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POLICY MODELING OF A DUAL GRAIN MARKET: THE CASE OF WHEAT IN INDIA

Raj Krishna
Ajay Chhibber

May 1983

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FOREWORD

Many developing countries are under strong political and humanitarian pressure to keep food prices—at least those faced by low-income consumers—low. At the same time pressure to provide remunerative prices to agricultural producers frequently increases, and such prices may be essential if agricultural output is to grow enough to meet domestic food, employment, and development needs. This often results in complex systems of consumer price subsidies and producer levies. Consequently, difficult decisions need to be made in setting fiscal and monetary policy and in making the system a country chooses cost effective.

The International Food Policy Research Institute has been pursuing a multipronged approach to these increasingly important and complex problems. Several studies have examined the efficiency of food subsidy schemes. The effects of food aid, multilateral financing of food imports, and other food stabilization efforts by the donor community are under study. The ways new technology affects fluctuations in food availability have been studied intensively, as have a wide range of crop and food supply insurance schemes. Several IFPRI studies have examined a wide range of price effects on food availability.

This report by Raj Krishna and Ajay Chhibber applies economic modeling to increase the efficiency of policies in such diverse but interrelated areas in the operation of a public grain distribution system as stocking, purchasing, pricing, and trade. India, a large country with a long history of operating a public distribution system, is ideal for developing such a model. Raj Krishna brings to this study his long experience with and well-developed convictions about food policy. He is the author of an early study of the response of farmers in developing countries to relative price changes, and he has served as a member of the Indian Planning Commission and of the Indian Agricultural Prices Commission. In the latter position he took firm public stands on a number of controversial issues. For example, he was an opponent of the zoning systems used to facilitate large purchases of grain in parts of the country producing surpluses for distribution to low-income people. These and similar positions form an important part of the background for this report and its stated assumptions.

Other researchers will undoubtedly examine the same problems as Raj Krishna and Ajay Chhibber. Some will assume that economic development in India will proceed at a rate somewhat more in keeping with its current stage of development than the historical rate assumed in this report. Some may want to use more nearly pure income and price elasticities rather than, as in this analysis, higher ones that include the effects of changes in taste. The framework provided can accommodate such approaches.

In its practical conclusions, the study is particularly useful in pointing to analytical approaches that reduce the size of carryover food stocks while meeting consumption stabilization objectives. Current extraordinarily high real interest rates and the generally high costs of holding stocks make such economies urgent. The savings shown by the authors are high, and they come in part from reduction in stocks, which were very large in the recent past. These stocks were accumulated through producer incentives, which were probably too high, but which were difficult to reduce until complex and time-consuming political processes were begun. Researchers will benefit immeasurably from the clear statement of the problem of operating a public distribution system, the display of the authors' assumptions for their model, and the careful development of a relevant model.

John W. Mellor

Washington, D.C.
May 1983

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1

SUMMARY

In many developing countries the government has divided the grain market into two sectors: an open market and a government-run, concessional food supply system. The concessional system is a necessity where mass poverty exists; it makes it possible to provide a minimum food supply to the poor. In operating this system the policymakers face the problem of ensuring this supply at the least possible cost to the government.

This paper presents a model that can enable policymakers to solve this problem.

The importance of wheat in India's overall grain supply increased greatly after the "green revolution" began in the late 1960s. The growth rate of wheat production between 1967/68 and 1980/81 was more than double the growth rate of production of all grains. Wheat now makes up more than a quarter of total grain output and over half of the government's grain supply.

This expansion of wheat production brought about drastic changes in government operations. Concessional sales of wheat remained between 4.5 and 8 million tons. But imports became negligible. And stocks, which seldom exceeded 3 million metric tons before 1975, exceeded 10 million between 1977 and 1979. This has raised the annual loss on the government's wheat operation to more than Rs 4 billion.

The model presented here approximates the present Indian wheat system. It has equations for supply, demand, imports, and government purchases and sales estimated with data for 1961-78. It shows that the system is highly sensitive to changes in prices. In fact, the supply of wheat responds to prices more like a commercial than a subsistence crop. The demand for wheat also responds more sensitively to prices than is usual for subsistence crops. Imports, concessional sales, and government purchases of wheat were also found to be sensitive to price movements.

The model shows that the consumption of wheat is also unusually sensitive to changes in income. Wheat consumption per capita has grown faster than per capita income. Wheat is clearly a highly preferred good.

Finally, the model shows that concessional sales are sensitive to changes in total expenditure and that government procurement is highly responsive to output.

The model was used to make projections of output, procurement, concessional sales, imports, stocks, and the open market price of wheat for 14 years, 1979-92. These projections, the "consistent projections," were made assuming that the government and the market interact in the same way during the projection years as in the past. It was also assumed that the irrigation ratio continues to grow. And though the general rate of inflation remains 10 percent, the two administered prices—the procurement price and the issue price—remain constant in real terms.

The projections were made using three scenarios. In the basic scenario, rainfall is normal every year. In the drought scenario, rainfall is 10-20 percent less than normal in 6 of the 14 years. In the drought and exchange shortage scenario, a 10 percent decline in aid utilized is added to the monsoon shortfall. These latter scenarios indicate the impact of the two major external shocks that affect the Indian grain system.

The projections show that the demand for concessional sales will be 8-9 million metric tons each year during the next decade. These sales will maintain per capita average supply at a higher level than in the past, even in drought years. In the projections, the policy variables adjust rationally and flexibly to changes in supply, demand, and foreign-exchange availability. The system also proves to be virtually self-reliant. The reduction in the availability of foreign exchange does not affect either the output or the real price of wheat.

But the current system keeps large stocks; the inventory nearly doubles by the end of the projection period. This raises the cost of the system: the discounted present value of the losses of the system range between Rs 75 billion and Rs 105 billion over the projection period. In order to examine whether this cost can be reduced while consumption grows,

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dynamic programming projections were made with alternative assumptions.

In these projections, concessional sales (issues) and procurement were allowed to be higher than their values in the consistent projections. But imports were not allowed to be greater than in the consistent projections.

Minimum opening stocks were to be either 25 or 50 percent of issues. As opening stocks were 19 percent of issues in 8 years of shortage in the 1960s and 1970s, 48 percent in normal years, and more than 100 percent in the surplus years of 1976-78, the 25 percent figure seems reasonable. The 50 percent figure provides a greater margin of safety.

Simulations were run using the two minimum limits on stocks, in all three scenarios, and both permitting and prohibiting exports. Thus a total of 12 simulations were made.

The simulations show the average per capita concessional consumption in all three scenarios to be greater than in the past. Projected per capita consumption of wheat, including open market and concessional sales, is also 20 percent larger than in the estimation period.

This growth of consumption has two evident causes. First, the steady growth of output makes more wheat available. And, second, the demand for wheat increases faster than income.

In the programming projections, the cost of the system is reduced. The cumulative loss in the basic scenario falls from Rs 105 billion in the consistent projections to Rs 83 billion in the programming projections when exports are not permitted. It falls to Rs 43 billion when exports are allowed and minimum stocks are 50 percent of issues, and to Rs 29 billion—27 percent of the consistent projection figure—when exports are allowed and minimum stocks are 25 percent of issues. These figures are somewhat larger in some of the drought and drought and exchange shortage projections, but they are in most cases nearly half of the cost in the consistent projections.

Stocks would be larger than necessary for the concessional system in some years, according to the programming projections. The excess could be exported, but it would be better to use it for the food-for-work program that would reduce rural unemployment, or for the supplemental nutrition program.

Two conditions are crucial to the success of the operating rules suggested by the simulations. The first is that the proportion of wheat area that is irrigated continues to grow. The second is that real procurement and issue prices are kept stable.

The projections demonstrate that if inventory and trade policies are rationalized, the government can ensure that per capita consumption rises and yet reduce the cost of the system to about a third of what it would be if current policies were continued. This is possible even when rainfall is below normal and foreign exchange availability is reduced.

The kind of model developed in this report can be used each year by governments to find the optimum values for the four main variables involved in government operations: purchases, sales, imports, and stocks. A by-product of simulations of the kind made here is that they indicate the demand a rationally managed wheat system in India will make on world supplies. The model here shows that, if policies are changed, India will need to import over the next decade only between a half million and a million metric tons of grain in some of the normal years and a little more than a million metric tons in drought years.

2

INTRODUCTION

Deliberate segmentation of the grain market by the government into concessional and commercial markets is an important feature of food policy in developing countries. Typically, the government purchases a part of the domestic marketed surplus of grain, monopolizes imports, and channels the resulting supply to the low-income, ration-card-carrying population at a subsidized price. Researchers have modeled dual-market regimes of this kind in order to answer a variety of questions. Scandizzo and Knudsen and Hayami and Subbarao derived theoretical expressions for the net social gain from a regime with two different demand curves.[1] Hayami and Subbarao also measured this gain with the known supply and demand elasticities for India. Scandizzo and Knudsen did the same for Bangladesh, Sri Lanka, Indonesia, and Morocco. World Bank researchers computed the social costs and welfare effects of farm price policies in Argentina, Egypt, Kenya, Pakistan, Portugal, Thailand, and Yugoslavia, several of which have dualistic food regimes.[2] Other researchers quantified the effects of PL 480 food aid, which is usually channeled into a concessional market, on output, prices, and food availability, with parameters derived from their own estimated models.[3]

Since concessional grain imports into India were negligible in the 1970s, measuring their effects is no longer important. Measuring the welfare cost of the two-market regime by the net loss of the sum of producer and consumer surpluses in comparison with a hypothetical equilibrium regime is also unsatisfactory as a guide to policy. The identification of welfare with the sum of areas under demand and supply curves has numerous theoretical difficulties, which researchers recognize but cannot overcome in their empirical work.[4] Moreover, the surplus approach merely generates negative judgments about all interventions, without addressing the many concerns of policy-makers or devising second-best policies.[5] If income cannot be redistributed directly and if the low-income population of a poor country would suffer unacceptable cuts in food consumption at market-clearing prices, a concessional (subsidized) food supply system becomes a necessity. One of the main tasks of an analysis, then, is to identify the policy mix with which the government can make the necessary minimum supply available to low-income consumers at the lowest possible budgetary cost.

In order to address this optimization problem, this report presents an estimated simultaneous-equation model of the wheat sector in India. (Earlier models are reviewed

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[1] Pasquale Scandizzo and Odin K. Knudsen, "The Evaluation of the Benefits of Basic Needs Policies," *American Journal of Agricultural Economics* 62 (February 1980): 46-57; and Yujiro Hayami and K. Subbarao, "Does Price Distortion Necessarily Reduce Social Welfare? The Case of Producer Levy in India," Institute of Economic Growth, Delhi, March 1981. (Mimeographed.)

[2] Pasquale Scandizzo and Colin Bruce, *Methodologies for Measuring Agricultural Price Intervention Effects*, World Bank Staff Working Paper No. 394 (Washington, D.C.: International Bank for Reconstruction and Development, June 1980).

[3] For Brazil, Colombia, and Peru, Lana L. Hall, "Evaluating the Effects of PL480 Imports in Brazil's Grain Sector," *American Journal of Agricultural Economics* 62 (February 1980): 19-28; for Egypt, Grant M. Scobie and Alberto Valdés, "Food Imports, Government Policy and the Balance of Payments—The Case of Wheat in Egypt," International Food Policy Research Institute, Washington, D.C., June 1981 (mimeographed); and for India, David Blandford and Joachim A. von Plocki, "Evaluating the Disincentive Effect of PL480 Food Aid: The Indian Case Reconsidered," Cornell International Agriculture Mimeograph 55, Department of Agricultural Economics, Cornell University, Ithaca, N.Y., July 1977.

[4] Scandizzo and Bruce, *Methodologies for Measuring Price Effects*; J. M. Currie, J. A. Murphy, and A. Schmitz, "The Concept of Economic Surplus and Its Use in Economic Analysis," *Economic Journal* 81 (December 1971): 749-799; and Willard W. Cochrane, "Some Nonconformist Thoughts on Welfare Economics and Commodity Stabilization Policy," *American Journal of Agricultural Economics* 62 (August 1980): 508-511.

[5] Cochrane, "Some Nonconformist Thoughts."

in Appendix I.) The model stresses the dualism of domestic demand and imported supplies, and the interaction of government-determined and market-determined prices and quantities. The reduced form of the model is derived to obtain multipliers that measure the marginal effects of changes in important environmental and policy variables on output, market prices, and government decision variables. "Consistent" projections of endogenous prices and quantities are made for the period 1979-92. And, finally, optimal, least-cost values of government-decision variables are derived for the same 14-year period with a dynamic optimizing model. In this model the sum of the present value of the annual financial loss of the government's wheat operation during the period is minimized subject to inequalities reflecting the concerns of policymakers.[6] Consistent as well as optimal simulations are derived for "normal" years, "drought" years, and years of drought and foreign exchange shortage. They show that the loss can be reduced to a fraction of what it is now with more rational policies, while concessional consumption and inventories remain at satisfactory levels.

[6] The total financial loss to the government from operations with all foodgrains was approximately Rs 7 billion in the single fiscal year 1981-82 (India, Ministry of Finance, *Budget 1982/83 Finance Minister's Speech [Part A]* [New Delhi: Controller of Publications, February 1982], p. 12). This amount alone accounts for about 41 percent of the total budgetary deficit of the central government.

