP), one standard deviation below mean temperature (LTEMP), one standard deviation above mean precipitation (HPREC), and one standard deviation below mean precipitation (LPREC). As this procedure proved unsatisfactory, the four dummy variables were reduced to two, so that above-average weather was defined as HPREC plus HTEMP and below-average weather was defined as LPREC plus

LTEMP. This would mean that the weather variable for a below-average year would have a dummy of 2 if low precipitation and low temperature were combined, 1 if only precipitation or temperature were low, or 0 if neither precipitation nor temperature were low. The dummy variables for the above-average year would be similarly defined.

All these weather specifications were tried using first four, then three inputs (with capital at 8 percent merged with current inputs), and with and without technical change. The results were either economically meaningless or statistically poor.

Equation (4) is first fit to all three sets of outputs without introducing weather. The results not presented here indicate that it is impossible to extract satisfactory estimates of the four input coefficients and the technical change parameter from 26 observations. When the technical change parameter is not considered, the t-values of the estimates improve only slightly. However, the problem of collinearity between the capital and current input series when both grow steadily still persists. Therefore, capital, with an 8 percent return, is merged with the current input series.⁴¹ When the technical change parameter is reintroduced in the estimation procedure, the results again indicate that the estimates of technical change and the input coefficient are strongly collinear for capital plus current inputs. A justifiable procedure, then, would be to estimate the production function without a technical change parameter and with capital and current inputs merged together with an 8 percent return assigned to capital.

When the dummy variables for weather discussed earlier are introduced, the same procedure is used, and the entire sequence of estimation is repeated. The production function then becomes:

$$Q = B \cdot t_1^{\beta_1} \cdot M_1^{\beta_2} \cdot I_1^{\beta_3} \cdot e^{u_t} \quad (5)$$

³⁹ The weather variable has been used several times in specifications for estimating and forecasting Soviet grain output. Hans Wagener adopted the more than 5 percent deviation of grain output from its trend value as a proxy for weather (Hans Jürgen Wagener, "Sectoral Growth—The Case of Soviet Agriculture," in *Forschungsbericht 1973* [München, Osteuropa Institut, 1974], p. 67). In their SOVMOD I model, Donald Green and Christopher Higgins used a weather index constructed on the basis of deviations of spring and summer precipitation from normal monthly values during the growing season and of winter temperatures in the Ukraine (see Donald W. Green and Christopher Higgins, *SOVMOD I: A Macroeconomic Model of the Soviet Union* [New York, Academic Press, 1977], pp. 259-260).

⁴⁰ CIA, *U.S.S.R. Impact of Recent Climate Change*, p. 90 and Appendix A.

⁴¹ The 8 percent rate of return, though arbitrary, is usually applied to capital stock in the Soviet economy and in Soviet industry.

where

$$B \geq 0, 0 \leq \beta_j \leq 1 \text{ and } \beta_1 + \beta_2 + \beta_3 = 1.$$

C_1 represents capital stock with an 8 percent annual flow plus current inputs. The other variables are defined as before. The results are in Table 5.

The reasons for omitting technical change as a parameter to be explicitly estimated in this production function seem persuasive.⁴² Although some factors, including policy changes in agriculture, may have contributed to increased factor productivity sporadically in scattered geographical areas of the country, they could not have contributed significantly to agricultural productivity in the entire country for the whole period since 1955. Furthermore, all the inputs that contribute to agricultural output are included explicitly in the estimating equation. This procedure minimizes the likelihood that the productivity of an omitted factor is left in the residual as technical change. Lastly, with the same end in view, dummy variables are included for weather as discussed above.

A feature of the estimates in Table 5 based on equation (5) is that the estimated coefficients reveal a steady range of values when the dependent variable is changed, making them quite credible. Almost all the estimates are statistically significant.

Several of the specific features of the estimates should be emphasized. The statistical criteria of the R^2 , SER, and D.W. statistics used to assess the estimates with and without weather generally indicate improvement when weather is introduced. In the specification with weather (Table 5), output increases between 43 and 61 percent in response to the application of land; the magnitude of the response to capital and current inputs is between 34 and 40 percent.⁴³ By contrast, the output response to the

application of labor is only 5 to 18 percent. It would be interesting to compare these figures with estimates of factor shares in value added to Soviet agriculture. The most recent estimate of these factor shares is available for 1966 with a share of 0.58 for labor, 0.12 for land, and 0.30 for capital (including current inputs and livestock).⁴⁴ In the production function estimates, the Western measure of net agricultural output corresponds most closely to value added. The corresponding coefficient of labor is 0.12; of land, 0.53; and of capital including current inputs and livestock, 0.36 (Table 5). If the Cobb-Douglas constant-returns-to-scale specification were accepted for the production function of Soviet agriculture and if factors were rewarded according to their marginal productivity, then it would seem that in Soviet agriculture labor is overpaid and land and capital (plus current inputs and livestock) underpriced. Indeed, the production function estimates raise doubts about whether factor productivity in Soviet agriculture can be calculated by plugging estimated factor shares into a Cobb-Douglas, constant-returns-to-scale production function.⁴⁵

Finally, the estimates of output response to weather show that the decline in output caused by below-average weather is larger than the gain in output caused by above-average weather. This asymmetry may reflect the meagerness of normal rainfall in areas such as the Ukraine so that marginal shortfalls have serious adverse effects whereas marginal increments of rainfall have limited impact. This asymmetry also implies that the distribution of the weather variable is skewed. Therefore, average weather is defined to reflect the asymmetry, with approximately 50 percent of the observations having between 3 and 11 steppe and desert regions. Because the distribution of the steppe and desert regions is skewed to the right, the

⁴² The econometric justification for omitting the residual is that, because the capital stock has a trend, the estimates of the residual and the capital coefficient have an inverse relationship. A discussion of this point in the context of Soviet agriculture can be found in Wagener, "Sectoral Growth," p. 71.

⁴³ Clearly the high output coefficient for capital and current inputs incorporates the technical change parameter—explicitly excluded from the estimating equation—because capital and current inputs are the only inputs that increase steadily. This parameter, therefore, has to be interpreted with caution.

⁴⁴ For details see Douglas B. Diamond and Constance B. Krueger, "Recent Developments in Output and Productivity in Soviet Agriculture," in U.S. Congress, Joint Economic Committee, *Soviet Economic Prospects for the Seventies* (Washington, D.C.: U.S. Government Printing Office, 1973), p. 329.

⁴⁵ Such an interesting procedure is used in Douglas B. Diamond, "Trends in Output, Inputs, and Factor Productivity in Soviet Agriculture," in U.S. Congress, Joint Economic Committee, *New Directions in the Soviet Economy* (Washington, D.C.: U.S. Government Printing Office, 1966), and Diamond and Krueger, "Recent Developments."

Table 5—Production function estimates for agriculture, 1950-75

Measures of Output	Coefficients ^a					lnB	R ² (SER)	D.W.
	Capital and Current Inputs ^b β_1	Labor β_2	Land β_3	Above-Average Weather ^c	Below-Average Weather ^c			
Western gross output	0.3956 (8.4697)	0.1788	0.4256 (2.4364)	0.0415 (1.3328)	-0.0759 (2.4694)	0.2960 (1.0996)	0.9706 (0.0474)	1.48
Western net output	0.3553 (7.3781)	0.1180	0.5268 (2.9262)	0.0433 (1.3477)	-0.0809 (2.5540)	-0.0041 (0.0148)	0.9667 (0.0489)	1.60
Agricultural production in tons	0.3409 (6.0587)	0.0503	0.6088 (2.6558)	0.0557 (1.6832)	-0.1313 (2.9562)	1.7595 (5.1889)	0.9993 (0.0633)	2.10

Sources: The output and input data from which the production functions are estimated are given in Appendix 2, Tables 10 and 11.

^a These coefficients are calculated from the production function stated in equation (5) of the text.

^b The estimates of capital stock are combined with current inputs assuming an 8 percent rate of return.

^c Weather for 1960-75 is classified as above average, below average, or average. Average years are given dummy variables of 0. Above-average and below-average years are given dummy variables of 1. Approximately 25 percent of the years are defined as above average and 25 percent are defined as below average on the basis of the number of regions that can be classified as steppe and desert in each year with the Koppen weather classification. The remaining years, approximately 50 percent, are classified as average. As a result, years with 2 or fewer desert and steppe regions are defined as above average and those with 12 or more such regions are defined as below average. For lack of information, all years before 1960 are treated as average.