3

THE BACKGROUND OF GOVERNMENT POLICY AND OPERATIONS

A two-market foodgrain regime has existed in India since World War II, though the proportion of the total grain supply handled by the government has varied. Government policies toward purchases, sales, imports, and stocks have also varied from year to year and state to state. The two important administered prices for major grains—the purchase (procurement) price and the issue (concessional wholesale) price—have been announced every year and revised with increasing frequency. And the controls exercised over the movement, storage, and pricing of grain in the open market have oscillated from extreme rigor to almost total deregulation. Several detailed descriptions of these policy shifts are available.[7] Here, it will be enough to provide a few salient facts, pertaining especially to wheat policy, as essential background for the modeling exercises that follow.

The Government's Share of the Grain Supply

The importance of government operations is indicated by the ratio of concessional sales (issues) to the total availability of foodgrains in the country, the latter being defined as net output plus net imports plus the reduction in government stock.[8] (Availability so defined differs from consumption, for availability includes the change in private stocks, for which figures are not available.) Between the early 1950s and late 1970s, total grain availability in India increased 82 percent from 58 to 105 million tons because average gross output itself nearly doubled, increasing from 63 to 120 million tons.[9] Issues through the public distribution system averaged 4.6 million tons in the early 1950s and 11 million tons in the late 1970s, or 8 and 11 percent of availability (Appendix 2, Table 15).[10] Thus the government has been handling only about a tenth of the total supply in recent years. But in the exceptional drought years of the mid-1960s it handled 14 percent.

The Importance of Wheat in Government Operations

The dominance of wheat in the growth of grain production is evidenced by the increase in wheat production from a mere 6.5 to 36.5 million tons (5.8 percent a year), while grain production rose from 51 million tons in 1950/51 to 130 million tons in 1980/81 (only 2.5 percent per year). During the "green revolution" (1967/68-1980/81), the growth rate of foodgrain production (2.4 percent) decelerated from the growth rate achieved between 1949/50 and 1964/65 (2.9 percent). The growth of the production of rice, pulses, and cereals as a whole also slowed down. But the growth rate of wheat production accelerated from 3.9 to 5.5 per-

[7] John Wall, "Foodgrain Management: Pricing, Procurement, Distribution, Import and Storage Policy," in *India Occasional Papers*, World Bank Staff Working Paper No. 279 (Washington, D.C.: International Bank for Reconstruction and Development, May 1978); V. K. Garg, *State in Foodgrain Trade in India* (New Delhi: Vision Books, 1980); Raj Krishna and G. S. Raychaudhuri, *Some Aspects of Wheat and Rice Price Policy in India*, World Bank Staff Working Paper No. 381 (Washington, D.C.: International Bank for Reconstruction and Development, 1980); and R. N. Chopra, *Evolution of Food Policy in India* (Delhi: Macmillan and Co., 1981).

[8] "Availability," "supply," and "absorption" are used synonymously in this report. Net output is gross output minus a 12.5 percent allowance for seed, feed, and wastage.

[9] Throughout this report, "tons" are metric tons.

[10] The public distribution system is the government's concessional sales network. "PDS supplies," "concessional sales," and "issues" are synonymous.

cent.[11] So the share of wheat in total grain output doubled from about an eighth to a fourth. And wheat alone contributed more than half of the total increase in grain output during the time of the green revolution. Thus the green revolution in India has been predominantly a "wheat revolution."

While the share of wheat in the total grain supply increased from 11 to 27 percent, its share in the public-sector supply rose from 43 to 60 percent between the early 1950s and the late 1970s (Appendix 2, Table 16).

Wheat has, in fact, been the mainstay of the public distribution system, constituting, over the last decade, not only 60 percent of concessional sales but more than half of government procurement, and 86-91 percent of grain imports (Appendix 2, Tables 16, 17, and 18). Therefore the importance of modeling and rationalizing Indian wheat policy cannot be overemphasized.

Sources of Supply

The relative contributions of three sources of supply—procurement, imports, and depletion of inventories—to the concessional sales of wheat are brought out in Appendix 2, Table 19. Until 1966, domestic procurement provided, on the average, less than 2 percent and imports almost 100 percent of issues; there was a small increase in the inventory. But within six years of the introduction of the new high-yielding variety (HYV) technology (1967-72), output growth enabled procurement to roughly equal issues. In 1972, imports provided only 5 percent of issues. In the next four years (1973-76), both procurement and imports (mainly commercial, because concessional imports were nearly cut off) formed more than 70 percent of issues; and the government inventory grew to an unprecedented size (12.5 million tons in 1976). In the next two years record harvests reduced imports to less than a half million tons (from the usual 3-7 million tons); and 90-95 percent of government sales came from domestic procurement and inventory depletion. Thus the remarkable growth of wheat output in the last 15 years made a heavily import-dependent public distribution system almost completely self-reliant.

Procurement

As Appendix 2, Table 20 shows, between 1959/60 and 1966/67, the all-India procurement/output ratio (PQR) averaged less than 2 percent, evidently because of the availability of concessional imports. The procurement ratio became significant only in 1967/68 after a record harvest that year and after the big increase in procurement prices in the previous marketing season. This was the first normal season after the introduction of the new HYV technology. In the next four years (1968/69-1971/72), the PQR rose from 14 to 21 percent. Punjab and Haryana farmers sold between one-half and one-third of their wheat crop to the government.[12] In the 1974 marketing season the government introduced the "socialization" of the wheat trade, which meant that market arrivals were purchased solely by state agencies. The PQR remained high in that year (18 percent) but lower than the peak (21 percent) reached earlier. In the 1965 marketing season the procurement price was raised by 38 percent to the high of Rs 105 per quintal (from Rs 76 in the preceding year); yet the PQR suddenly sank to 9 percent. There are two reasons for this decrease: output declined by about 3 million tons and a 50 percent compulsory levy was imposed on traders (in place of monopoly purchase). Since the market price far exceeded the procurement price, and was expected to rise still further, traders preferred to sell in the open market, or hold on to their stocks, rather than sell to the government; so the levy was widely evaded. In the next five years (1975/76-1979/80), as output rose and government policy was relaxed, the PQR recovered and averaged about 20 percent.

Two striking facts are brought out by this brief account of the evolution of wheat procurement. First, the proportion of wheat

[11] International Bank for Reconstruction and Development, *Economic Situation and Prospects of India* (Washington, D.C.: IBRD, April 1982), pp. 273-275.

[12] Raj Krishna and G. S. Raychaudhuri, "Some Aspects of Wheat Price Policy in India," *Indian Economic Review* 14 (October 1979).

output handled by the government escalated from 2 to 20 percent within two decades. And, second, the experience of 1974 and 1975 illustrated the self-defeating nature of systems of procurement like monopoly purchase and high compulsory levies.

In general, five systems have been used by the central government and the states to obtain grain for the public distribution system: outright acquisition of stocks from traders; monopoly purchase, under which farmers are allowed to sell grain only to the government or its agents; a compulsory progressive levy on farmers, traders, or millers, which requires them to deliver to the government a proportion of their output or turnover, the proportion being larger for larger units; preemptive purchases in the market, with the government exercising the legal right of prior purchase of any lot of grain sold in the market at the going price; and open-market purchases at the going price without preemption or compulsion.[13]

As noted above, the states have used different systems for different crops, and changed these systems from year to year. The kind of system-mix that can exist in any year is illustrated by the arrangements in effect for the procurement of wheat in 1975. Gujarat, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh used progressive levies. Bihar had a proportionate levy (15 percent) on all stocks held and purchases made by wholesale and retail traders. Madhya Pradesh collected a 16.25 percent levy on all wheat exported by traders from one zone to another even within the state, in addition to a progressive levy on farmers. Punjab and Haryana collected a 50 percent levy after the attempted socialization of trade in 1974.[14]

But for wheat, the details of variations in purchase systems have little significance, because Punjab and Haryana, which contributed 60-90 percent of all-India procurement in the decade 1967-77 (Appendix 2, Table 21), have purchased most of their grain in the open market at the prevailing price, with the right of preemptive purchase exercised by government agents only occasionally (except during the brief experiment with socialization and the 50 percent levy in 1974 and 1975). This is confirmed by the difference between the procurement and market prices of wheat in Punjab during 1968-75. In six of the eight years the two prices were either identical or differed by less than 5 percent (Appendix 2, Table 22).

There are strong arguments against imposing on farmers a price less than the market price for government purchases. First, there is no reason why the burden of financing a food subsidy should be placed on the farmers alone, and not on the overall resources of the government. Second, farmers and traders—especially the more resourceful—can and do evade lower-price procurement. And, third, if lower-price procurement is made to succeed through coercion, it would decelerate the growth of output and procurement over a longer run. The whole experience of alternative purchase systems in India suggests that the most rational and effective system is open-market purchase, combined, where necessary, with the government's preemptive right to purchase lots at the market price.

The determination of procurement prices has been debated extensively in India.[15] But there is a consensus that the support price should cover at least the full average cost of production, including the cost of family resources valued at market prices. It has been shown that the procurement price of wheat did not cover the full average cost in the 1950s and early 1960s; but in the late 1960s the procurement price exceeded the full average cost in the major wheat-producing states by a comfortable margin of between 11 and 66 percent (Appendix 2, Table 23). In the 1970s, too, the procurement price was consistently above cost (in the Punjab) although the steep increase in the prices of fertilizer and other inputs reduced the margin in some years (Appendix 2, Table 24). If sustained growth of output and procurement is desired, an assurance that the full average

[13] Chopra, *Evolution of Food Policy*, Chapter 26.

[14] India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics 1976* (New Delhi: Controller of Publications, 1976).

[15] Illustrative recent studies are Krishna and Raychaudhuri, *Some Aspects of Wheat and Rice Policy*; D.S. Sidhu, *Price Policy for Wheat in India* (New Delhi: S. Chand and Co., 1979), and K. Subbarao, "Farm Prices: A Survey of the Debate," Institute of Economic Growth, Delhi, September 1981 (Mimeographed.)

cost will be covered will continue to be necessary.

Concessional Sales

The main, avowed purpose of a dual-market regime is to keep a minimum portion of the grain supply within reach of the vulnerable low-income population. In a country like India where mass poverty forces malnutrition on at least a quarter of the population even in normal years, any significant increase in the market-clearing price of grain due to drought or inflation can easily result in mass starvation. This was illustrated dramatically by the drought of 1967, when only a massive expansion of the public distribution system averted tragedy in the drought-affected areas, particularly in Bihar.

However, the Indian public distribution system has normally served a different and more limited purpose, namely, to make a part of the grain requirements of the urban population available at a subsidized price. The rural areas, where 80 percent of the population below the poverty line reside (they are mostly landless workers and small-farm owners) are hardly served by the system. The number of "fair price shops" or ration shops grew impressively from about 47,000 in 1961 to 239,000 by 1978 (Appendix 2, Table 25), and it is reported that the proportion of outlets in the rural areas has risen. But no data are available about the proportion of grain flowing through them into the rural areas, or about the distribution of cardholders or supplies among income classes. Therefore little can be said about the extent to which the vulnerable sections of the population have really been served by the system. Knowledgeable administrators report informally that almost the whole supply of the public distribution system goes to the middle-income and low-income urban population, except in emergencies, when the flow to rural areas affected by drought or flooding is increased. Kerala is the sole state in which the system normally serves almost the whole population.

There have been many exercises to define the vulnerable population at whom the public distribution system should be targeted, the alternative standards of per capita supply, and the total grain requirements of a rationalized and more purposeful public distribution system. These have been reviewed by Gupta.[16] It has been proposed that the system cover the landless rural households, and urban households that do not pay income tax. Recommended per capita norms have varied between 100 and 180 kilograms per year, and estimated total requirements between 4.5 and 30 million tons. But these calculations remain mere exercises. For the government has never had the will to target supplies, or even to reduce the well-known abuses of the system.

Data have not even been tabulated about the annual variations in each state in entitlements or actual deliveries per card or household. Therefore only aggregate issues per capita can be discussed. During 1961-78, overall grain supply per capita averaged 163 kilograms per year (in the range of 146-175 kilograms, Appendix 2 Table 26). Wheat availability averaged 37 kilograms per capita. Concessional supply on the other hand averaged 17.6 kilograms for foodgrains and 10.8 kilograms for wheat (Appendix 2, Tables 26 and 27). Thus the public distribution system has provided about 11 percent of total grain consumption and 29 percent of wheat consumption per capita at subsidized prices.

The issue price at which the government purchase agencies supply grain to licensed fair price shop retailers (who are allowed a fixed markup) has been essentially determined by conflicting pressures—the pressures of the financial authorities to cut losses by raising the price and urban political pressure resisting any increase in it. The outcome is reflected in the ratio of the issue price to the procurement price (PI/PP) and the ratio of the issue price to the import price (PI/PM) for wheat (Appendix 2, Table 28). The loss incurred by the government would, of course, vary inversely with these ratios. The accounts for the 1970s of the Food Corporation of India (FCI), which handles all grain operations for the central government, indicate that the issue price would have to be at least 30 percent greater than the procurement price and the import price (or PI/PP and PI/PM above 1.30) for the

[16] Arvind Gupta, *Public Distribution of Foodgrains in India* (Ahmedabad, Indian Institute of Management, 1977).

corporation to break even.[17] But as Appendix 2, Table 28 shows, during 1961-67, when imports dominated issues, the PI/PM ratio declined steadily from 1.11 to 0.78 (except in 1965 and 1966) and the PI/PP ratio fell from 1.11 to 0.64. In the later years when procurement dominated issues, PI/PP recovered slowly to 1.05 by 1973 and 1.19 by 1976 but declined again to 1.11 by 1979. Thus the ratios have fluctuated but always remained much below the minimum no-loss ratio (1.30). Meanwhile, both farmer and consumer pressures have increased and the FCI has mushroomed into a vast and wasteful bureaucracy, so that the budgetary burden of the grain operation has risen to a staggering Rs 7 billion a year.

Import Policy

Grain imports have been a government monopoly in India through most of the postwar period, and the allocation of foreign exchange received by the country has been tightly regulated. It will be shown below that the imports of wheat have been influenced mainly by the availability of foreign aid and by the expected domestic grain supply deficit. But it is interesting that the shift of the public distribution system from total dependence on imports to reliance on domestic supplies has been associated with a complete reversal of the relationship between import prices and domestic prices. In the years 1964-71, imported wheat was 14-34 percent cheaper than domestic wheat and the ratio between the import price (PM) and the domestic wholesale price (PW) generally declined. But since 1972 imported wheat has been 8-52 percent more expensive than domestic wheat; and the ratio PM/PW has been rising (Appendix 2, Table 29).

Stock Policy

One of the constant preoccupations of numerous government committees reporting on food policy has been to recommend targets for the public sector grain stocks. Recommended targets have risen from 1 million tons (in the report of the Foodgrains Policy Committee of 1948) through 2, 4, 5, and 7 million tons (in various reports) to 12 million tons (in the report of the technical group of the Department of Food, 1975-76.[18]). They have been usually inoperative as ex ante goals, for the actual amounts stocked have been residuals passively determined by imports—constrained by foreign exchange availability and other things—and domestic procurement and issues governed by the domestic supply and prices.[19] Sometimes the committees simply rationalized actual stocks as desirable. For example, when the actual amount stocked reached 5-7 million tons in the early 1970s, that was made a norm; and when the inventory rose above 17 million tons during 1976-79, the 12 million ton recommendation could safely be made. The capacity of the government to achieve any ex ante target higher than the actual has always been limited; and its capacity to deal rationally with excessive inventory has been no less limited in recent years.

Zoning

A peculiar feature of Indian policy up to 1977 was the frequent enforcement of restrictions on the movement of grain by private traders between states. The degree of restriction again varied from period to period. Sometimes movement outside a state required a license; this was the "single-state zone" system. Sometimes movement between groups of contiguous states was restricted and movement within each group was free; this was the "large-zone" system. The rationale for these restrictions was that they enabled the government to pick up grain in the surplus states at a price lower than the price that would prevail if traders were free to transfer the grain. The subject has aroused

[17] Many open and hidden subsidies are neglected.

[18] Chopra, *Evolution of Food Policy*, pp. 232-235.

[19] For the same reasons the technical distinction between "operational stock" and "buffer stock" some committee reports make is meaningless. The separation of stocks and their use according to different rules has never been permitted by the exigencies of the supply situation. Even in recent years, when the stock rose to record amounts far in excess of operational needs, no differences in the treatment of stocks for various purposes emerged. In most discussions the word "buffer" has simply been a nice but empty prefix for the word "stock."

much theoretical controversy.[20] But a recent analysis has demonstrated empirically that interstate price dispersion increased systematically with the intensity of movement restrictions. For wheat, the large-zone system prevailed during 1951/52-1954/55 and in 1967/68, and the single-state zone system in 1957/58-1960/61, 1964/65-1966/67, 1968/69-1969/70, and 1972/73-1974/75. In 7 years (1955/56-1956/57, 1961/62-1963/64, and 1970/71-1971/72), there were no zonal restrictions. The coefficient of variation of state prices averaged 11.7 percent in the 7 years of unrestricted movement, 14.93 percent in the 5 large-zone years, and 19.42 percent in the 12 single-state zone years (Appendix 2, Table 30). This relationship is faithfully captured by an estimated equation in which the coefficient of variation of state prices is a function of total availability, a production concentration index, and a zone-system dummy.[21]

The equation provides strong support for the view that with movement restrictions surplus producers earn less and deficit-area consumers pay more than they would otherwise, and that both lose more in bad crop years than in normal years. This proposition would hold even if it were true that the government can procure more grain with zoning; for price dispersion clearly increases in spite of the transfer of this "extra" grain from surplus to deficit areas. The transfer must be less than it would be without zoning, otherwise dispersion could not increase. Whatever the motive for zoning might have been, it did not increase producer and consumer welfare.

In 1977 an increase in supplies and the accumulation of an unprecedented inventory by the government finally persuaded it to remove all movement restrictions.

Other Controls

Much need not be said about other attempts to control traders' market operations, such as fixing wholesale and retail price ceilings, raids on traders' establishments to confiscate "hoarded" grain, and the operation of rationing in big cities. Most of these controls only generated black-marketing and corruption on a large scale, and impaired the flow of supplies to consumers. Only the public distribution system—direct marketing by the government—gave the government real leverage to lower prices for at least a section of consumers; and rationing partially succeeded in a few large cities and in Kerala in maintaining minimum supplies to low-income consumers in times of scarcity.

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[20] See Raj Krishna, "Rice Zone Policy: A Minute of Dissent," in India, Agricultural Prices Commission, *Report on the Price Policy for Kharif Cereals for 1965-66 Season* (Delhi: Manager of Publications, 1965); and Jagdish N. Bhagwati and S. Chakravarty, *Indian Economic Analysis—A Survey* (Bombay: Lalvani Publishing House, 1971).

[21] Krishna and Raychaudhuri, "Some Aspects of Wheat Price Policy."

4

THE WHEAT MODEL AND RESULTS

The model developed in this report contains six relations, including five equations and an identity. The equations determine output (Q), total absorption (demand, D), concessional sales (issues, IS), government purchases (procurement, PR), and total imports (IM). (All symbols are defined in Appendix 3.)

The identity for the government's wheat operations equates the sum of the opening stock (SO), procurement, and imports with the sum of issues and the closing stock (SC):

$$SO + PR + IM \equiv IS + SC. \qquad (1)$$

This identity is used to determine the closing stock.

Output

The gross output (supply) function is

$$Q = f_2 (PW21, PBG21, RAW, IRW, Q1), \qquad (2)$$

where,

PW21 = the wholesale price of wheat deflated by the general wholesale price index, lagged one year;

PBG21 = the price index of major production substitutes of wheat, barley, and gram, deflated by the general wholesale price index, lagged one year;

RAW = the wheat-specific rainfall index (with wheat-share weights for rainfall in different rainfall regions);

IRW = the ratio of gross irrigated area in wheat to gross total wheat area; and

Q1 = lagged wheat output.

These variables are designed to capture the relative-price effect, the weather effect, the technology effect, and the adjustment lag. Ideally, the price indexes for wheat and the major production substitutes for wheat should be deflated by input price indexes, but since these are not available, the general price index is used as a proxy deflator. The irrigation ratio has been found in many studies to be the dominant determinant of, and hence the best proxy for, technical changes such as the increasing use of hybrid seeds, fertilizer, and equipment.[22]

The OLS coefficients of the output equation are given in Table 1, equation (2). All the coefficients have the expected signs, all except PBG21 are significant at the 1 percent level, and they explain 99 percent of the variance of output. The estimate of the one-period elasticity of supply (0.58) is comparable with an earlier estimate (0.59) made by Krishna and Raychaudhuri for the 1960s.[23] The supporting equations (in Table 2) imply one-period elasticities of 0.19 for area and 0.12 for yield. These two estimates are comparable to earlier estimates (0.22 and 0.34) made by Krishna and Raychaudhuri.

The supporting area and yield equations (Table 2, equations [1] and [2]) were estimated

[22] Fred H. Sanderson and Shyamal Roy, *Food Trends and Prospects in India* (Washington, D.C.: Brookings Institution, 1979); and Dayanatha Jha, "Fertiliser Use and Its Determinants: A Review with Special Reference to Semi-Arid Tropical India," International Crops Research Institute for the Semi-Arid Tropics, Patancheru, June 1980. (Mimeographed.)

[23] Krishna and Raychaudhuri, *Some Aspects of Wheat and Rice Policy*, p. 41. Comparisons of elasticities estimated in this paper and in earlier studies are not based on statistical tests because the specifications of equations differ. They are made only to see whether the new estimates are similar to the earlier ones. References to comparisons of elasticities estimated in this paper are, however, based on statistical tests where applicable.

Table 1—Wheat model equations, ordinary least squares, 1961-78

Equation Number	Dependent Variable	Constant	Independent Variable/Estimated Coefficient					$\bar{R}^2$	D.W.
			PW21	PBG21	RAW	IRW	Q1		
2	Q	-26,020.50[a]	5,704.08[a]	-2,619.61[c]	1.11[a]	29.42[a]	0.62[a]	0.99	...
		(8.18)	(4.48)	(-1.96)	(5.48)	(3.99)	(5.54)		
			[0.58]	[-0.14]	[0.56]	[0.75]			
			WAP	PCS	X				
3	D	-10,887.70[a]	-11,112.70[b]	3,857.72[b]	1.12[a]	...	...	0.96	3.01
		(-3.17)	(-2.64)	(2.47)	(19.97)				
			[-0.46]	[0.45]	[1.55]				
			PILL2	PW2	X				
4	IS	220.74	-13,305.50[a]	4,796.98[a]	0.20[a]	...	...	0.84	2.25
		(0.18)	(-5.26)	(5.49)	(5.12)				
			[-1.57]	[1.64]	[0.96]				
			Q	PP2	PW2				
5	PR	-4,384.71[a]	0.31[a]	4,680.40[c]	-995.80	...	...	0.94	1.98
		(3.00)	(16.32)	(1.82)	(0.88)				
			[2.22]	[1.19]	[-0.74]				
			DEFM	PMM	ADU				
6	IM	3,206.41	0.13	-2,685.21	4.54[c]	...	...	0.92	2.16
		(1.90)	(6.19)	(-3.25)	(5.04)				
			[0.06]	[-0.89]	[1.14]				

Notes: The figures in parentheses are t-values. Those in brackets are the elasticities of the variables at their means. The D.W. statistics show no serial correlation.

Q is gross output; D is total demand (absorption). IS stands for government issues (concessional sales) and PR, for procurement. IM is total imports.

ADU is total foreign aid utilized. DEFM is the foodgrain deficit for imports. IRW is the ratio of irrigated wheat area to total wheat area. PBG21 is the ratio of the price index of the major substitutes for wheat in production to the wholesale price index, lagged one year, and PCS is the ratio of the price index of the major substitutes for wheat in consumption to the wholesale price index. PILL2 is the deflated price of issues; PMM is the deflated price of imports. PP2 is the ratio of the procurement price to the wholesale price index for all commodities, and PW2 is the ratio of the open market wholesale price to the wholesale price index for all commodities. PW21 is PW2 lagged one year. Q1 is Q lagged one year. RAW is the rainfall index for wheat. WAP is the weighted average of the market wholesale and concessional issue prices of wheat. X is aggregate real consumption expenditures.

[a] This coefficient is significant at the 1 percent level.

[b] This coefficient is significant at the 5 percent level.

[c] This coefficient is significant at the 10 percent level.

with the same explanatory variables as the output equation, but only the output equation was used to estimate the reduced form and projections.

Theoretically, the elasticity of output (e_{QP}) with respect to the deflated price of wheat should be equal to the sum of the elasticities of area and yield with respect to the same price (e_{ACP} and e_{YDP}). (Since output Q = AC [area] × YD [yield], $e_{QP} = e_{ACP} + e_{YDP}$.) The sum of estimated one-period e_{ACP} and e_{YDP} (0.31) is less than the estimated e_{QP} (0.58). The sum of long-run e_{ACP} and e_{YDP} (0.71) is also less than the long-run e_{QP} (0.92). But the differences are not statistically significant. Responses of area and yield to irrigation are, however, significantly different, and so are their adjustment lags.

Numerous other estimates of the one-period elasticity of wheat area in different regions of India are also available. Eleven of them lie between 0.02 and 0.11, and five

Table 2—Supplementary wheat model equations, ordinary least squares, 1961-78

Equation Number	Dependent Variable	Constant	Independent Variable/Estimated Coefficient					$\bar{R}^2$	D.W.
1	AC	-3.89[b] (-2.76)	PW21 1.64[a] (3.48) [0.19]	PBG21 -1.88[b] (-2.61) [-0.12]	RAW 0.00034[a] (3.96) [0.20]	IRW 0.01[a] (3.01) [0.30]	AC1 0.68[a] (5.71)	0.97	...
2	YD	-436.11[b] (-2.41)	PW21 70.91 (1.02) [0.12]	PBG21 -63.04 (0.57) [-0.06]	RAW 0.04[a] (3.32) [0.35]	IRW 1.61[a] (3.46) [0.71]	YD1 0.28 (1.34)	0.91	...
3	DPC	-69.94[a] (6.98)	WAP -29.35[a] (-3.53) [-0.66]	PCS 0.85[a] (3.22) [0.61]	XPC 2.11[a] (12.16) [2.95]	...	...	0.95	2.00
4	D	-11,038.80[b] (2.28)	WAP -5,656.40 (-0.98) [-0.23]	PCS 4,014.20[c] (1.82) [0.47]	YC 0.79[a] (13.99) [1.32]	...	...	0.93	1.56
5	DPC	-39.85[b] (2.46)	WAP -7.76 (-0.61) [-0.17]	PCS 7.96[c] (1.57) [0.51]	YPC 1.05[a] (5.76) [1.75]	...	...	0.68	1.45
6	ISPC	0.11 (0.01)	PILL2 -27.07[a] (-4.46) [-1.702]	PW2 9.58[a] (5.09) [1.75]	XPC 0.20 (1.25) [0.93]	...	...	0.77	2.09
7	IS	7,163.97 (1.31)	PILL2 -12,144.70[a] (-4.31) [-1.45]	URXR -5,948.69[c] (-1.37) [-1.04]	PW2 4,212.54[a] (4.44) [1.44]	X 0.16[a] (3.62) [0.77]	...	0.85	2.13
8	IS	4,257.64[c] (1.57)	PILL2 -1,469.10 (-0.48) [-0.17]	PW2 549.36 (0.48) [0.18]	DEF 0.16[a] (4.11) [0.27]	...	...	0.52	1.51
9	PR	-6,194.11[a] (-3.14)	Q 0.30[a] (15.16) [2.19]	PP2/PW2 8,985.13[c] (1.65) [1.16]	...	...	...	0.93	1.87
10	IM	9,580.21[a] (4.47)	DEFM 0.095[b] (2.13) [0.04]	PMM -3,516.51[b] (-2.46) [-1.17]	FE -53.78 (-0.50) [-0.26]	...	...	0.52	1.74

Notes: The D.W. statistics have no serial correlation. The figures in parentheses are t-values; the figures in brackets are the elasticities of the variables at their means.