This procedure failed to give a meaningful result for the production function defined in terms of agricultural production in tons. Therefore, the reported results incorporate an arbitrary classification of the weather variable. Years with above-average weather have 3 or fewer regions defined as deserts and steppes and years with below-average weather have 10 or more regions defined as deserts and steppes.

modal value of such regions will be less than the mean and the weather categorization tilts the average weather in the direction of the lower modal value.

Predicting Future Output of Grain and Inputs in Soviet Agriculture

Several sets of problems arise when the production function results of Table 5 are used to forecast Soviet grain output. The first set of problems arises in estimating capital stock, area sown, man-hours, and current inputs during 1980-85. There are particularly difficult problems in predicting the capital stock. These are only matched by the difficulty of making a "scientific" prediction of the weather.

Capital Stock

Ideally, capital stock can be estimated in two steps. The value of investment in the economy and agriculture's share of it could be estimated first. Then the completed investment projects in agriculture, when added to existing capital stocks (minus scrappage), would yield the required capital stock predictions at a given time. Unfortunately this cannot be done.

Thus, whereas aggregate Soviet investment increased 42 percent during 1971-75, it is expected to grow by only 25 percent during 1976-80. The share of agricultural investment is expected to rise from 26 percent during 1971-75 to 27 percent during 1976-80.⁴⁶ These figures suggest that aggregate investment in the economy during 1981-85 may grow no more than 22.5 percent

⁴⁶ For details see David M. Schoonover, "Soviet Agriculture in the 1976-80 Plan," in Roy Laird, Joseph Hajda, and Betty Laird, eds., *The Future of Agriculture in the Soviet Union and Eastern Europe* (Boulder, Colo.: Westview Press, 1977), p. 80. Capital investments in agriculture accounted for 26 percent of total investment in the economy in 1978, compared with 27 percent in 1977 (see ESCS, *U.S.S.R.: Review of 1978 and Outlook for 1979*, p. 19).

with agriculture's share about 25 percent.

However, it may be difficult to translate investment in agriculture into agricultural capital stock formation. The investment figure includes several items. It certainly includes disbursements for new irrigation, land reclamations, and acquisition of trucks and tractors. "During the 1971-75 period, it was apparent that a new type of investment expenditure was 'credited' to the agricultural sector—the investments in the state repair shops of Sel'khoztekhnika, in the facilities of rural construction, in local agricultural product processing plants, in construction materials for irrigation and amelioration and in construction and operation of research institutions."⁴⁷ However, Soviet agricultural capital stock figures always include capital stock formation for such items as agricultural raw material processing and construction material for irrigation. All of these are subsidiary or auxiliary to agriculture. Therefore, a spurt in investment for these items would imply growth corresponding to it after a suitable time lag in agricultural capital stock formation.

However, it is not clear in what precise manner and to what extent the exercise should include "... investments in the industrial branches supplying agriculture: the tractor and truck industry, the mineral fertilizer industry, pesticide production, etc."⁴⁸ According to official practice, these investments result in capital formation in industry, but only deliveries of trucks, tractors, and farm equipment add to capital stock in agriculture. Fertilizer and pesticide deliveries are additional flows of current inputs. Therefore the growth of agricultural investment these account for would not account for a corresponding growth of agricultural capital stock except for deliveries of items such as trucks and tractors.

Another problem arises because, though the growth of agricultural capital stock

includes the growth of livestock inventories, it is not certain that the targeted outlays of agricultural investments do. All these complications make it impossible to translate the targeted outlay of agricultural investment into the formation of agricultural capital stocks.

While agricultural capital stock during 1980-85 cannot be estimated in this fashion, neither can the past pattern of capital stock in agriculture provide a reliable guide to future capital stock formation. This stock has fluctuated considerably but grew at a rate of 10 percent annually during 1970-75 when investment was shifted into agriculture. (The average of these fluctuating annual growth rates of agricultural capital stock was, during 1955-60, 9.3 percent; during 1960-65, 7.4 percent; and during 1965-70, 6.6 percent.) It is generally agreed that the extraordinary rate of growth of 1970-75 cannot be maintained.

Capital stock in agriculture during 1980-85, therefore, has to be estimated somewhat arbitrarily. For this exercise, a growth rate for capital stock of 7 percent each year was chosen, beginning with a capital stock of 179.022 billion rubles in 1955 prices on January 1, 1979.

Area, Man-Hours, and Current Inputs

It will be assumed that the area sown during 1980-85 will remain at the current (1975-78) annual level of 218 million hectares.⁴⁹

Perhaps the most difficult input to predict is man-hours. Although the number of man-hours worked fluctuated between 1950 and 1975, it had declined by the end of the period. The decline between 1965 and 1975 was at an annual rate of 0.46 percent (this is the average of 10 annual growth rates). It is certain that the number of man-hours worked

⁴⁷ See Arcadius Kahan, "Shifts to Off-Farm Agricultural Inputs in the Tenth Economic Plan: The Economic and Institutional Implications," in Roy Laird, Joseph Hajda, and Betty Laird, eds., *The Future of Agriculture in the Soviet Union and Eastern Europe* (Boulder, Colo.: Westview Press, 1977), p. 21.

⁴⁸ *Ibid.*

⁴⁹ This assumption that area will be constant seems to conflict with the provision in Table 2 that seed requirements increase gradually, at the rate of 0.5 million tons annually. However, as was said when equation (3) was interpreted, the coefficient of seed with respect to land is statistically not significant. It is possible that increasing yields per hectare (with area constant) will require increasing amounts of seed along with more equipment services, fertilizer application, and so forth.

(continued)

will continue to decline in Soviet agriculture, but it is difficult to predict the size of the decline with confidence. The figure cited above makes a decline of 0.5 percent annually, starting with a man-hour application of 67.6 billion in 1975, seem reasonable.

Finally, current inputs are projected from the declining annual growth rates of the past. They showed average annual increases of 9.2 percent during 1960-65, 6.2 percent during 1965-70, and 5.3 percent during 1970-75. (These, too, are averages of annual growth rates.) Considering the significant shortfalls in fertilizer application during 1975-79,⁵⁰ the current input application during the Tenth Five-Year Plan (1976-80) cannot exceed the annual increase of 1970-75 cited above. Assuming that fertilizer production and distribution during 1980-85 cannot improve dramatically, an annual growth rate of 5 percent of input application during 1975-85, beginning with 9.73 billion rubles in 1975, will be assumed.

Weather During 1981-85

It shall be assumed as before that the years 1981 to 1985 will have three average years, one above-average year, and one below-average year. The sequence will be ignored. Since the estimated production function parameters with Western gross output in Table 5 already account for the asymmetry of weather's effects on output, the asymmetry will not be allowed for separately in these forecasts.

Converting Predicted Agricultural Output into Tons of Grain Output

The final set of problems with predicting future grain output arises because the pro-

duction function estimates are based on total agricultural production, in value and in tons, whereas the requirement estimates of grain use, in tons, make it necessary to predict grain output in tons. It will be recalled that the Western output measures use 1968 price weights to aggregate individual items and are therefore in value terms, whereas the third measure of output used to estimate the production function above is a simple addition of tonnage figures from Soviet sources. The last estimate would therefore seem at first sight to be appropriate, despite its crudeness. It lends itself more readily to predicting grain output in tons from agricultural output (also in tons). This procedure, however, does imply an assumption of a systematic relationship based on the past pattern between Soviet grain output and total agricultural output.

On the other hand, both the Western measures, gross and net output in 1968 rubles, are sound methodologically. They are derived by applying 1968 price weights to physical outputs of agriculture. However, it is difficult to convert these predicted values into tons of grain except by making highly restrictive assumptions. More to the point, these values are based on estimates of tonnage that are far below the official Soviet estimates. This raises the problem of comparing the predicted grain tonnage outputs with the official estimates of grain requirements given in Table 1. This makes it necessary to increase the predicted outputs in order to make them comparable to the estimates of grain use. Furthermore, the tonnage estimates for 1981-85 based on the Western net ruble measure would need to be increased also by adding independently made forecasts of feedgrain use. This is on top of the adjustments required because both Western ruble measures incorporate tonnage figures made on a standard basis

(footnote 49 continued)

Rather than assume that area is constant, in Land and Land, "The Widening Soviet Grain Crop," p. 30, it is assumed that the area sown will decline from about 218.0 million hectares to 210.0 million hectares in 1985. The Lands argue that "... the Khrushchev new lands policy had grossly overextended the sowing base" (Land and Land, "The Widening Soviet Grain Crop," p. 28). Furthermore, they say, grain area was expanded to over 130 million hectares in the early 1960s, in part by reducing unjustifiably the area left fallow in the arid regions. On the other hand, it may be possible to keep area constant by steadily reclaiming new land by drainage and by irrigating meadows and pastures, approximately 1 million hectares may have been added annually to crop cultivation in recent years (see I.S.C.S., *USSR Review of 1978 and Outlook for 1979*, p. 20). It is difficult to predict how long this will continue. Such a steady increase might permit efficient agricultural practices by allowing an equivalent amount of land to be kept fallow while total area is held constant.