AC stands for the area sown with wheat; YD for the yield. D is total demand (absorption), while DPC is total demand (absorption) per capita. IS stands for government issues (concessional sales) and ISPC, government issues per capita. PR is procurement; IM is total imports.

AC1 is AC lagged one year. DEF is the foodgrain deficit for issues, and DEFM is the foodgrain deficit for imports. FE is foreign exchange available, deflated by the index of the unit value of imports. IRW is the ratio of irrigated wheat area to total wheat area. PBG21 is the ratio of the price index of the major substitutes for wheat in production to the wholesale price index, lagged one year, and PCS is the ratio of the price index of the major substitutes for wheat in consumption to the wholesale price index. PILL2 is the deflated price of issues; PMM is the deflated price of imports. PP2 is the ratio of the procurement price to the wholesale price

(continued)

Table 2—Continued

index for all commodities, and PW2 is the ratio of the open market wholesale price to the wholesale price index for all commodities. PW21 is PW2 lagged one year. Q is gross output. RAW is the rainfall index for wheat. URXR is the ratio of urban consumption expenditures per capita to rural consumption expenditures per capita. WAP is the weighted average of the market wholesale and concessional issue prices of wheat. X is aggregate real consumption expenditures, and XPC is X per capita. YC is national income. YD1 is YD lagged one year. Finally, YPC is YP per capita.

[a] This coefficient is significant at the 1 percent level.

[b] This coefficient is significant at the 5 percent level.

[c] This coefficient is significant at the 10 percent level.

between 0.16 and 0.24.[24] Estimates for Pakistan lie between 0.07 and 0.20.[25] The new estimate (0.2) is thus close to the higher of the earlier figures.

Absorption

The absorption function is:

$$D = f_3(WAP, PCS, X), \qquad (3)$$

where

D = total absorption, defined as the sum of net output, net imports, and government inventory depletion;[26]

WAP = the weighted average of the market wholesale price of wheat, weighted by the proportion of commercial absorption in total absorption, and the concessional price of wheat, weighted by the proportion of concessional absorption in total absorption; the average is deflated by the general wholesale price index;

PCS = the price index of the consumption substitutes for wheat—that is, cereals other than wheat—deflated by the general wholesale price index; and

X = aggregate real consumption expenditure.

The specification includes the usual variables of a demand function, namely, own price (deflated), substitute prices (deflated), and total expenditure. But an adjustment has been made: as there are two related markets (the commercial market and the concessional market), the own price is a weighted sum of prices in both.

Aggregate expenditure, not income, is used as the scale variable, because its performance is better, so it can generate better simulations. An equation with income in place of expenditure is, however, given in Table 2, equation (4).

Convenience of simulation also explains why aggregate rather than per capita absorption and consumption expenditure is included in the demand function. Again, equations with per capita expenditure and per capita income variables are given for comparison (Table 2, equations [3] and [5]).

The estimated absorption equation, Table 1, equation (3), reveals a high aggregate expenditure elasticity of demand for wheat (1.55). The t-value of the expenditure coefficient exceeds 19. The price elasticity of aggregate absorption is −0.46.

The corresponding equation with per capita absorption and consumption expenditure (Table 2, equation [3]) turns up different expenditure and price elasticities (2.95 and −0.66).

Different elasticity estimates are also derived from equations in which income

[24] Krishna and Raychaudhuri, *Some Aspects of Wheat and Rice Policy*, p. 35.

[25] Scandizzo and Bruce, *Methodologies for Measuring Price Effects*

[26] Private stock figures are not available. Private stock accretion is included in total absorption. Net output is gross output minus a 12.1 percent allowance for seed, feed, and wastage. It is denoted by SP = 0.879Q.

replaces expenditure. If aggregate income is used, the income elasticity is 1.32 and the own-price elasticity is −0.23 (Table 2, equation [4]). If per capita income is used, the income elasticity is 1.75 and the own-price elasticity is −0.17 (Table 2, equation [5]); these are comparable to estimates from another study (1.06 and −0.22).[27]

The estimated expenditure and income elasticities of wheat absorption (2.95 and 1.75) appear to be high indeed; they are in fact close to the elasticities for manufactured luxury goods. But independent evidence is consistent with high estimates.

First, during 1960/61-1977/78 income per capita grew only 1.45 percent a year and expenditure per capita 0.90 percent a year but wheat absorption per capita increased 2.69 percent a year.[28] Thus wheat consumption growth was 2.99 times expenditure growth and 1.86 times income growth (Appendix 2, Table 31). These ratios are comparable to the elasticities noted above (2.95 and 1.75).

Second, National Sample Survey data indicate a clear shift of cereal consumption from other cereals (including rice) to wheat in the early 1960s and early 1970s. Between 1961/62 and 1973/74, monthly per capita consumption of nonwheat cereals decreased 22 percent in rural and 4 percent in urban areas, but the consumption of wheat increased 33 percent in rural and 5 percent in urban areas. So the share of wheat in per capita cereal consumption increased from 15 to 23 percent in rural and 33 to 38 percent in urban areas.[29]

Thus wheat has clearly been a highly preferred superior good whose consumption per capita has grown much faster than the growth of total income or expenditure per capita, while the per capita consumption of other cereals has declined. Millet is the sole cereal, other than wheat, whose consumption grew in the period 1961-74, but only in rural areas.

Concessional Sales

The concessional sales (issues) function is

$$IS = f_4 (PW2, PILL2, X), \qquad (4)$$

where

IS = concessional sales (issues),[30]

PW2 = the wholesale price of wheat deflated by the general wholesale price index, and

PILL2 = the issue price deflated by the general wholesale price index.

The specification includes the real open-market price as well as the real concessional price, because the substitution that determines the concessional offtake is the switching of consumers between the two markets, depending on differences in price and quality, and the length of the queues at the concessional (fair price) shops. The scale variable in the equation, as in the total absorption equation, is total real consumption expenditure.

The estimated equation (4) implies significant and high own- and cross- (intermarket) price elasticities (1.6 and −1.6), with the signs as expected (Table 1). The expenditure elasticity is not significantly different from unity. The elasticities of concessional sales estimated with the per capita variables (Table 2, equation [6]) are 0.93 with respect to expenditure and −1.7 with respect to the real issue price.

The inclusion of a distributional variable in the concessional offtake equation is obviously necessary. But as noted earlier, in Chapter 3, basic data on the distribution of sales or even ration cards between rural and urban consumers, and between poor and nonpoor consumers, are not available. The distribution of shops between rural and urban areas is known, but most of the issues

[27] R. K. Pandey, "The Analysis of Demand for Foodgrains," *Indian Journal of Agricultural Economics* 28 (No. 2, 1973): 49-55.

[28] Calculated from data in India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics* various issues (New Delhi: Controller of Publications, various years); and India, Central Statistical Organisation, *National Accounts Statistics* various issues (New Delhi: Controller of Publications, various years).

[29] J. S. Sarma, Shyamal Roy, and P. S. George, *Two Analyses of Indian Foodgrain Production and Consumption Data*, Research Report 12 (Washington, D.C.: International Food Policy Research Institute, 1979).

[30] The "sales" here are not actual retail sales, but "issues" to registered concessional retailers ("fair price shops") from the government agency, the Food Corporation of India.

flow through the urban shops to middle-income as well as low-income households. Therefore the distribution of shops would be a poor proxy for the distribution of sales between rural and urban consumers or between poor and nonpoor consumers.

However, a distributional variable, the ratio of urban consumption expenditure per capita to rural consumption expenditure per capita (URXR), was tried as an additional variable. The coefficient of this variable is not significant and its inclusion significantly alters neither the price and expenditure elasticities of concessional sales nor the variance explained (Table 1, equation [4] and Table 2, equation [7]).

More data are clearly required to permit measurement of the segment of consumption expenditure relevant to concessional offtake.

Equation (4) has the form of a standard demand function. But it can be argued that the actual concessional sales of wheat do not depend solely on the usual demand function variables. The overall deficit in the supply of all grains—the difference between "desired" consumption and actual availability—could be an important determinant of the concessional offtake of wheat. Therefore, the grain supply deficit (DEF) was included as an alternative scale variable in an experimental issue equation, in addition to the two relative price variables, PW2 and PILL2. The deficit (DEF) is defined as target consumption (the average per capita consumption during 1961-78 multiplied by the population of each year, DFG*) minus net output (SP) plus procurement (PR). In the equation with DEF (Table 2, equation [8]), only the coefficient of DEF is significant; the coefficients of the price variables PW2 and PILL2 have low t-values. Moreover, this equation explains much less of the variance of concessional sales (52 percent) than the corresponding standard demand function specification with expenditure (84 percent, Table 1, equation [4] and 85 percent, Table 2, equation [7]).

Procurement

In the government procurement function,

$$PR = f_5 (Q, PP2, PW2), \qquad (5)$$

where

PP2 = the official procurement price deflated by the general wholesale price index.

It was noted earlier that procurement policy has changed over time and differs among states. But to explain changes in procurement in the country as a whole only two important variables are needed: output and the ratio of the procurement price to the open-market wholesale price. This price ratio reflects the choice the farmer has of selling his produce to the procuring agency or to the private trader. If nothing else changes, a higher ratio would increase the profitability of selling grain to the government's procuring agency.

Variations in output obviously affect procurement directly: the larger the output, the larger is the marketed surplus and the quantity the government can procure. But output also influences procurement indirectly, via the open-market price. In a bad crop year the market price tends to rise and it would be more profitable for the producer to sell grain to the private trader. In a good crop year the market price is likely to fall (or rise less) and an improved ratio of procurement prices to market prices would induce higher sales to the government.

For the multi-equation system, it was found convenient to specify the (deflated) procurement price and the (deflated) open-market wholesale price as separate explanatory variables (Table 1, equation [5]) instead of the ratio of the two prices as a single variable. (The equation with the ratio is in Table 2, equation [9].) The elasticity of procurement with respect to output is found to be high (2.2) with a t-value exceeding 16 (Table 1, equation [5]). And the elasticity of procurement with respect to the procurement price is also high (1.19), though the t-value of the procurement price, 1.82, is low.

The coefficient of the open-market wholesale price is, however, not significant (even at the 15 percent level), though it has the expected negative sign. This outcome seems to be due to multicollinearity between output and the open-market price.

Imports

The wheat import equation is

$$IM = f_6 (PMM, DEFM, ADU), \qquad (6)$$

where

PMM = the import price of wheat, deflated by UVIM, the unit value index of all Indian imports; and

ADU = total foreign aid utilized during the year.

The supply gap, DEFM, shows the amount the government would like to import to meet its total grain sale commitments. It is defined as the "issue-deficit" (DEF) defined earlier minus the sum of the opening stock (SOFG) and procurement(PRFG) of all foodgrains. Thus DEFM = DEF – SOFG – PRFG. The proportion of the deficit that the government actually covers with imports depends on foreign aid availability and the import price of wheat, relative to the weighted average price of all imports. The OLS equation estimated on the basis of this reasoning (equation [6]) accounts for a significant proportion of the variance of wheat imports (Table 1, equation [6]). The supply gap and the price variables have significant coefficients with the right signs. The gap elasticity turns out to be 0.06, and the price elasticity, –0.89. The elasticity with respect to aid is positive and not significantly different from unity.

Aid utilized turns out to be the most appropriate variable to represent foreign exchange availability in the wheat import equation for India. In other recent studies, broader definitions of exchange availability, including exchange reserves, export earnings, or both, have been used.[31] Given Indian trade and exchange policy, however, none of the more inclusive representations of exchange supply (opening reserves plus aid or opening reserves plus aid plus export earnings) proved to be significant.

One of the experimental equations with the latter, the most inclusive definition of exchange supply (FE) is reported as equation (10) in Table 2. A comparison of this with equation (6) in Table 1 reveals that while the coefficient of aid alone in equation (6) is highly significant, the coefficient of FE in Table 2, equation (10) is not. And the latter equation explains much less (52 percent) of the variance of imports than the former (92 percent).

The explanation for this seems to be that the average ratio of the value of wheat imports to aid utilized varied between 7 and 37 percent except during the four years 1973-76, when it was high (66 percent; see Appendix 2, Table 32). Therefore in most years the government could finance wheat imports mainly with aid. The allocation of available foreign exchange among import commodity groups has always been directly controlled by the government so that non-wheat imports could be squeezed when wheat imports required a high proportion of aid, other foreign exchange, or both.

The high price elasticity of wheat imports (–0.89) can also be explained. When heavy concessional imports were necessary (in the late 1950s and early 1960s), the relative price of imported wheat (PM/UVIM) was low. Since concessional imports were stopped, government imports became sensitive to prices, except in 1973 and 1974 when heavy commercial imports had to be bought at a high price to make up the shortage created by two successive droughts (Appendix 2, Tables 29 and 33). The responsiveness of imports to prices could be high in recent years because reliance on imports to meet concessional sale requirements was reduced by the growth of wheat output.

Simultaneity

The five interrelated equations relating to output, total absorption, and the government's purchases, imports, and concessional sales have been estimated by the 3SLS procedure in order to correct the coefficients for simultaneity biases (Table 3).

Three-stage least square coefficients are used to compute the reduced form and projections.

The Sensitivity of the System

All the estimated 3SLS elasticities in Table 4 show that the Indian wheat system is highly sensitive to prices. The one-period price elasticity of supply (0.66) is in the

[31] Scobie and Valdés, "Food Imports, Government Policy;" Hall, "Evaluating the Effects of Imports."

Table 3—Wheat model equations, three-stage least squares, 1961-78

Equation Number	Dependent Variable	Constant	Independent Variable/Estimated Coefficient				
2	Q	-25,555.8[a] (6.68)	PW21 6,339.48[a] (3.91) [0.64]	PBG21 -2,491.18 (-1.73) [-0.14]	RAW 0.9977[a] (6.01) [0.51]	IRW 26.0802[a] (3.39) [0.66]	Q1 0.6764[a] (5.71)
3	D	-9,708.24[a] (-2.79)	WAP -10,434.8[a] (-2.75) [-0.42]	PCS 3,444.18[a] (2.69) [0.40]	X 1.0904[a] (19.88) [1.50]	...	...
4	IS	1,139.32 (0.29)	PILL2 -9,958.78[a] (-3.07) [-1.14]	PW2 3,576.81[a] (2.68) [1.20]	X 0.1586[b] (2.45) [0.75]	...	...
5	PR	3,868.01[b] (2.24)	Q 0.3159[a] (15.08) [2.22]	PP2 6,390.06[b] (2.51) [1.54]	PW2 -1,928.56[c] (-1.57) [-1.37]	...	...
6	IM	5,589.57[b] (2.30)	DEFM 0.1668[a] (3.16) [0.07]	PMM 3,933.28[a] (-3.67) [-1.30]	ADU 3.2845[b] (2.34) [0.82]	...	...

Notes: The figures in parentheses are t-values. Those in brackets are the elasticities of the variables at their means. Q is gross output. D is total demand (absorption). IS stands for government issues (concessional sales) and PR, for procurement. IM is total imports.

ADU is total foreign aid utilized. DEFM is the foodgrain deficit for imports. IRW is the ratio of irrigated wheat area to total wheat area. PBG21 is the ratio of the price index of the major substitutes for wheat in production to the wholesale price index, lagged one year, and PCS is the ratio of the price index of the major substitutes for wheat in consumption to the wholesale price index. PILL2 is the deflated price of issues; PMM is the deflated price of imports. PP2 is the ratio of the procurement price to the wholesale price index for all commodities, and PW2 is the ratio of the open market wholesale price to the wholesale price index for all commodities. PW21 is PW2 lagged one year. Q1 is Q lagged one year. RAW is the rainfall index for wheat. WAP is the weighted average of the market wholesale and concessional issue prices of wheat. X is aggregate real consumption expenditures.

[a] This coefficient is significant at the 1 percent level.

[b] This coefficient is significant at the 5 percent level.

[c] This coefficient is significant at the 10 percent level.

range of elasticities found for commercial crops rather than subsistence crops in developing countries.[32] The price elasticity of demand for wheat (-0.4) is also higher than for subsistence crops. The price elasticity of government purchases is about 1.5. And the price elasticities of imports and concessional sales are not significantly different from unity.

The system is also found to be sensitive to scale variables. The high expenditure elasticity of wheat consumption (1.5) was discussed earlier, but the elasticity of concessional sales with respect to consumption expenditures (0.75) is also high, considering that wheat is a staple food. Finally, government procurement is sensitive to output with an elasticity of about 2.2.

[32] Scandizzo and Bruce, *Methodologies for Measuring Price Effects*

Table 4—Wheat model: elasticities estimated with ordinary least squares and three-stage least squares coefficients, 1961-78

Elasticity of	With Respect to	Ordinary Least Squares	Three-Stage Least Squares
Q	PW21	0.58[a]	0.66[a]
	PBG21	-0.14[c]	-0.14[c]
	RAW	0.56[a]	0.50[a]
	IRW	0.75[a]	0.66[a]
D	WAP	-0.46[b]	-0.42[b]
	PCS	0.45[b]	0.40[b]
	X	1.55[a]	1.50[a]
IS	PILL2	-1.57[a]	-1.14[a]
	PW2	1.64[a]	1.20[b]
	X	0.96[a]	0.75[b]
PR	Q	2.22[a]	2.22[a]
	PP2	1.19[c]	1.54[b]
	PW2	-0.74[d]	1.37[d]
IM	DEFM	0.06[a]	0.07[a]
	PMM	-0.89[a]	-1.30[a]
	ADU	1.14[a]	0.82[b]

Notes: Q is gross output; D is total demand (absorption). IS stands for government issues (concessional sales) and PR, for procurement. IM is total imports.

ADU is total foreign aid utilized. DEFM is the foodgrain deficit for imports. IRW is the ratio of irrigated wheat area to total wheat area. PBG21 is the ratio of the price index of the major substitutes for wheat in production to the wholesale price index, lagged one year, and PCS is the ratio of the price index of the major substitutes for wheat in consumption to the wholesale price index. PILL2 is the deflated price of issues; PMM is the deflated price of imports. PP2 is the ratio of the procurement price to the wholesale price index for all commodities, and PW2 is the ratio of the open market wholesale price to the wholesale price index for all commodities. PW21 is PW2 lagged one year. RAW is the rainfall index for wheat. WAP is the weighted average of the market wholesale and concessional issue prices of wheat. X is aggregate real consumption expenditures.

[a] This coefficient is significant at the 1 percent level.

[b] This coefficient is significant at the 5 percent level.

[c] This coefficient is significant at the 10 percent level.

[d] This coefficient is not significant at the 10 percent level.

5

THE REDUCED FORM OF THE MODEL

Writing the five estimated 3SLS equations for Q, D, IS, PR, and IM, and the stock identity (equation [1]) in matrix form,

$$AE = BG, \qquad (7)$$

where E is the column vector of endogenous variables (Q, PW2,[33] IS, PR, IM, and SC); G is the column vector of predetermined variables (Q1, IRW, RAW, PBG21, PW21, PP2, PILL2, X, PMM, DEFM, ADU, PCS, and SO); and A (6 × 6) and B (6 × 13) are coefficient matrices, the reduced form of the system is

$$E = RG \qquad (8)$$

where $R = A^{-1}B$. The reduced form matrix shown in Table 5 sheds some light on the causal links between variables. Some are noteworthy.

Table 5—Wheat model: reduced form of the three-stage least squares system, 1961-78

Predetermined Variable	Output (Q)	Procurement (PR)	Issues (IS)	Imports (IM)	Deflated Wholesale Price (PW2)	Closing Stock (SC)
Constant	2,555.8	11,875.3	1,017.3	11,006.2	-0.0341	-1,866.3
Lagged gross output (Q1)	0.6764	0.2908	-0.1430	-0.0987	-0.00004	0.3351
Wheat irrigation ratio (IRW)	26.0802	11.2117	-5.5137	-3.8064	-0.0015	12.9190
Rainfall index for wheat (RAW)	0.9977	0.4289	-0.2109	-0.1456	-0.00006	0.4942
Deflated, lagged wholesale price (PW21)	6,339.48	2,725.29	-1,340.26	-925.25	-0.37	3,140.30
Price index of production substitutes (PBG21)	-2,491.18	-1,070.94	526.67	363.59	0.15	-1,234.02
Deflated procurement price (PP2)	0.00	5,096.48	2,399.14	0.00	0.67	2,697.35
Deflated issue price (PILL2)	0.00	-1,699.16	-6,807.43	0.00	0.88	5,108.27
Aggregate consumption expenditure (X)	0.00	-0.1886	0.[illegible]84	0.00	0.000098	-0.6971
Grain deficit for imports (DEFM)	0.00	0.00	0.00	0.1668	0.00	0.1668
Deflated import price (PMM)	0.00	0.00	0.00	-3,933.28	0.00	-3,933.28
Aid utilized (ADU)	0.00	0.00	0.00	3.2845	0.00	3.2845
Deflated price index of consumption substitutes (PCS)	0.00	-697.23	1,293.11	0.00	0.3615	-1,990.34
Opening stock (SO)	0.00	0.00	0.00	-0.1668	0.00	0.8332

[33] The equation for D is actually used to determine prices.

First, all the predetermined variables that determine output (rainfall, the irrigation ratio, lagged relative price indexes, and lagged output) also influence procurement and closing stocks with the same signs as in the output equation. They also affect issues, imports, and (deflated) wholesale prices with signs opposite to their own in the output equation. This accords with expectations: procurement and closing stocks should vary with output, and concessional sales, imports, and the market price should decrease as output increases.[34]

Second, the three predetermined variables in the import equation (aid, the deflated import price, and the foodgrain deficit) do not affect any other quantity except the closing stock. For these variables, and imports determined by them, do not enter any relation other than the stock identity.

Third, though the deflated procurement price directly enters only the procurement equation, it has an indirect, positive relation with issues, market price, and closing stocks. A higher procurement price makes larger procurement and, hence, larger concessional sales and closing stocks possible. It also raises the market price by causing a larger withdrawal from the open market.

Similarly, a higher deflated issue price directly reduces concessional sales but, indirectly, it reduces procurement as well by raising the market price relative to the procurement price.

Fourth, increases in aggregate consumption expenditures raise absorption and through it the market price. But this depresses procurement and, hence, the closing stock.

And, finally, the price index of consumption substitutes (PCS) and the price of wheat (PW2) move in the same direction, as expected. A rise in the PCS also decreases procurement and increases issues by inducing an increase in the real market price of wheat.

[34] In this chapter, partial causal relations reflected in impact multipliers are discussed assuming that the variables indicated change and other predetermined variables remain the same.

6

CONSISTENT PROJECTIONS

The reduced form of the model was used to make projections of the five endogenous variables for 14 years (1979-92) beyond the estimation period (1961-78).[35] The projections are "consistent" in two ways. First, they are consistent with the estimated simultaneous-equation (three-stage least squares) coefficients that reflect the interaction of the market and the government during the estimation period. And, second, they are not optimal, just consistent; no objective function is maximized or minimized.[36]

The projected values of the endogenous variables are shown in Table 6. The assumptions used to project exogenous variables, and projections based on these assumptions, are given in Appendix 2, Table 34. Apart from the statistical significance of the estimated coefficients, the validity of endogenous projections depends on the realism of the assumptions with which exogenous quantities are projected. It is, therefore, necessary to review briefly the grounds for the main assumptions made. (For intercept adjustments see Appendix 4.)

Assumptions for Exogenous Projections

Three scenarios are simulated: "the basic scenario," in which rainfall is normal every year; "the drought scenario," in which rainfall is below normal by 10-20 percent in 6 of the 14 years (1980, 1981, 1984, 1985, 1988, and 1989);[37] and "the drought and a shortage of foreign exchange scenario," in which, in addition to monsoon shortfalls, 10 percent less aid is available than in the basic scenario in the drought years.[38] The two latter scenarios are designed to study the effects of the two major external shocks that the Indian grain economy is vulnerable to. During the 18-year period, 1961-78, nominal aid decreased in seven years. The decreases, ranging between 7 and 26 percent, averaged 17 percent. In the simulated exchange shortage cases, aid is kept 10 percent below the 1978 level (Rs 11 billion) in every year 1979 to 1992. In the present aid milieu there seems to be little prospect of an increase in aid, even in nominal terms.

Accepting the irrigation ratio for 1990 projected by Sanderson and Roy, the ratio for each projection year has been interpolated linearly.[39] It increases 0.8-0.9 of a percentage point annually, from 67 percent in 1979 to 79 percent in 1992. This rate of increase is less than half the average increase in the estimation period (an increment of 2 percentage points a year) because the rate of increase is expected to decelerate.

The basic assumption about domestic and import prices is that both rise by 10 percent a year. After four years of an unusually low rate of inflation (1.6 percent a year) the Indian economy experienced double-digit inflation of about 15 percent a year for two fiscal years ending in April 1981, and 10 percent in 1981/82. It is not likely to average less than 10 percent in the coming years. The average rate of inflation in the European countries and the United States, where most Indian imports come from, ranged between 5 and 16 percent a

[35] Though projections for the later years of a long period are likely to lose realism, they were nevertheless computed to simulate the smaller size at which the inventory, which was abnormally large in 1979, stabilizes in the long run.

[36] The quantities for each year also satisfy the basic stock-flow identity: the closing stock equals the opening stock plus procurement and imports minus sales.

[37] Between 1961 and 1978 there were five major dips in rainfall, below normal, of 34 percent in 1966, 18 percent in 1967, 15 percent in 1969, 22 percent in 1973, and 23 percent in 1975. Except in 1966 when the dip was abnormally steep, 34 percent below normal, the other declines averaged 19.5 percent.