⁵⁰ Michael D. Zahn, "The 1979 Grain Harvest and Prospects for the Future," a paper presented at the Corporate Sponsor Seminar, Russian Research Center, Harvard University, Cambridge, Mass., 1979.

whereas the Soviet estimates are made on a bunker weight basis.

In view of these considerations, the output estimates used and forecasted here are based on the estimates in Table 5 derived from Western gross output in 1968 rubles. On balance, this seems the least objectionable procedure.

To convert the predicted ruble values of these outputs into the comparable Soviet tonnage measure, it is first assumed that the ratio of the 1968 ruble measure and the underlying Western tonnage estimate for 1980-85 remain the same as for the period 1960-75. The ruble estimate is multiplied by this estimated ratio, 1.3209, to get the corresponding Western tonnage estimate. The latter is then divided by 0.6302, producing the comparable official Soviet measure of grain output, because the official Soviet figures for grain tonnage must be discounted by 0.6302 to get the Western grain tonnage figures.

Admittedly, these are not satisfactory procedures. But as production function data are available only for Soviet agriculture as a whole and as it is desirable to forecast grain output on the basis of the Western gross ruble measure because it is methodologically less problematic to interpret than the Soviet tonnage output, these procedures seem to be the only ones available. The resulting output estimates are presented in Table 6.

How do these production function output estimates compare with the estimates based on the linear trend of past output? The estimates of grain output in Table 2 were made with above-average and below-average variations, attributable to weather, from the mean output with a 60 percent confidence interval range. In other words, if the weather is better than average or worse than average, there is a 60 percent chance that the actual surpluses and deficits will not exceed these estimates.

By contrast, the methodology used for the estimates of Table 6 defines above-average and below-average years more explicitly by the number of regions that can be classified as steppe and desert with the Koppen weather classification. However, this methodology has limitations. In an above-average year output cannot be predicted if the number of steppe and desert regions is 0, 1, or 2, because the dummy variable of 1 assigned to the year includes all three possibilities. Similarly, in a below-

Table 6—Estimates of grain output based on production function parameters for agriculture, 1976/77-1985/86

Year	Average Output	Below-Average Output	Above-Average Output
	(million metric tons)		
1976/77			208.248 ⁴
1977/78	204.616 ⁴		
1978/79			218.707 ⁴
1979/80		198.886 ⁴	
1980/81		203.391 ⁴	
1981/82	224.467	208.061	233.978
1982/83	229.575	212.794	239.303
1983/84	234.800	217.639	244.748
1984/85	240.214	222.656	250.392
1985/86	245.681	227.725	256.092

Notes: The coefficients used for deriving the output figures of this table are estimated from equation (5) of the text using Western gross output. These coefficients are stated in Table 5. Furthermore, taking past and recent growth patterns into account, it is assumed that agricultural capital stock will grow 7 percent and current inputs, 5 percent each year; that man-hour application will decline 0.5 percent annually; and that the amount of cultivated land in agriculture will remain fixed at 218 mill on hectares.

Above-average output is output in a year with 2 or fewer desert and steppe regions in terms of the Koppen weather classification. Below-average output is output in a year with 12 or more such regions. Both classes of years are given dummies of 1. Average years with desert and steppe regions from 3 to 11 are given dummies of 0. For lack of information, a dummy of 0 is adopted for each year before 1960.

⁴ As in Table 2, the predictions of output during the Tenth Five-Year Plan (1976-80) assume that weather was above average during 1976/77 and 1978/79, below average during 1979/80 and 1980/81, and average during 1977/78.

average year, the output and corresponding import possibilities cannot be distinguished if the number of steppe and desert regions is 12 or more. (It could exceed 16 in the future).

While the definition of the weather index is discrete in terms of a stated interval of steppe and desert regions and therefore unsatisfactory, this methodology does give forecasts of grain output and the corresponding imports associated with given amounts of inputs. This improves on the

earlier method of extrapolating future output from past trends. Also, the explicit incorporation of the weather, however imperfect, is a step in the right direction.

The resulting estimates of grain output are stated in Table 6. Since the Koppen weather classification of the CIA is not available beyond 1975, the weather information available in USDA annual reports on Soviet agriculture was used to designate two years, 1976/77 and 1978/79, as above average; and two others, 1979/80 and 1980/81, as below average. For the period between 1976/77 and 1980/81, annual output averaged 206.8 million tons. The estimate of output from the trend methodology in contrast was

204.7 million tons and actual output was 204.9 million tons.

Table 7 shows the estimated deficits of grain corresponding to the output estimates in Table 6. Assuming that between 1981/82 and 1985/86 three years are average, one is above average, and one is below average; allowing for 25 million tons of stock to accumulate; and assuming that 10 million tons will be committed to exports, aggregate imports during the period will be 76.8 million tons. This is less than the 88.3 million tons estimated earlier from past trends. It suggests that 15.4 million tons will be imported each year, less than the earlier estimate of up to 17.7 million tons.

Table 7—Estimated grain deficits and surpluses based on production function parameters, 1980/81-1985/86

Grain Output	Surplus or Deficit							Annual Average, 1981/82-1985/86
		1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	
(million metric tons)								
Average	Deficit	...	-9.1	-8.7	-8.2	-7.5	-6.3	-8.0
Below average	Deficit	-27.3 ^a	-13.4	-13.1	-12.7	-12.2	-11.6	-12.6
Above average	Deficit	...	-6.4	-5.9	-5.3	-4.6	-3.8	-5.2

Notes: The estimates of deficits represent the excess of grain use over output. Furthermore, they are based on the assumption that existing grain stocks remain unchanged and that there are no grain imports or exports.

The figures for average, below-average, and above-average output are given in Table 6. Among the components of use, the estimates of feed and seed requirements are given in Table 2; grain use for human and industrial consumption is assumed to remain constant at 50 million tons; waste is estimated to be 5 percent for below-average, 10 percent for average, and 12.5 percent for above-average outputs.

^a The estimated deficit for 1980/81 is based on the following estimates: output, 189 million tons; seed use, 30.3 million tons; human and industrial use of grain, 50 million tons; and feedgrain use, 126.5 million tons. Five percent of the 189 million tons is subtracted as waste. As the slaughtering of livestock may continue through 1980, the estimated feedgrain use is a little high.

5

PREDICTING GRAIN IMPORTS USING REGRESSION ESTIMATES OF IMPORT DEMAND FUNCTIONS

The last set of estimates of grain imports for 1981-85 is made by fitting Soviet import data for grain directly to several explanatory variables (see Appendix 2, Table 12).

One of these variables is Soviet output of grain (Q_G). Since the imports (although reported and taken from official Soviet sources) would be weighted by the American system, the Soviet bunker weight estimates of domestic production must be lowered. The method used by the USDA is used here.

Another variable, the price in rubles per metric ton of grain imports (P_G), is derived by dividing the value of grain imports by the tonnage. Both are reported in official Soviet sources. The data for a third variable, Soviet production of meat (Q_M), are taken from official sources.

A fourth variable, Soviet production of feedgrains (Q_{FG}), could contribute to an explanation of grain imports (which are largely feedgrain imports). Another, Soviet exports of grain to allies (X_G), may influence Soviet grain imports. Finally, a dummy variable incorporates the decision, evident in 1971, to maintain grain imports at levels at which livestock slaughter is avoided and the production of livestock products rises steadily.⁵¹

The regressions, both linear and log-linear, are estimated for the period 1950-75. All the data from Soviet sources are for calendar years. Among the explanatory variables, domestic grain output (Q_G), price per ton of imported grain (P_G), and domestic production of feedgrains (Q_{FG}) are lagged one year to account for the lag between the decision to import grain and the delivery of the grain.

The dependent variable, grain imports (M_G), is specified on a gross basis. This can be justified by arguing that the Soviet Union imports grain for the entire Soviet bloc. Having thus defined M_G on a gross basis, it is possible to investigate, on the basis of the size of the estimated parameter, whether grain exports to allies (X_G) influence these imports.⁵² The practical consideration for adopting Soviet grain imports on a gross basis (rather than a net basis) is that some entries in official sources for net grain imports during 1950-75 are characterized as zero, negative, or insignificant. This makes it difficult to estimate the regressions. Finally, the dummy variable is explicitly introduced in 1971 to reflect the shift in policy mentioned above.

Characteristics of the Actual Import Pattern

The estimated parameters, however, must be interpreted in terms of an analytical framework suggested by the actual Soviet import pattern during the period, including the change in policy that became evident in 1971. The characteristics of this pattern can be determined by answering several questions.

Do Soviet imports of grain (M_G) more than make up the shortfall in domestic production? If so, the coefficient of imports to domestic output (lagged one year) would be greater than 1 in the linear regression. The evidence provided by the pattern of Soviet imports of grain suggests that the Soviets do not normally use imports to make

⁵¹ Because reliable and sufficiently long time-series data are lacking, Soviet hard-currency balances and gold reserves cannot be included as an explanatory variable that could influence the decision to import grain. Similarly, because firm data on grain reserves are not available, the impact of grain reserves on the decision to import grain will not be considered.

⁵² The problem could also be handled by estimating two separate equations, of gross Soviet grain imports and Soviet grain exports, and deriving net Soviet grain imports as the difference between the two.

up the entire shortfall of domestic production. Instead, the evidence suggests that a shortfall is usually accompanied by other measures, such as rationing of bread, slaughtering of cattle, and reduction of stocks. Therefore, one restriction placed on the estimated parameters is to reject values of the estimated coefficients of imports (M_{Gt}) in relation to domestic production (Q_{Gt}) that are greater than 1 in the linear relationship.⁵³ The signs of the estimated parameters should, however, be negative.

Second, while it is reasonable to assume that the Soviet planners do not make up the entire shortfall in domestic production with imports, the amount of grain imported will certainly be influenced by the amount of grain produced domestically. Rather than introduce the unsatisfactory weather dummy variables 0 and 1, used earlier in the production function estimates, directly in the import equation, the range of below-average and above-average outputs generated by the 60 percent confidence interval presented in Table 2 will be relied on instead. They will be used to estimate the corresponding amounts of grain imported.

Third, how large is the response of imports to prices of grain (P_{Gt}) lagged by one year? One would assume that the price elasticity response is low, perhaps much less than 1 in the log-linear relationship, because Soviet import decisions in the past were influenced by considerations other than price. Also, if the Soviet planners decide in the future to continue to maintain their livestock inventories, price will not have the decisive effect on imports. In any case, the signs of the estimated coefficients should be negative.

The implications for grain imports of Soviet meat production also need to be discussed. These are straightforward in the sense that rising meat production would, other things being equal, require feedgrain inputs, including those from imports, to increase, so that the sign of the estimated parameter will be positive. As some livestock was slaughtered in the past when harvests failed, the value of the estimated parameter would be less than it would be otherwise.

Finally, it would be reasonable to expect, as before, that grain exports to allies (X_{Gt}) are unlikely to influence Soviet imports of grain (M_{Gt}). When harvests are good in the Soviet Union and crops fail in allied countries, the Soviet Union will not need to import grain to export to allies. When harvests fail in the Soviet Union and in allied countries, Soviet planners may decide to meet export commitments out of stocks. They may also decide not to export grain to an ally when there are acute shortages in the Soviet Union.

Estimation Procedure and Criteria of Selecting the Preferred Regression

When estimating the regressions, three types of dummy variables were specified in order to explain the policy change evident in 1971. These were 0 for the period 1950-70 and 1 for 1971-75, a dummy variable specified for 1971-75 with a coefficient related to Q_{Gt} , and a dummy variable specified, again for 1971-75, with a constant term and a slope with respect to Q_{Gt} . It is clear that the first specification alters only the intercept of the regression from 1971, the second one alters only the slope, and the third one alters both the intercept and the slope. The results of the third had to be rejected outright because the t-values of the slope and the intercept dummies when used simultaneously were not statistically significant. Although the value of the second is statistically significant when defined in terms of the slope parameter alone, the result had to be rejected because it implied that the effect of domestic grain production on imports had increased since 1971. This contradicts the interpretation that the policy change of 1971 was to increase imports above the 1950-70 trend only to avoid livestock slaughter and maintain the livestock inventory. Therefore, the dummy variable selected, also statistically significant, was defined in terms of the intercept alone (that is, 0 for 1950-70 and 1 for 1971-75).

Time and meat production were included in the initial specifications as explanatory

⁵³ M_{Gt}/Q_{Gt} , being less than 1 is consistent with $\partial(M_{Gt}/Q_{Gt})/\partial Q_{Gt}$, Q_{Gt} , being greater than 1 in the log-linear relationship because the latter also depends on the proportion of domestic production the average value of imports make up. It is small for the Soviet Union.

variables. However, they were highly col-linear. Also, though meat is more explicit, time is easier to forecast. In any case, the equation with the time trend meets the statistical criterion of R^2 a little better. Therefore, the specification defined in terms of time, rather than meat output, was selected.

The parameters for feedgrain output (Q_{FG}) and grain exports (X_G) were statistically not significant. As a matter of fact, removing these variables from the specifications improves the R^2 of the regressions and the t -values of the remaining parameters.

Finally, the elasticity coefficient for the price of grain (P_G) in the log-linear specification suggests a high (greater than 1) sensitivity of Soviet grain imports to price. This, however, contradicts the interpretation stated earlier that price does not have a decisive effect on the decision to import grain.

Taking all considerations into account, the most satisfactory estimates are given by the linear equation (6) below, defined in terms of $(Q_G)_{t-1}$, $(P_G)_{t-1}$, time, and a simple dummy variable 0 (up to 1970) and 1 (after 1971):

$$(M_G)_t = -23.3603 - 0.1834(Q_G)_{t-1} - 0.0520(P_G)_{t-1} + 0.8343(\text{time}) + 10.5179(\text{dummy}), \quad (6)$$

(1.7808) (3.1099) (1.0452)
(3.2619) (4.2386)

$$R^2 = 0.7095, \text{ S.E.R.} = 3.3494, \text{ D.W.} = 2.35$$

The variable t runs from 51 to 75.

This equation suggests an interesting pattern of the effects of the explanatory variables on Soviet grain import behavior. The coefficient of 0.18 for domestic grain output implies that only 0.18 million tons of grain is imported to offset a 1 million ton decline of grain output. Moreover, the estimated price elasticities of grain imports are decidedly below 1 when the coefficient of 0.0520 is used to estimate the elasticities for the period under consideration. And finally, the decision to increase meat output from 1971 without slaughtering cattle will add 10.5 million tons to grain imports each year.

Estimates of Grain Imports

Estimates of the imports of grain based on equation (6) are presented in Table 8. Average, below-average, and above-average Soviet grain production between 1980 and 1985 are assumed to be the same as in Table 2 (minus the waste discount of 10, 5, and 12.5 percent of average, below-average, and above-average output); the price per ton of grain will rise from \$165 per ton in 1979 to \$238 in 1984.⁵⁴ Dollar prices are converted into rubles at the rate of 1 ruble for \$1.11; this is the conversion rate for the ruble price data in the equation.

Table 8—Estimated grain imports calculated from an import demand equation, 1981-85

Grain Output	1981	1982	1983	1984	1985	Annual Average
	(million metric tons)					
Average	9.34	8.73	8.11	7.43	6.66	8.05
Below average	10.66	10.05	9.42	8.73	7.97	9.37
Above average	7.25	6.64	6.01	5.32	4.52	5.95

Notes: The figures for this table are derived using equation (6). The output figures used are from Table 2. Ten percent is subtracted from the output of average years to allow for waste, 5 percent is subtracted from the output of below-average years, and 12.5 percent is subtracted from the output of above-average years. It was assumed that the price of grain will increase from 149 rubles (\$165) per ton in 1979 to 214 rubles (\$238) per ton in 1984.