[38] In the rest of the paper, "aid" means aid utilized.

[39] Sanderson and Roy, *Food Trends and Prospects*

Table 6—Wheat model: consistent projections, 1979-92

Scenario/ Year	Output (Q)	Procurement (PR)	Issues (IS)	Imports (IM)	Closing Stock (SC)	Opening Stock (SO)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
			(1,000 metric tons)					(Rs billion)
Basic								104.90
1979	32,986	7,415	7,095	-670	10,138	10,488	88.7	
1980	33,063	7,285	7,517	-720	9,186	10,138	87.0	
1981	33,856	7,463	7,788	-360	8,501	9,186	92.4	
1982	34,865	7,734	8,014	466	8,687	8,501	94.7	
1983	35,939	8,033	8,225	741	9,237	8,687	95.8	
1984	37,033	8,341	8,433	673	9,818	9,237	96.6	
1985	38,159	8,662	8,634	713	10,559	9,818	97.4	
1986	39,268	8,976	8,838	825	11,523	10,559	98.2	
1987	40,399	9,299	9,037	935	12,720	11,523	99.0	
1988	41,510	9,614	9,241	1,042	14,135	12,720	99.9	
1989	42,641	9,938	9,441	1,145	15,777	14,135	99.1	
1990	43,778	10,264	9,639	1,246	17,647	15,777	100.7	
1991	44,916	10,590	9,837	1,351	19,751	17,647	101.3	
1992	46,058	10,918	10,035	1,663	22,296	19,751	103.3	
Average	38,891	8,895	8,698	646	12,855	12,012	96.7	
Drought								95.74
1979	32,986	7,415	7,095	-670	10,138	10,488	88.7	
1980[a]	31,068	6,533	7,653	308	9,326	10,138	94.7	
1981[a]	31,908	6,679	8,057	124	8,071	9,326	97.4	
1982	34,103	7,407	8,175	466	7,769	8,071	96.6	
1983	35,709	7,935	8,274	741	8,171	7,769	96.2	
1984[a]	34,968	7,559	8,584	1,786	8,933	8,171	99.9	
1985[a]	36,190	7,869	8,907	1,257	9,152	8,933	100.7	
1986	38,500	8,646	9,000	825	9,623	9,152	99.5	
1987	40,167	9,200	9,086	935	10,671	9,623	98.9	
1988[a]	39,444	8,832	9,392	2,293	12,405	10,671	103.3	
1989[a]	40,671	9,144	9,714	1,760	13,595	12,405	105.5	
1990	43,009	9,933	9,802	1,246	14,972	13,595	103.8	
1991	44,685	10,491	9,886	1,351	16,927	16,927	103.3	
1992	45,986	10,887	10,050	1,663	19,428	19,428	103.8	
Average	37,814	8,466	8,834	1,006	11,370	10,732	99.5	
Drought and exchange shortage								75.25
1979	32,986	7,415	7,095	-1,031	9,777	10,488	88.7	
1980[a]	31,068	6,533	7,653	-54	8,602	9,777	94.7	
1981[a]	31,908	6,679	8,057	-238	6,985	8,602	97.4	
1982	34,103	7,407	8,175	104	6,322	6,985	96.6	
1983	35,709	7,935	8,274	379	6,362	6,322	96.2	
1984[a]	34,968	7,559	8,584	1,424	6,761	6,362	99.9	
1985[a]	36,190	7,869	8,907	896	6,618	6,761	100.7	
1986	38,500	8,646	9,000	464	6,728	6,618	99.5	
1987	40,167	9,200	9,086	573	7,414	6,728	98.9	
1988[a]	39,444	8,832	9,392	1,932	8,786	7,414	103.3	
1989[a]	40,671	9,144	9,714	1,398	9,614	8,786	105.5	
1990	43,009	9,933	9,802	884	10,629	9,614	103.8	
1991	44,685	10,491	9,886	989	12,223	10,629	103.3	
1992	45,986	10,887	10,050	1,301	14,631	12,223	103.8	
Average	37,814	8,466	8,834	644	8,656	8,379	99.5	

[a] It is assumed that a drought occurs in this year.

year during 1970-79. Therefore it seems reasonable to assume that inflation in India's import prices will continue, at a rate of about 10 percent a year.[40]

The two administered prices in the wheat system are the procurement price and the issue price. It is assumed that they remain constant in real terms. In the past the procurement price has consistently lagged behind the market wholesale price.[41] But in recent years the government has been under intense and growing pressure from farmers to raise procurement prices to the full extent of, and even in excess of, increases in the full average cost of production. Therefore it is a plausible assumption that the procurement price will rise at least as much as the wholesale price index.

With persistent inflation, the government is also under growing pressure from consumers not to raise the real issue price for concessional sales of wheat, even though the government's losses from the wheat operation have increased. Therefore it can be expected that the real issue price of wheat will not change significantly. The government will not be able to raise it and cannot afford to lower it.

The import price of wheat used for projections is derived from the recent projections of the world price of wheat made by the World Bank.[42]

Endogenous Projections

The projections of Table 6, computed with exogenous quantities based on the above assumptions, and the reduced form of the model, reveal some interesting features of the existing wheat system. In the basic scenario, as output rises steadily year after year, concessional sales increase. Procurement increases too, except in 1980. But the behavior of imports and stocks is more complex. In the first three years imports are negative: a little more than half a million tons are "exportable" on the average.[43] After 1981 imports rise every year (except in 1984), apparently because the world wheat price declines relative to the price of all imports (Appendix 2, Table 29).[44] The model also reduces the large initial inventory (10.5 million tons in 1979) in the first four years and then adds to it each year until it reaches a high of 22.3 million tons by 1992.

Two features of these results should be noticed. First, given steady output growth, the system does ensure that concessional sales are adequate. In the basic scenario, issues per capita increase each year up to 1988 (from 10.84 to 11.53 kilograms) and then they decline to 11.44 kilograms (see Table 7). The projected average for 1979-92 (11.42 kilograms) is much higher than the actual average for 1961-78 (10.78 kilograms). In fact even the minimum of the projection period for the basic scenario (10.84 kilograms) is higher than the average in the past.

Total absorption per capita in the basic scenario also rises every year (except for minor dips in 1980 and 1992) to a high of 45.14 kilograms. Its minimum for the projection period (43.75 kilograms) too is much higher than the average for the estimation period (36.7 kilograms).

The second significant outcome is that even without optimization, the system under the basic scenario is sensitive to the import price of wheat. However, without any pressure to cut losses, it carries large inventories.

The projections for the drought scenario and the drought and exchange shortage scenario show how the system responds to shocks (Table 6). If a drought occurs, concessional sales are higher in the drought

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[40] World Bank, *World Development Report 1981* (Washington, D.C.: International Bank for Reconstruction and Development, 1981).

[41] Krishna and Raychaudhuri, "Some Aspects of Wheat Price Policy."

[42] World Bank, "Biennial Review of Commodity Price Forecasts," Washington, D.C., May 1982. (Mimeographed.)

[43] It is not proposed in this report that "exportable" surpluses that show up in some of the projections should actually be exported. All that is implied is that these quantities are not needed to maintain adequate concessional sales of wheat. Preferable alternative uses are mentioned in the concluding chapter.

[44] Earlier World Bank projections had world wheat prices rising slightly. Import price series based on these projections were also tried in the main programming run of the next chapter (exports allowed; minimum opening stocks 25 percent of issues). The series showed that losses were lower because earnings from "exports" were higher. But none of the other endogenous quantities changed significantly. These results are not reported here; they are available from the authors.

Table 7—Wheat model: projections of total annual absorption and concessional issues per capita, 1979-92

	Absorption				Issues			
	Consistent		Programming		Consistent		Programming	
Year	Basic Scenario	Drought and Drought and Exchange Shortage Scenarios	Basic Scenario	Drought and Drought and Exchange Shortage Scenarios	Basic Scenario	Drought and Drought and Exchange Shortage Scenarios	Basic Scenario	Drought and Drought and Exchange Shortage Scenarios
	(kilograms)							
1979	43.81	43.81	44.12	44.12	10.84	10.84	11.17	11.17
1980	43.75	42.46	43.14	42.77	11.23	11.43	10.62	11.71
1981	43.93	42.97	43.81	43.28	11.37	11.77	11.27	12.03
1982	44.15	48.90	44.44	44.21	11.44	11.67	11.75	11.96
1983	44.37	44.29	44.65	44.59	11.48	11.55	11.18	11.85
1984	44.55	43.35	43.99	43.66	11.51	11.72	11.66	11.98
1985	44.72	43.83	44.62	44.13	11.52	11.89	12.08	12.13
1986	44.85	44.61	45.14	44.87	11.53	11.74	12.05	11.96
1987	44.96	44.89	45.23	45.18	11.53	11.59	11.78	11.83
1988	45.04	43.94	44.53	44.22	11.53	11.71	10.97	11.92
1989	45.10	44.29	45.01	44.56	11.51	11.85	11.37	12.03
1990	45.13	44.91	45.39	45.20	11.49	11.69	11.71	11.90
1991	45.14	45.08	45.38	45.33	11.47	11.52	11.64	11.72
1992	45.13	45.11	45.39	45.35	11.43	11.45	11.62	11.61
Average	44.62	44.10	44.63	44.39	11.42	11.60	11.49	11.84

Notes: Absorption and issues remain the same in all programming runs whether exports are permitted or prohibited, and whether the minimum opening stock is 25 or 50 percent of issues. But they differ between the basic and the other two scenarios.

years than in the basic scenario, as additional consumers switch from the open market to fair price shops. The system meets this extra demand by raising annual average imports and keeping the average closing stock lower than in the basic scenario. Since average output is lower because of the drought, average procurement is also lower than when rainfall is normal. Thus the system changes the proportions in which it draws upon the three sources of supply to meet the increased demand for concessional sales that follow a drought. In the basic scenario, procurement provides 102.3 percent and imports 7.4 percent of issues; the inventory increases by 9.7 percent of issues (see Table 8). But in the drought scenario, procurement contributes less (95.8 percent) and imports more (11.4 percent) to issues. Inventories also accumulate less, about 7.2 percent of issues.

As one would expect, the average real price of wheat is higher in the drought scenario than in the basic, particularly in the drought years (Table 6).

In the drought and exchange shortage scenario, output, procurement, and issues are the same as in the drought scenario. But the system draws more on stocks: the average closing stock is 76 percent of what it is in the drought scenario. And to meet the shortage of foreign exchange, the system also keeps imports, on the average, at about two thirds of what they are in the drought scenario. An exportable surplus shows up in the first three years as in the basic scenario (see Table 6). But imports provide a smaller proportion (7.3 percent) of issues when a foreign-exchange shortage is added to drought than the proportion (11.4 percent) when drought occurs alone. And the increase of inventories is less than in the basic and drought scenarios (Table 8).

These projections reveal the Indian wheat system to be largely self-reliant: a 10 percent reduction in annual foreign exchange availability over 14 years affects neither output nor the real domestic price of wheat; the series for the drought and drought and exchange shortage scenarios remain the

Table 8—Wheat model: sources of projected issues, 1979-92

Projection/Scenario	Procurement (PR)	Imports (IM)	Stock Reduction[a]	Issues (IS)
		(percent)		
Consistent projections				
Basic	102.3	7.4	-9.7	100
Drought	95.8	11.4	-7.2	100
Drought and exchange shortage	95.8	7.3	-3.1	100
Programming projections				
Exports allowed, opening stock one fourth of IS				
Basic	102.1	-8.6	6.5	100
Drought	93.9	-0.2	6.3	100
Drought and exchange shortage	93.9	-0.2	6.3	100
No exports, opening stock one fourth of IS				
Basic	102.1	0.0	-2.1	100
Drought	93.9	0.6	5.5	100
Drought and exchange shortage	93.9	0.6	5.5	100

[a] This is the opening stock minus the closing stock.

same (see Table 6).

The projections also show that under the existing system, government decision variables adjust rationally and flexibly in response to environmental shocks.

Nevertheless, the system provides concessional supplies at a high financial cost to the exchequer. The present value of the system cost over 14 years ranges between Rs 75 and 105 billion (Table 6), with the cost concept and assumptions of the following chapter. Ways to reduce this cost need to be explored. A set of programming simulations is developed below for this purpose.

7

PROGRAMMING SIMULATIONS

It was noted in Chapter 2 that it was estimated that the Government of India would lose Rs 7 billion on its operations in foodgrains in the fiscal year 1981/82. An estimate of the loss from wheat operations alone is not available in official data. But if the cost per metric ton of issues is the same for all grains, the loss from wheat operations should be 58 percent of the aggregate loss, or about Rs 4 billion.