⁵⁴ See Daniel L. Bond and Herbert S. Levine, "Energy and Grain in Soviet Hard Currency Trade," in U.S. Congress, Joint Economic Committee, *Soviet Economy in a Time of Change*, 2 vols. (Washington, D.C.: U.S. Government Printing Office, 1979), 2:264. According to the latest reports available at the time of writing, the December 1980 delivery price of wheat on the Chicago Board of Trade was \$198.5 per ton, and of corn, \$148.5 per ton. See the *Wall Street Journal* October 29, 1980, p. 44.

The import estimates of Table 8 corresponding to the three categories of outputs make it possible to calculate grain imports between 1981 and 1985, assuming three average years, one above-average year, and one below-average year. Two adjustments are made to the resulting total of 39.5 million tons. As noted earlier, the impact on output of below-average weather is 14.6 million tons greater than the impact of above-average weather. When multiplied by the coefficient of 0.18 (for $[Q_G]_{t-1}$), an additional 2.7 million tons of grain must be imported in a below-average year. This adjustment raises the estimated total to 42.2 million tons.

Furthermore, it must be emphasized that the grain import estimates of Table 8 are derived from import data taken from Soviet sources. These are for calendar years, whereas the import estimates of Table 1, from USDA sources, are for a consumption year lasting from July 1 to June 30. If imports increase steadily, the USDA figures will be consistently higher than the corresponding import figures in Table 8, because the USDA consumption year ends six months after the calendar year used to calculate the figures in Table 8. In fact, Soviet imports in official sources fluctuated between 1950 and 1976 with a rising trend. They can therefore be expected to be generally lower than the USDA estimates, as they are for the majority of the observations. For the recent period between 1971 and 1975, the USDA overestimated imports by an average of 23 percent per year. Adjusting for this increases the estimated total of imports to 51.9 million tons.

Finally, the assumed requirement that

grain reserves be augmented by 25 million tons between 1981/82 and 1985/86 raises estimated grain imports to 76.9 million tons, or an average 15.4 million tons each year. It should be noted that, because these import estimates are on a gross basis, the export commitment of 10 million tons does not need to be added.

Import Estimates from the Three Methods

The three sets of import estimates are summarized in Table 9. They indicate that grain imports will be between 15.4 and 17.7 million tons each year between 1981/82 and 1985/86. Grain imports in 1980/81 were already estimated to be 30 million tons.

How do these import projections compare with actual Soviet imports since 1971/72, when the Soviets decided to maintain their livestock inventory at a specified level? If it is assumed that actual Soviet grain imports during 1979/80, following the latest estimate of the USDA, will be 28 million tons, the grain imports between 1971/72 and 1979/80 averaged 16.4 million tons. In contrast, projected imports between 1980/81 and 1985/86 will be about 18-20 million tons each year if 30 million tons are imported during 1980/81 and 15.4-17.7 million tons are imported annually during the rest of the period. It seems that annual Soviet grain imports in the six years beginning July 1, 1980 will be higher than comparable recent imports by between 2 and 4 million tons.⁵⁵

⁵⁵ If the Soviet Union can actually import 25 million tons of grain during 1980/81, then annual Soviet grain imports in the six years that began July 1, 1980, which will average between 16.2 and 18.8 million tons, will be greater than average imports in the current period by -0.2 to 2.4 million tons.

Table 9—Average annual grain imports, 1981/82-1985/86

Assumptions	Difference Between Supplies and Requirements		Import Demand Equation ^c
	Output Predicted From Past Trend ^a	Output Predicted From Production Function ^b	
	(million metric tons)		
Above-average weather with no additions to stocks and no export commitments	+2.9	-5.2	-7.3
Average weather with no additions to stocks and no export commitments	-8.6	-8.0	-9.9
Below-average weather with no additions to stocks and no export commitments	-30.4	-12.6	-14.8
Three years of average weather, one of above-average weather, and one of below-average weather, with 5 million tons added to stocks annually and 2 million tons exported annually	-17.7	-15.4	-15.4

Notes: Positive numbers represent exports; negative numbers represent imports.

The bottom figure in the column with output predicted from past trend requires that the difference between grain output and use, that is, the surplus, in a year with above-average weather be exactly 2.9 million tons (see Table 4). Similarly, the bottom figure in the column containing the results of the import demand equation requires that the average deficit in an above-average year be exactly 5.95 million tons (Table 8). As explained in the note below, this estimate of 5.95 million tons has to be adjusted upward by 23 percent because the Soviet official grain import data used in the import demand equation tend to understate imports in relation to the USDA grain import estimates.

The difference between the import estimates of the calendar year used by Soviet sources and the consumption year used by the USDA make it necessary to increase the original import demand equation results by 23 percent, the average amount by which the USDA overestimates Soviet imports between 1971 and 1975. These results, which are based on data from Soviet sources, can then be compared with the other two sets of figures, which are based on data from the USDA. As the import estimates of the import demand equation are gross figures rather than net, the export commitment of 10 million tons does not need to be added to get the figure of 15.4 million tons of imports in the bottom row of the column.

The estimates for the years with below-average weather in the bottom two rows of the table allow for the asymmetrical effect that bad weather has on grain output. In getting the differences between supplies and requirements, 14.6 million tons were subtracted from the output figures of below-average years predicted from the lower estimates of the 60 percent confidence interval around the trend of equation (1); for the results of the import demand equation, 2.7 million tons are added to the import figures for below-average years. This asymmetrical effect of weather was accounted for directly in the production functions through the estimated weather parameters.

^a These estimates are derived from the figures in Table 4. The estimate for the below-average year includes also an import figure of 14.6 million tons attributable to weather asymmetry.

^b These estimates are derived from the figures in Table 7.

^c These estimates are derived from the figures in Table 8.

6

THE HARD CURRENCY COSTS OF GRAIN IMPORTS AND THE FUTURE ROLE OF THE U.S.-U.S.S.R. GRAIN AGREEMENT

Soviet sources indicate that the highest price the Soviet Union paid for grain was \$138 per ton in 1975. According to the World Bank report cited earlier, the price of grain per ton is expected to rise from \$165 in 1979 to \$274 in 1985. Even at the lower price of \$165 per ton, importing 18-20 million tons of grain will cost the Soviet planners \$3.0-\$3.3 billion each year. An average price of \$220 per ton would push the hard currency cost to \$4.0-\$4.4 billion annually. As the world grain market is likely to have excess demand, the latter estimate seems to be more realistic.⁵⁶

Can the Soviet Union afford to spend that much hard currency? In 1978, the Soviet debt service burden was estimated to be 24 percent of the value of its hard currency merchandise exports.⁵⁷ If Soviet hard currency export earnings are assumed to increase annually at the rate of 15 percent in 1979 and 1980 and if this rate slows 1 percent annually to 10 percent in 1985,⁵⁸

then the annual grain import cost of \$4.0-\$4.4 billion will be 20-22 percent of the projected hard currency merchandise earnings in 1981, and 13-14 percent of these earnings in 1985. The amortization of debt can also be expected to increase from about 27 percent of these earnings in 1981 to 31 percent in 1985, leaving the Soviet Union with 51-56 percent of its hard currency export trade for machinery imports from the West. Considering that the hard currency earnings do not include receipts from sales of arms and nonmonetary gold or from transport and tourism, the grain import bill estimated above seems to be manageable.

Potential Exportable Surplus of Grain During 1980/81 and Soviet Share

The 30 million tons of grain the Soviet

⁵⁶ The excess demand from the developing countries is for wheat, whereas the Soviet demand is for feedgrains, including corn. The Soviet Union has imported large quantities of wheat, and will probably continue to (see footnote 36). It uses the imported wheat to feed people and to allow domestic low-grade wheat to be used as cattle feed. Since a ton of imported wheat costs much more than a ton of imported corn (65 percent more on a delivered-Gulf basis toward the end of 1979, according to Morton I. Sosland, "U.S.-U.S.S.R. Agreement on Grains," a paper presented at the Corporate Sponsor Seminar, Russian Research Center, Harvard University, Cambridge, Mass., November 1979, p. 6), the Soviets would like to import more corn (as they have) and to produce more of the superior variety of wheat domestically.

The latest reports available at the time of writing indicate that corn and wheat prices hit "six-year highs" after the Soviet announcement in November 1980 of their poor grain crop (181 million tons) and indications from shipping markets that the Soviets chartered grain carriers in the last two weeks of October 1980, paying 10 to 15 percent more than market rates. See the *Wall Street Journal* October 29, 1980, p. 44.

⁵⁷ See Paul G. Ericson and Ronald S. Miller, "Soviet Foreign Economic Behavior: A Balance of Payments Perspective," in U.S. Congress, Joint Economic Committee, *Soviet Economy in a Time of Change*, 2 vols. (Washington, D.C.: U.S. Government Printing Office, 1979), 2: 225.

⁵⁸ The average of the annual growth rates of hard-currency export earnings between 1971 and 1978 was 26.8 percent (see *ibid.*, p. 212). This includes the massive spurts of 1973, 71 percent, and 1974, 56 percent (earnings from oil exports increased 124 percent in 1973 and 104 percent in 1974). The doubts being expressed about the ability of the Soviet Union to maintain current levels of oil production make it clear that earnings from hard-currency sales will not increase dramatically again. The latest pronouncement of the CIA on this matter is that the Soviet Union will become a net importer of oil in 1981 (*New York Times*, April 23, 1980, p. D2).

The growth rates for hard-currency exports adopted here are not based on a detailed investigation of the likely pattern of Soviet oil exports; rather they are based on estimates of Soviet hard-currency export earnings in the recent period and incorporate the assumption that the growth of export earnings will gradually decline. It has been assumed implicitly that the terms of trade will remain as they were in 1978.

It is also assumed that the ratio of Soviet hard-currency debt repayment to hard-currency export earnings will steadily rise 1 percent annually from 24 percent in 1978 to 31 percent in 1985.

Union needs to import in 1980/81 will have an important effect on foreign exchange costs. If the Soviet Union actually imports less grain, the foreign exchange burden will be lower. Preliminary estimates of 1980 grain harvests in the grain-exporting countries, among them the United States, Canada, Australia, Argentina, and Western Europe, indicate that the prospects of raising 30 million tons of grain from all available sources are not good.

Thus, according to preliminary estimates, total world grain production during the 1980/81 crop year is expected to be virtually the same as last year.⁵⁹ The record American wheat crop, supplemented by increased wheat production in Canada and Western Europe, will be balanced by poor wheat crops in Australia and Argentina and by much smaller harvests of other grains in the United States.⁶⁰

If world grain production is about the same, the world can consume more only by drawing grain out of reserves, with the grain surplus countries exporting grain to the deficit countries. Among the latter, the Soviet Union and Japan will need to import feedgrains; China and several countries of North Africa, East Asia, and Eastern Europe will need to import mostly wheat. According to the USDA, by June 1981, when new wheat harvests begin, the global imbalance will be most acute when world grain reserves are estimated at 155.2 million tons. This represents 35 days' grain supplies—less than the 40 days' supplies available at the worst point in the mid-1970s.

The United States can increase exports of wheat and rice without diverting them from regular customers but cannot do the same with corn and soybeans.⁶¹ It can be

assumed that U.S. exports of grain to the Soviet Union during 1980/81 will be the 8 million tons permitted without consultations by the U.S.-U.S.S.R. Grain Agreement. Furthermore, Canada is expected to export 5.3 million tons of grain to the Soviet Union during the crop year.⁶² Australia, traditionally an exporter of wheat to the Soviet Union and the Middle East, may export no more than 9 million tons, of which 5 million tons will probably be shipped to the Soviet Union.⁶³ These, Western Europe's 5 million tons, and another 2 million tons from other sources such as Argentina, mean that total grain imports by the Soviet Union could reach 25 million tons during 1980/81. Given acute global shortages, this would be a lion's share of potential world exports in the coming months when competition for limited supplies of wheat, corn, and soybeans will be fierce. Indeed with world grain consumption rising faster than production, and with grain reserves steadily dwindling, the Soviet need to import about 30 million tons in a below-average year may cause problems in the future.⁶⁴

U.S.-U.S.S.R. Grain Agreement

However, will the Soviet policymakers want to renew the U.S.-U.S.S.R. Grain Agreement which will expire in October 1981? The agreement stipulates that for the five years beginning October 1, 1976, the Soviet Union shall purchase from the United States at least 6 million tons of wheat and corn in equal amounts for shipment each year, that it may buy another 2 million tons, up to 8 million tons, without consultations unless there is a serious shortfall in the U.S. grain crop,⁶⁵ and that the U.S. government will be

⁵⁹ The crop year is analogous to U.S.A.'s consumption year.

⁶⁰ The latest available estimates of U.S. grain production in 1980 are: wheat, 64.3 million tons (31 percent more than in 1979 despite the summer drought); corn, 164 million tons (17 percent less than in 1979), and soybeans, 48.3 million tons (22 percent less than last year's record). For details, see the *New York Times*, November 3, 1980, pp. A1 and D8; November 11, 1980, p. D18; and November 24, 1980, p. D7.

⁶¹ *New York Times*, November 11, 1980, p. D18.

⁶² *Wall Street Journal*, November 20, 1980, p. 46.

⁶³ *New York Times*, November 3, 1980, p. 18.

⁶⁴ Indeed, this might make a shift in Soviet strategy necessary. Soviet planners may decide to import fewer feedgrains and to intensify measures to develop domestic sources of alternative feeds such as roughages. They might also import meat. For example, it was reported that the Soviet Union signed an agreement with Brazil in November 1980 to import 50,000 tons of chicken broilers—the first such contract with Brazil.

⁶⁵ A "serious shortfall" in U.S. output of wheat and corn is production of less than 225 million tons in any one year. Considering how much grain the United States has produced in the past five years, this constraint is not really binding.

consulted before the U.S.S.R. can buy more than 8 million tons for delivery in any year.

If the agreement is assessed objectively, it is a commercial transaction advantageous to both sides. It guarantees a buyer for corn and wheat to American farmers and assures supplies to the Soviet Union. Its provisions are designed to help stabilize prices for the American farmer and consumer and for the Soviet purchaser.

As a mutually advantageous economic and commercial proposition, the chances of the agreement being renewed are good. Of course, the exact configuration of political and military considerations that will contribute to its renewal are not known, nor is the timing of its renewal. It is important to note that until the embargo, in each year of the agreement the Soviet Union asked for and was authorized to buy much more than 8 million tons of grain.⁶⁶ Also, the estimated 18-20 million tons of imports required by

the Soviet Union between 1980/81 and 1985/86 are much higher than the minimum purchase of 6 million tons stipulated in the agreement.

Taking all these considerations into account, it might be expected that the minimum grain purchase required by the Soviet Union in the renewed agreement would be increased, perhaps to 8 or 10 million tons.⁶⁷ If the Soviet negotiators view the acceptance of a higher minimum level as a concession to American farm interests, they could try to extract a reverse concession by being allowed to buy more corn, which they need, and less wheat, which has a higher return for the U.S. farmers.⁶⁸ These estimates of the minimum grain purchases can be expected to be incorporated in the renewed agreement if the negotiations of the next U.S.-U.S.S.R. grain agreement were to be motivated strictly by pragmatic economic considerations.

⁶⁶ These details are in Sosland, "U.S.-U.S.S.R. Agreement," p. 5. For the 1979/80 year of the agreement, the Soviet Union was authorized to purchase up to 25 million tons at first. The embargo later imposed did not apply to the 8 million tons that could be purchased without prior consultation.

⁶⁷ An increase of the minimum would imply that the Soviet Union would carry forward unused grain stocks and bear the costs of holding them. Both of these implications are desirable from the perspective of the grain-deficit developing countries because larger Soviet grain reserves, given everything else, would make it less likely that the Soviets would wreak havoc in the world grain market when their harvests failed.

⁶⁸ In Sosland, "U.S.-U.S.S.R. Agreement," p. 5, an upper limit of 15 million tons on the amount the Soviets could buy without prior consultations is suggested.

7

CONCLUSIONS

The estimates of Soviet imports made in this paper (summarized in Table 9) indicate that the Soviet Union will import an average of between 15 and 18 million tons of grain each year between 1981/82 and 1985/86. Grain imports in 1980/81 were estimated to be 30 million tons. It can therefore be predicted that average annual grain imports for the Soviet Union between 1980/81 and 1985/86 will be between 18 and 20 million tons. This is between 2 and 4 million tons above the 16.4 million tons the Soviet Union imported each year between 1971/72 and 1979/80 (assuming that Soviet grain imports in 1979/80 were 28 million tons).

The Soviet Union can afford to import the amounts of grain estimated in this paper. At the average price suggested in a World Bank report—\$220 per ton—such grain imports would cost \$4.0-\$4.4 billion. Even if Soviet hard currency merchandise export earnings increase only 10 percent in

1985 (they increased 16 percent in 1978) and debt payments take up 31 percent of those earnings (they took up only 24 percent in 1978), Soviet planners will still be able to allocate between 51 and 56 percent of these hard currency earnings to imports of machinery from the West.