For this study, a different cost (loss) concept is used. It is the sum of three basic costs and three marketing costs; the revenue from issues is deducted. The three basic costs are the value of purchases (the procurement price [PP'] × procurement [PR]), the value of imports (the price of imports [PM] × imports [IM]), and the cost of storage (the average carrying cost [ST']) × (the opening stock [SO] + the closing stock [SC] × 0.5). The three marketing costs are the cost of procurement (15 percent of the procurement price), the cost of distribution of domestic and imported grain (15.6 percent of the procurement price), and the port clearance cost for imports (7.8 percent of the procurement price). These marketing cost percentages are computed from data in Garg and from the FCI (see Appendix 5).[45] The net cost is the sum of basic and marketing costs minus the sale revenue (the issue price [PI'] × [IS]).[46] Thus

$$
\begin{aligned}
C = {} & (PP' \times PR) + (PM \times IM) \\
& + [ST' \times (SO + SC) \times 0.5] + (0.15)(PP')(PR) \\
& + (0.156)(PP')(IS) + (0.078)(PP')(IM) \\
& - (PI')(IS) = (1.15\ PP')(PR) \\
& + (PM + 0.078\ PP')(IM) \\
& + (0.5)(ST')(SO + SC) \\
& - (PI' - 0.156\ PP')(IS).^{47} \qquad (9)
\end{aligned}
$$

The present value of this annual cost over the projection period (PVC) is minimized in the programming simulations. Thus

$$PVC = \sum_t C_t/(1+\delta)^{t-1979} \qquad (10)$$

where δ is the discount rate (assumed to be 10 percent) and t runs from 1979 to 1992.

The specification of the constraints is designed to reflect the concerns of the policymaker. If the interaction of the environment, the government, the producers, and the consumers, as captured in the structural equations, continues, only consistent projections of government-decision variables can be produced for the three scenarios, and the cost, defined in equation (9), associated with these quantities can be computed. But the cost cannot be substantially reduced. Its present value over the 14-year period is Rs 105, 96, and 75 billion under the three scenarios (Table 6). If this cost is to be reduced, the values of the government's decision variables must be allowed to vary. Since an increase in issues reduces the net cost by increasing sale revenue, issues must be allowed to be greater than or equal to what they are in the consistent projections. In consequence it becomes necessary to allow procurement to increase above consistent levels to support the increase in issues. However, the government would prefer not to let imports be larger than they are in the consistent projections because foreign exchange is limited.

Besides constraining imports, a decision has to be made about whether to permit exports or not. If exports are not permitted, imports have to be constrained, like other quantities, to being positive or zero. If exports are permitted, imports can be negative.

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[45] Garg, *State in Foodgrain Trade*

[46] PP', ST', and PI' are prices per ton, whereas PP, ST, and PI are prices per quintal.

[47] The annual cost computed with this expression would be higher than the cost shown as food subsidy and its wheat component in the budget of the central government. As Garg showed in detail, the budget underestimates the loss on the grain operations by about 20 percent (Garg, *State in Foodgrain Trade*).

Both alternatives are specified in different runs. The size of the stock would of course be determined by the stock-flow identity, given the solution values of purchases, imports, and issues. If no lower limit is set for the inventory, the model would reduce it to zero to minimize the storage cost component of C. Therefore the minimum permissible opening stock in any year has to be made a proportion of the solution value of issues. Two proportions are chosen for alternative programming runs, 25 and 50 percent. In the five years of shortage in the 1960s and three years in the 1970s, the actual ratio of the opening stock to issues averaged only 19 percent. In normal years it averaged 48 percent, and in the three surplus years, 1976-78, it exceeded 100 percent (Appendix 2, Table 35). Thus 25 percent is a reasonable lower limit of the opening stock/issue ratio even for bad years.[48] But in order to compute the cost of a greater measure of safety, simulations with a minimum 50 percent opening stock/issue ratio have also been made.

Thus the programming specification is to minimize PVC subject to

$$PR^* \geqq \overline{PR}, \quad (11)$$

$$IS^* \geqq \overline{IS}, \quad (12)$$

$$IM^* \leqq \overline{IM}, \quad (13)$$

$$SC^* = SO^* + PR^* + IM^* - IS^*, \quad (14)$$

$$SO^* \geqq 0.25 \text{ (or } 0.50) \; IS^*, \quad (15)$$

$$IM^* \geqq 0 \text{ (or } IM^* \gtreqless 0), \quad (16)$$

and

$$PR^*, IS^*, SC^*, SO^* \geq 0, \quad (17)$$

where quantities with a ($^-$) are obtained from the consistent projections and quantities with a (*) are given by the programming projections.

The two equalities for output (Q) and the real market price (PW2) are also included in the constraint structure, with solution values of other endogenous variables entering them, along with predetermined variables. But since these endogenous solution values are different in the consistent and programming simulations, the projected Q and PW2 series also differ.

The procedure here is similar to that of macroplanning exercises in which an open Leontief system is used to generate the consistent output vector; then the planners' objective function is maximized, subject to the input-output balance equations, upper and lower bounds on primary resources, and inequalities representing objectives other than those included in the objective function.[49]

However, the difference between the present model and macroplanning practice is that here the solution values of some decision variables (procurement, issues, and imports) given by the consistent equation system are turned into lower or upper bounds for these quantities in the programming model. The possibility of reducing costs cannot even be explored without this procedure. Moreover, the use of values from the consistent projections as upper or lower bounds in the programming model ensures that the feasibility zone is defined objectively and realistically.

The results of the main programming simulation, given in Table 9, vindicate the procedure. This is the simulation in which the lower limit for the opening stock is 25 percent of issues and exports are permitted. The programming-solution values turn out to be strikingly different from the consistency results in many respects (compare Tables 6 and 9).

The averages of output, procurement, issues, and real market price are almost equal in the programming and consistent simulations of the basic scenario. But the average carryover stock is cut down severely from 12.8 to 2.4 million tons (in the basic scenario). And exports are generated in 9 of the 14 years, instead of only the 3 initial years in the consistency run.

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[48] It should be noted that the ratios of stocks to issues are for the beginning of every calendar year. It is assumed that the stock will vary normally from month to month. Data show that variation in the monthly stock is small, ranging from the low of 7.2 percent of the annual offtake in April and 9.6 percent in September. The January stock (8.4 percent) is normally close to the monthly mean (8.33 percent). See Chopra, *Evolution of Food Policy*, p. 300.

[49] See Lance Taylor, "Theoretical Foundations and Technical Implications" and Daniel Loucks, "Planning for Multiple Goals," in Charles R. Blitzer, Peter B. Clark, and Lance Taylor, eds., *Economy-Wide Models and Development Planning* (London: Oxford University Press, 1975).

Table 9—Wheat model: programming projections with exports allowed and minimum opening stocks one fourth of issues, 1979-92

Scenario/ Year	Output (Q)	Procurement (PR)	Issues (IS)	Imports (IM)	Closing Stock (SC)	Opening Stock (SO)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
			(1,000 metric tons)					(Rs billion)
Basic								29.23
1979	32,986	7,423	7,309	-6,491	4,111	10,488	85.9	
1980	33,048	7,278	7,110	-2,058	2,221	4,111	90.4	
1981	33,848	7,468	7,720	88	2,057	2,221	92.4	
1982	34,825	7,713	8,230	566	2,107	2,057	92.9	
1983	35,920	8,016	8,428	307	2,001	2,107	94.8	
1984	37,030	8,323	8,006	-176	2,142	2,001	95.9	
1985	38,178	8,663	8,542	0	2,264	2,142	96.8	
1986	39,259	8,961	9,054	138	2,308	2,264	97.8	
1987	40,385	9,274	9,234	-149	2,200	2,308	98.8	
1988	41,517	9,588	8,799	-657	2,332	2,200	99.8	
1989	42,680	9,933	9,327	-483	2,455	2,332	100.7	
1990	43,797	10,243	9,819	-382	2,496	2,455	101.6	
1991	44,949	10,563	9,985	-524	2,550	2,496	102.5	
1992	46,124	10,912	10,200	-712	2,550	2,550	103.3	
Average	38,896	8,883	8,697	-752	2,414	2,381	96.7	
Drought								32.71
1979	32,986	7,423	7,309	-4,511	6,051	10,488	85.9	
1980[a]	31,108	6,546	7,837	-991	3,768	6,051	93.5	
1981[a]	31,951	6,687	8,238	36	2,253	3,768	96.9	
1982	34,123	7,410	8,380	839	2,122	2,253	95.4	
1983	35,704	7,927	8,488	1,166	2,727	2,122	95.6	
1984[a]	35,009	7,565	8,779	980	2,494	2,727	99.3	
1985[a]	36,226	7,865	9,092	1,024	2,291	2,494	101.5	
1986	38,519	8,627	9,165	565	2,318	2,291	100.2	
1987	40,210	9,198	9,272	145	2,389	2,318	99.2	
1988[a]	39,523	8,839	9,557	795	2,467	2,389	103.2	
1989[a]	40,746	9,141	9,867	755	2,496	2,467	105.4	
1990	43,070	9,932	9,984	69	2,514	2,496	104.0	
1991	44,716	10,470	10,055	-381	2,548	2,514	103.2	
1992	46,031	10,862	10,191	-671	2,548	2,548	103.6	
Average	37,852	8,464	9,015	-13	2,785	3,352	99.1	
Drought and exchange shortage								35.25
1979	32,986	7,423	7,309	-2,154	8,448	10,488	85.9	
1980[a]	31,108	6,546	7,837	-1,227	5,929	8,448	93.5	
1981[a]	31,951	6,687	8,238	-1,119	3,259	5,929	96.9	
1982	34,123	7,410	8,380	629	2,918	3,259	95.4	
1983	35,704	7,927	8,488	958	3,315	2,918	95.6	
1984[a]	35,009	7,565	8,779	707	2,808	3,315	99.3	
1985[a]	36,226	7,865	9,092	709	2,291	2,808	101.5	
1986	38,519	8,627	9,165	565	2,318	2,291	100.2	
1987	40,210	9,198	9,272	145	2,389	2,318	99.5	
1988[a]	39,523	8,839	9,557	795	2,467	2,389	103.2	
1989[a]	40,746	9,141	9,867	755	2,496	2,467	105.4	
1990	43,070	9,932	9,984	69	2,514	2,496	104.0	
1991	44,716	10,470	10,055	-381	2,548	2,514	103.2	
1992	46,031	10,862	10,191	-671	2,548	2,548	103.6	
Average	37,852	8,464	9,015	-15	3,303	3,871	99.1	

[a] It is assumed that a drought occurs in this year.

Thus programming cuts costs mainly by increasing exports and by decreasing the inventory to about a quarter of its initial size.

These drastic changes in inventory and exports, produced by optimization, reduce the PVC from Rs 105 billion in the consistency run to only Rs 29 billion in the basic programming simulation in Table 9.

In the drought and drought and exchange shortage scenarios, issues are larger than in the basic scenario (Table 9). Output and procurement remain lower, but the carryover is higher. And in 1988 and 1989, wheat is imported. The overall loss (PVC) is higher too, Rs 33 and 35 billion.

The outcomes vary as the minimum inventory specification is changed and exports are permitted or prohibited. Choosing two alternative inventory specifications and two export specifications, 12 different programming simulations are generated (Tables 9, 10, 11, and 12). These sensitivity runs indicate the trade-offs between the four concerns of policymakers: cost reduction, adequate concessional consumption, a stock large enough to be "safe," and self-reliance (reduced dependence on imports, economy in the use of foreign exchange, or both).

The average annual solution values of the simulations are summarized in Table 13 and Figure 1. The table confirms and quantifies the following relationships.

The basic PVC falls as the minimum inventory/issue ratio (SO/IS) is lowered to 50 and then to 25 percent; that is from about Rs 105 billion in the consistent projections to Rs 83 billion when exports are not allowed. But it falls to Rs 43 or 29 billion (with 50 or 25 percent inventory requirements) when exports are allowed. This means that the wheat operation cannot be profitable with the assumed constraints. But the loss (PVC) can be reduced by programming to about one fourth (27 percent) of the loss in the basic, consistent scenario if exports are allowed and the minimum stock requirement is only 25 percent of issues.

In all programming simulations, average concessional consumption per capita in the basic scenario, 11.5 kilograms per year, exceeds the average of the past 18 years (10.8 kilograms) as it does in the consistent simulations. In drought and drought and exchange shortage simulations it is even higher, 11.8 kilograms. Different inventory and export policy stipulations do not affect concessional consumption adversely (Table 7 and Appendix 2, Table 27). (For simulations with concessional sales linked to the overall grain deficit, see Appendix 6.)

The results for aggregate (concessional plus open-market) absorption per capita are similar. In the basic scenarios, its average, at 44.6 kilograms, is 21 percent greater than the average of the past (36.7 kilograms). In the other two scenarios, too, it is more than 44 kilograms (Table 7 and Appendix 2, Table 27).

There are two evident causes of consumption growth. Output growth increases availability, and income growth stimulates aggregate wheat consumption to grow at an even higher rate because the income elasticity of demand for wheat exceeds unity. Hence all simulations increase total absorption, though a tendency for basic absorption per capita to flatten out in the last four or five years of the projection period can be observed in Table 7.

Besides costs and total consumption, imports and inventories also change substantially with different specifications. But output, procurement, and issues do not change in the four sets of simulations, because of the constraints reflecting multiple objectives. The model can achieve economies mainly by adjusting imports and inventories (Table 13).

In the main programming runs, as in the consistent projections, the proportions in which issues are derived from procurement, imports, and inventories are rationally adjusted to different situations. In the drought scenarios, procurement is reduced, and exports are lower or imports higher than in the basic scenarios. And the programming models use inventory reduction more than the consistency model to meet issue requirements. But in all simulations, 90 to more than 100 percent of issues come from domestic procurement (Table 8).

The deflated market price is of course higher in the drought and drought and exchange shortage scenarios than in the basic. But it is insensitive to variations in the export and inventory specifications. The shocks are absorbed more by adjustments in imports and stocks than by price changes (Table 13).