Soviet grain imports in the early 1980s need not disrupt world grain trade, even if they do reach the 30 million tons estimated for a below-average year. But they must be planned for.

If they are not, and if a bad harvest in the Soviet Union occurs at the same time as bad harvests in grain-exporting countries, then world grain prices may become unstable and developing countries that import grain may be unable to get the grain they need. International buffer stocks should be created to guard against this prospect. If they are created, the world should take Soviet grain needs into account.

APPENDIX 1

THE METHOD OF BOND AND LEVINE

Bond and Levine recently estimated Soviet grain imports during 1979-90 by formulating the question: "...what might be the pattern of Soviet grain imports if the Soviet leaders wished to avoid the sharp pitfalls in meat production by bringing (through imports) domestic grain availability up to the level of projected normal grain output (which most likely approximates the Soviet plan since it incorporates not only the expectation of normal weather, but also a projection of past input and output relationships)?"⁶⁹

Bond and Levine projected normal output using Green's normal output series for 1956-75.⁷⁰ Green removed the years with bumper harvests or harvest failures from the series and interpolated the missing observations. He then regressed this series on employment, area, and capital and current purchases from other sectors. The predicted values from the estimated relationship were accepted by Bond and Levine as projected normal outputs.⁷¹ One problem of estimating normal output in this way arises because the actual inputs used in the estimation cannot be regarded as normal (or peak capacity) inputs since, in reality, they must involve adjustments to good and bad weather.

To project actual outputs, Green regresses the proportional deviation of actual output from estimated normal output on the weather variables.⁷² Bond and Levine use these regressions to predict future output, assuming that spring and autumn precipitation during 1979-90 will be identical to the pattern of 1962-68. They extend this pattern from 1979 to 1985 and then start again in

1986 with the 1962 weather variables.⁷³ And finally, a possible pattern of grain imports for 1979-90 is calculated as the difference between normal and actual grain outputs.

The second question is how do the normal outputs defined and projected by Bond and Levine correspond to Soviet output targets? Commenting on the methodology used to derive normal outputs, Green states: "It is 'normal' in the Soviet sense of an above-average standard of performance. This measure of normal output thus incorporates information from output growth (mediocre to good harvests) and the growth pattern of productive inputs."⁷⁴ However, whereas the normal outputs thus predicted by Bond and Levine increase from 242 million tons in 1981 to 263 million tons in 1985,⁷⁵ with an average of 252.4 million tons, the preliminary Soviet goal for the Eleventh Five-Year Plan (1981-85) is 238-243 million tons. It seems that the normal outputs derived by Green, Bond, and Levine are high compared to the Soviet targets. By contrast, the average estimates in Table 2, which are derived by a linear trend of all observations, give a lower average for 1981-85 of 234.3 million tons. As argued in Chapter 3, the average impact of adverse weather on grain output is greater than the impact of favorable weather. This means that the figures for normal output derived by eliminating both these sets of observations are biased upward in relation to the average derived by estimating a trend line through all the observations. In any case, the upward bias is large even in relation to the Soviet output targets.

⁶⁹ Bond and Levine, "Energy and Grain in Trade," 2:261-262.

⁷⁰ Donald W. Green, "Soviet Agriculture: An Econometric Analysis of Technology and Behavior," in U.S. Congress, Joint Economic Committee, *Soviet Economy in a Time of Change* 2 vols (Washington, D.C.: U.S. Government Printing Office, 1979), 2:119-122.

⁷¹ Bond and Levine, "Energy and Grain in Trade," 2:264.

⁷² Green, "Soviet Agriculture: Econometric Analysis," 2:119.

⁷³ Bond and Levine, "Energy and Grain in Trade," 2:264.

⁷⁴ Green, "Soviet Agriculture: Econometric Analysis," 2:119.

⁷⁵ Bond and Levine, "Energy and Grain in Trade," 2:264.

The next question is how much meat production can be supported if grain availability is equal to normal production? Suppose, as Bond and Levine do, that Soviet planners, given the actual grain output of 198 million tons in 1980 estimated by Bond and Levine, raised 1980 availability to 236 million tons. Then, applying a seed-use figure of 30.3 million tons (Table 2), a human and industrial consumption total of 50 million tons, and a waste discount of 5 percent to the actual output of 1980—a year in which the weather was worse than normal—an estimate is produced of 145.8 million tons in 1980 for feedgrain use. Note that Bond and Levine assume that about 80 percent of the deficits would be covered by imports,⁷⁶ thus implying that the Soviets can run down stocks to fill in the deficits. This being so, the question of imports contributing to grain reserves does not even arise. Nor is there any indication of possible grain exports by the Soviet Union in 1979/80; therefore it can be assumed that, of the 236

million tons available in 1980, the surplus remaining after seed, industrial and human consumption, and the waste discount (the latter applicable to actual domestic output) are provided for is available as feedgrains.

If it is further assumed, as argued in Table 3, that the feedgrain provision of 126.5 million tons in 1980 will support the Soviet target for meat output of 15.7 million tons in 1980 (along with the other specified targets of dairy products), then an additional 19.3 million tons of feedgrains are available in 1980. With a norm of 3.6 kilograms of feedgrains resulting in 1 kilogram of meat (Table 3), an extra 5.4 million tons of meat appear in 1980. This is 34 percent of the 1930 Soviet meat target of 15.7 million tons. Such a sharp, sudden spurt in meat output, which the Bond-Levine methodology of estimating Soviet grain imports implies, does not seem meaningful as the Soviet Union would be unable to store and distribute the extra meat efficiently.

⁷⁶ *ibid.*

APPENDIX 2

SUPPLEMENTARY TABLES

Table 10—Estimates of total agricultural output, 1950-75

Year	Western Estimates		Estimates Derived From Soviet Sources
	Gross	Net	
	(billion 1968 rubles)		(million metric tons)
1950	40.002	36.065	246.518
1951	37.667	34.057	217.386
1952	39.880	35.764	241.514
1953	41.934	37.586	239.762
1954	43.204	39.045	244.304
1955	48.698	44.096	279.234
1956	54.766	49.159	333.634
1957	56.412	50.561	315.965
1958	60.028	54.263	367.895
1959	59.623	53.355	345.188
1960	59.256	53.793	365.149
1961	63.617	57.835	365.146
1962	62.728	56.553	358.258
1963	55.434	50.047	321.810
1964	65.628	59.580	431.495
1965	69.370	61.519	395.847
1966	74.164	66.815	452.405
1967	74.833	66.393	457.724
1968	78.290	69.794	494.310
1969	76.522	67.426	452.393
1970	85.017	75.875	495.143
1971	85.488	75.892	479.555
1972	81.624	71.371	455.460
1973	93.409	82.028	564.142
1974	92.234	80.979	504.912
1975	86.264	74.153	441.272

Sources: The Western estimates of total agricultural output are from Douglas F. Whitehouse and Joseph P. Havelka, "Comparison of Farm Output in the U.S. and U.S.S.R., 1950-71," in U.S. Congress, Joint Economic Committee, *Soviet Economic Prospects for the Seventies* (Washington, D.C.: U.S. Government Printing Office, 1973), pp. 368-371; and David W. Carey, "Soviet Agriculture: Recent Performance and Future Plans" in U.S. Congress, Joint Economic Committee, *Soviet Economy in a New Perspective* (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 597-599. The estimates of agricultural production in tons are put together from Soyuz Sovetskikh Sotsialisticheskikh Respublik, Tsentral'noe Statisticheskoe Upravleniye pri Sovete Ministrov, *Narodnoe khozyaistvo SSSR v 1975 godu* (Moskva: Statistika, 1976), pp. 310-311.

Notes: The Western estimates of gross output include all crops produced and gross production of livestock other than draft animals. The estimates include seed and feedgrains but not moisture, trash, and waste (that is, grain lost between the farm and the storage facilities). The Western net estimates exclude feedgrains as well.

The estimates of agricultural output in tons include grain, raw cotton, sugar beets, sunflower seeds, flax, potatoes and vegetables, meat, milk, eggs, and wool. Eggs are converted into tons using a rate of 18,182 eggs to one metric ton (U.S. Department of Agriculture, Economic Research Service, *USSR Agricultural Situation: Review of 1974 and Outlook for 1975*, Foreign Agricultural Economic Report No. 102 [Washington, D.C.: U.S.D.A., 1975] p. 31).

The Whitehouse-Havelka estimates in 1968 prices are available up to 1971. The remaining estimates, for 1972-75, are derived by multiplying Carey's gross and net agricultural output estimates, which are in 1970 prices, by 0.92. The Whitehouse-Havelka output estimates for 1960-71, both gross and net, are approximately 92 percent of the corresponding Carey estimates, so 0.92 seems to be the ratio between the two sets of output estimates.

Table 11—Estimates of inputs into Soviet agricultural production, 1950-75

Year	Weather		Capital Stock	Labor	Current Inputs	Area Sown
	Above Average	Below Average				
			(billion rubles)	(billion man-hours)	(billion rubles)	(million hectares)
1950			21.226	77.017	1.60	146.300
1951			21.573	73.483	1.76	153.000
1952			21.926	71.537	1.79	155.700
1953			22.279	72.800	2.21	157.200
1954			23.027	77.676	2.32	166.100
1955			27.412	78.649	2.45	185.800
1956			31.798	80.480	2.54	194.700
1957			32.131	79.654	2.72	193.700
1958			36.570	79.472	2.96	195.600
1959			41.010	75.899	3.10	196.300
1960		I	42.127	73.558	3.59	203.000
1961			46.136	71.155	3.90	204.600
1962		I	48.000	70.637	4.27	216.000
1963		I	52.740	68.635	4.46	218.500
1964			57.000	68.817	4.92	212.800
1965			61.728	70.483	5.57	209.100
1966			66.000	79.658	6.01	206.800
1967			71.985	69.377	6.47	206.900
1968			76.060	68.180	6.83	207.000
1969	I		80.813	66.269	7.14	208.600
1970	I		84.888	66.829	7.51	206.700
1971	I		91.000	66.934	7.96	207.300
1972			98.000	66.682	8.44	210.700
1973	I		108.248	67.151	8.87	215.000
1974	I		119.778	67.606	9.30	216.500
1975		I	131.947	67.606	9.73	217.700

Sources: The information on weather is from U.S. Central Intelligence Agency, *USSR: The Impact of Recent Climate Change on Grain Production*, ER76-10577 U (Washington, D.C.: CIA, 1976), p. 90.

The estimates of capital stock are from Soyuz Sovetskikh Sotsialisticheskikh Respublik, Tsentral'noe Statisticheskoe Upravleniye pri Sovete Ministrov (TsSU), *Narodnoe khozyaistvo SSSR 1956-75* (Moskva: Statistika, 1957-76). The estimates of labor are from Murray Feshbach and Stephen Rapawy, "Soviet Population and Manpower Trends and Policies," in U.S. Congress, Joint Economic Committee, *Soviet Economy in a New Perspective* (Washington, D.C.: U.S. Government Printing Office, 1976), p. 138.

Estimates of current inputs are from Douglas B. Diamond, "Trends in Output, Inputs and Factor Productivity in Soviet Agriculture," in U.S. Congress, Joint Economic Committee, *New Directions in the Soviet Economy* (Washington, D.C.: U.S. Government Printing Office, 1966), p. 373; and Douglas B. Diamond and Constance B. Krueger, "Recent Developments in Output and Productivity in Soviet Agriculture," in U.S. Congress, Joint Economic Committee, *Soviet Economic Prospects for the Seventies* (Washington, D.C.: U.S. Government Printing Office, 1973), p. 332.

The 1950 and 1960-70 estimates of area sown are from TsSU, *Sel'skoe khozyaistvo SSSR 1971* (Moskva: Gosstatizdat TsSU SSSR, 1972), pp. 108-109 and 357. The 1951-59 estimates are from TsSU, *Sel'skoe khozyaistvo SSSR 1960* (Moskva: Gosstatizdat TsSU SSSR, 1961), p. 127, and the 1971-75 estimates are from TsSU, *Narodnoe khozyaistvo SSSR v 1975 godu* (Moskva: Statistika, 1976), p. 347.

Notes: Weather for 1960-75 is classified as above average, below average, or average. Average years are given dummy variables of 0. Above average and below average years are given dummy variables of 1. Approximately 25 percent of the years are defined as above average, and 25 percent are defined as below average on the basis of the number of regions that can be classified as steppe and desert in each year. The remaining years, approximately 50 percent, are classified as average. For lack of information, all years before 1960 are treated as average. Capital stock estimates as of January 1 of each year include machinery, "productive" buildings and other structures, land improvements such as irrigation and drainage, and, finally, livestock. These are all undepreciated, do not include retirements, and are said to have been estimated in "comparable prices." The missing estimate of January 1, 1950 is derived from the 1.6 percent growth rate of 1951-52 and the estimate of 1951.

(continued)

Table 11—Continued

Current inputs include purchases from other sectors of "(1) fuels and lubricants, (2) current repairs of machinery and buildings including repair activity carried out by the farms on their own account, (3) use of electric power for productive purposes, (4) deliveries of fertilizer, and (5) production of processed feeds (mill feed, oil cake) by industry." For details see Diamond, "Trends in Output," pp. 375-376.

In the original sources, current input purchases for 1950-64 are estimated in 1959 prices and the purchases for 1960-72 are estimated in 1966 prices. We have linked the series and expressed the purchases in 1966 prices. The estimates of current inputs for 1973-75 are predicted from the linear trend of current input use from 1950 to 1972.

The area sown is the "productive" sown area in the spring. It excludes the winter kill of the previous year's winter plantings and includes spring sowing.

Table 12—Soviet grain import data, 1950-75

Year	Imports	Domestic Grain Production	Price of Imports	Domestic Meat Production
	(million metric tons)	(million metric tons)	(rubles per metric ton)	(million metric tons)
1949	0.248	n.a.	114.113	3.8
1950	0.254	81.2	82.677	4.9
1951	0.347	78.7	84.730	4.7
1952	0.392	92.2	98.470	5.2
1953	0.311	82.5	115.434	5.8
1954	0.535	85.6	95.888	6.3
1955	0.855	93.3	96.608	6.3
1956	1.186	112.5	90.219	6.6
1957	0.578	92.3	91.176	7.4
1958	1.314	121.2	80.746	7.7
1959	0.984	107.5	95.732	8.9
1960	0.771	112.9	98.314	8.7
1961	0.727	117.7	63.274	8.7
1962	0.411	126.9	111.436	9.5
1963	3.650	96.7	65.123	10.2
1964	8.873	135.0	63.473	8.3
1965	6.981	109.0	59.089	10.0
1966	8.431	157.0	60.788	10.7
1967	2.847	136.0	75.413	11.5
1968	2.195	153.0	75.800	11.6
1969	1.239	139.0	85.918	11.8
1970	2.846	165.0	65.731	12.3
1971	4.182	168.0	61.542	13.3
1972	16.123	153.0	48.890	13.6
1973	24.437	189.0	48.839	13.5
1974	7.720	172.0	81.253	14.6
1975	16.611	126.0	124.167	15.0

Sources: The data for imports and their prices are from successive volumes of Soyuz Sovetskikh Sotsialisticheskikh Respublik, Ministerstvo Vneshnei Torgovli, *Vneshnyaya torgovlya SSSR, statisticheskii obzor*, 1970-74 (Moskva: Vneshtorgizdat, 1971-75).

The data for domestic grain production from 1955 to 1975 are derived by subtracting the figures for dockage waste in Table 1 from the figures for domestic grain production in that table. The data for 1950-54 are from Soyuz Sovetskikh Sotsialisticheskikh Respublik, Tsentral'noe Statisticheskoe Upravleniye pri Sovete Ministrov (USSR), *Narodnoe khozyaistvo SSSR v 1975 godu* (Moskva: Statistika, 1976), p. 310. They were not adjusted for the waste discount because the required information is not available from the USDA.

The data for meat production are also from USSR, *Narodnoe khozyaistvo v 1975 godu*, pp. 310-311.

Notes: Imports of grain include imports of wheat flour. The wheat flour figures are converted into grain figures using an assumed milling rate of 80 percent.

The price per metric ton of imported grain is derived by dividing the ruble value of imports by their physical volume. It represents the f.o.b. price of grain paid by the Soviet Union.

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Padma Desai is a professor in the Economics Department and the Russian Institute of Columbia University. Formerly she was a research associate at the Russian Research Center of Harvard University.

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