The upshot of the various simulated scenarios is that the government can ensure that total and concessional consumption increase in normal years and in years of

Table 10—Wheat model: programming projections with exports allowed and minimum opening stocks half of issues, 1979-92

Scenario/ Year	Output (Q)	Procurement (PR)	Issues (IS)	Imports (IM)	Closing Stock (SC)	Opening Stock (SO)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
			(1,000 metric tons)					(Rs billion)
Basic								42.92
1979	32,986	7,423	7,309	-6,491	4,111	10,488	85.9	
1980	33,048	7,278	7,110	-271	4,008	4,111	90.4	
1981	33,848	7,468	7,720	358	4,115	4,008	92.4	
1982	34,825	7,713	8,230	616	4,214	4,115	92.9	
1983	35,920	8,016	8,428	201	4,003	4,214	94.8	
1984	37,030	8,323	8,006	0	4,320	4,003	95.9	
1985	38,178	8,663	8,542	85	4,527	4,320	96.8	
1986	39,259	8,961	9,054	183	4,617	4,527	97.8	
1987	40,385	9,274	9,234	-258	4,400	4,617	98.8	
1988	41,517	9,588	8,799	-525	4,664	4,400	99.8	
1989	42,680	9,933	9,327	-360	4,910	4,664	100.7	
1990	43,797	10,243	9,819	-340	4,993	4,910	101.6	
1991	44,949	10,563	9,985	-471	5,100	4,993	102.5	
1992	46,124	10,912	10,200	-712	5,100	5,100	103.3	
Average	38,896	8,883	8,697	-570	4,506	4,891	96.7	
Drought								46.69
1979	32,986	7,423	7,309	-3,859	6,743	10,488	85.9	
1980[a]	31,108	6,546	7,837	0	5,451	6,743	93.5	
1981[a]	31,951	6,687	8,238	290	4,190	5,451	96.9	
1982	34,123	7,410	8,380	1,024	4,244	4,190	95.4	
1983	35,704	7,927	8,488	827	4,510	4,244	95.6	
1984[a]	35,009	7,565	8,779	1,249	4,546	4,510	99.3	
1985[a]	36,226	7,865	9,092	1,263	4,582	4,546	101.5	
1986	38,519	8,627	9,165	591	4,636	4,582	100.2	
1987	40,210	9,198	9,272	216	4,779	4,636	99.5	
1988[a]	39,523	8,839	9,557	873	4,933	4,779	103.2	
1989[a]	40,746	9,141	9,867	784	4,992	4,933	105.4	
1990	43,070	9,932	9,984	87	5,028	4,992	104.0	
1991	44,716	10,470	10,055	-347	5,095	5,028	103.2	
1992	46,031	10,862	10,191	-671	5,095	5,095	103.6	
Average	37,852	8,464	9,015	166	4,916	5,301	99.1	
Drought and exchange shortage								47.80
1979	32,986	7,423	7,309	-2,154	8,448	10,488	85.9	
1980[a]	31,108	6,546	7,837	-1,065	6,091	8,448	93.5	
1981[a]	31,951	6,687	8,238	24	4,565	6,091	96.9	
1982	34,123	7,410	8,380	826	4,421	4,565	95.4	
1983	35,704	7,927	8,488	1,185	5,045	4,421	95.6	
1984[a]	35,009	7,565	8,779	968	4,799	5,045	99.3	
1985[a]	36,226	7,865	9,092	1,010	4,582	4,799	101.5	
1986	38,519	8,627	9,165	591	4,636	4,582	100.2	
1987	40,210	9,198	9,272	216	4,779	4,636	99.5	
1988[a]	39,523	8,839	9,557	873	4,933	4,779	103.2	
1989[a]	40,746	9,141	9,867	784	4,992	4,933	105.4	
1990	43,070	9,932	9,984	87	5,028	4,992	104.0	
1991	44,716	10,470	10,055	-347	5,095	5,028	103.2	
1992	46,031	10,862	10,191	-671	5,095	5,095	103.6	
Average	37,852	8,464	9,015	166	5,179	5,564	99.1	

[a] It is assumed that a drought occurs in this year.

Table 11—Wheat model: programming projections with no exports and minimum opening stocks one fourth of issues, 1979-92

Scenario/ Year	Output (Q)	Procure-ment (PR)	Issues (IS)	Imports (IM)	Closing Stock (SC)	Opening Stock (SO)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
			(1,000 metric tons)					(Rs billion)
Basic								83.22
1979	32,986	7,423	7,309	0	10,602	10,488	85.9	
1980	33,048	7,278	7,110	0	10,770	10,602	90.4	
1981	33,848	7,468	7,720	0	10,518	10,770	92.4	
1982	34,825	7,713	8,230	0	10,002	10,518	92.9	
1983	35,920	8,016	8,428	0	9,589	10,002	94.8	
1984	37,030	8,323	8,006	0	9,907	9,589	95.9	
1985	38,178	8,663	8,542	0	10,028	9,907	96.8	
1986	39,259	8,951	9,054	0	9,935	10,028	97.8	
1987	40,385	9,274	9,234	0	9,976	9,935	98.8	
1988	41,517	9,588	8,799	0	10,765	9,976	99.8	
1989	42,680	9,933	9,327	0	11,371	10,765	100.7	
1990	43,797	10,243	9,819	0	11,794	11,371	101.6	
1991	44,949	10,563	9,985	0	12,372	11,794	102.5	
1992	46,124	10,912	10,200	0	13,084	12,372	103.3	
Average	38,896	8,883	8,697	0	10,765	10,580	96.7	
Drought								44.46
1979	32,986	7,423	7,309	0	10,602	10,488	85.9	
1980[a]	31,108	6,546	7,837	0	9,310	10,602	93.5	
1981[a]	31,951	6,687	8,238	0	7,760	9,310	96.9	
1982	34,123	7,410	8,380	0	6,790	7,760	95.4	
1983	35,704	7,927	8,488	0	6,229	6,790	95.6	
1984[a]	35,009	7,565	8,779	0	5,015	6,229	99.3	
1985[a]	36,226	7,865	9,092	0	3,789	5,015	101.5	
1986	38,519	8,627	9,165	0	3,251	3,789	100.2	
1987	40,210	9,198	9,272	0	3,177	3,251	99.5	
1988[a]	39,523	8,839	9,557	7	2,467	3,177	103.2	
1989[a]	40,746	9,141	9,867	755	2,496	2,467	105.4	
1990	43,070	9,932	9,984	69	2,514	2,496	104.0	
1991	44,716	10,470	10,055	0	2,928	2,514	103.2	
1992	46,031	10,862	10,191	0	3,600	2,928	103.6	
Average	37,852	8,464	9,015	59	4,995	5,487	99.1	
Drought and exchange shortage								44.46
1979	32,986	7,423	7,309	0	10,602	10,488	85.9	
1980[a]	31,108	6,546	7,837	0	9,310	10,602	93.5	
1981[a]	31,951	6,687	8,238	0	7,760	9,310	96.9	
1982	34,123	7,410	8,380	0	6,790	7,760	95.4	
1983	35,704	7,927	8,488	0	6,229	6,790	95.6	
1984[a]	35,009	7,565	8,779	0	5,015	6,229	99.3	
1985[a]	36,226	7,865	9,092	0	3,789	5,015	101.5	
1986	38,519	8,627	9,165	0	3,251	3,789	100.2	
1987	40,210	9,198	9,272	0	3,177	3,251	99.5	
1988[a]	39,523	8,839	9,557	7	2,467	3,177	103.2	
1989[a]	40,746	9,141	9,867	755	2,496	2,467	105.4	
1990	43,070	9,932	9,984	69	2,514	2,496	104.0	
1991	44,716	10,470	10,055	0	2,928	2,514	103.2	
1992	46,031	10,862	10,191	0	3,600	2,928	103.6	
Average	37,852	8,464	9,015	59	4,238	4,730	99.1	

[a] It is assumed that a drought occurs in this year.

Table 12—Wheat model: programming projections with no exports and minimum opening stocks half of issues, 1979-92

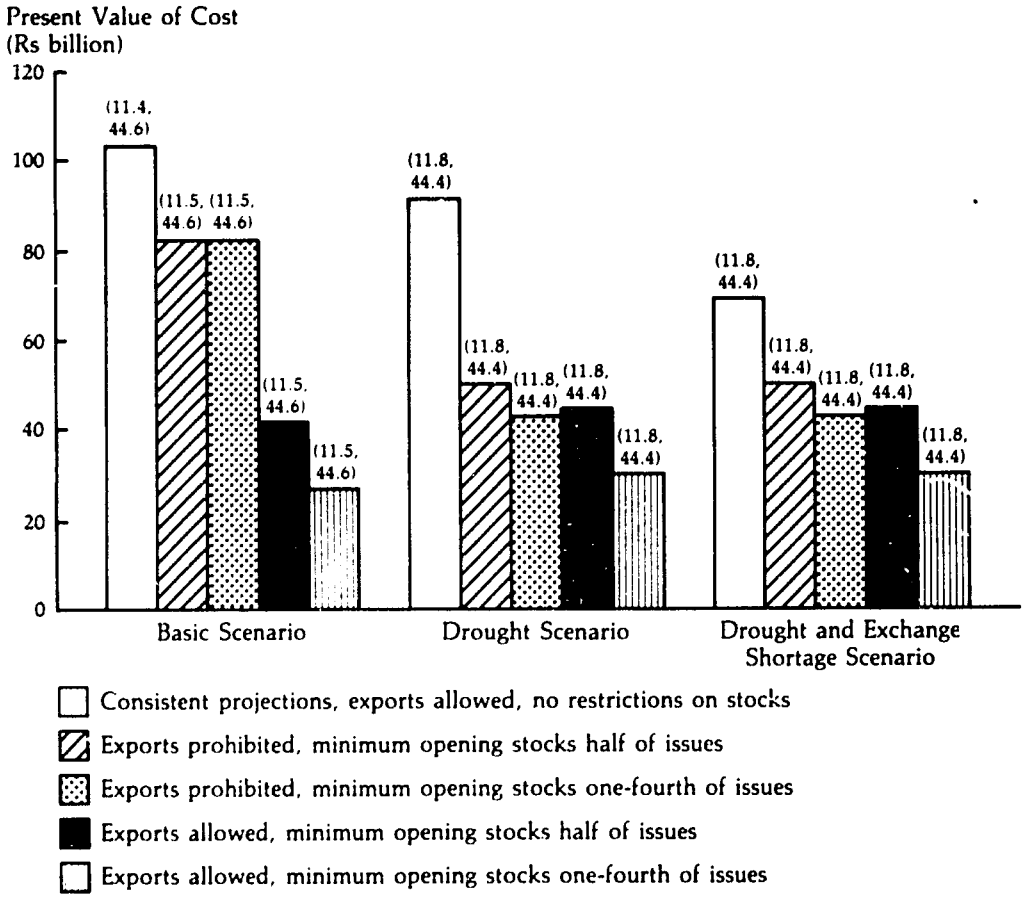
Scenario/ Year	Output (Q)	Procurement (PR)	Issues (IS)	Imports (IM)	Closing Stock (SC)	Opening Stock (SO)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
	(1,000 metric tons)							(Rs billion)
Basic								83.22
1979	32,986	7,423	7,309	0	10,602	10,488	85.9	
1980	33,048	7,278	7,110	0	10,770	10,602	90.4	
1981	33,848	7,468	7,720	0	10,518	10,770	92.4	
1982	34,825	7,713	8,230	0	10,002	10,518	92.9	
1983	35,920	8,016	8,428	0	9,589	10,002	94.8	
1984	37,030	8,323	8,006	0	9,907	9,589	95.9	
1985	38,178	8,663	8,542	0	10,028	9,907	96.8	
1986	39,259	8,961	9,054	0	9,935	10,028	97.8	
1987	40,385	9,274	9,234	0	9,976	9,935	98.8	
1988	41,517	9,588	8,799	0	10,765	9,976	99.8	
1989	42,680	9,933	9,327	0	11,371	10,765	100.7	
1990	43,797	10,243	9,819	0	11,794	11,371	101.6	
1991	44,949	10,563	9,985	0	12,372	11,794	102.5	
1992	46,124	10,912	10,200	0	13,084	12,372	103.3	
Average	38,896	8,883	8,697	0	10,765	10,580	96.7	
Drought								53.59
1979	32,986	7,423	7,309	0	10,602	10,488	85.9	
1980[a]	31,108	6,546	7,837	0	9,310	10,602	93.5	
1981[a]	31,951	6,687	8,238	0	7,760	9,310	96.9	
1982	34,123	7,410	8,380	0	6,790	7,760	95.4	
1983	35,704	7,927	8,488	0	6,229	6,790	95.6	
1984[a]	35,009	7,565	8,779	0	5,015	6,229	99.3	
1985[a]	36,226	7,865	9,092	794	4,582	5,015	101.5	
1986	38,519	8,627	9,165	591	4,636	4,582	100.2	
1987	40,210	9,198	9,272	216	4,779	4,636	99.5	
1988[a]	39,523	8,839	9,557	873	4,933	4,779	103.2	
1989[a]	40,746	9,141	9,867	784	4,992	4,933	105.4	
1990	43,070	9,932	9,984	87	5,028	4,992	104.0	
1991	44,716	10,470	10,055	0	5,442	5,028	103.2	
1992	46,031	10,862	10,191	0	6,113	5,442	103.6	
Average	37,852	8,464	9,015	239	6,158	6,470	99.1	
Drought and exchange shortage								53.59
1979	32,986	7,423	7,309	0	10,602	10,488	85.9	
1980[a]	31,108	6,546	7,837	0	9,310	10,602	93.5	
1981[a]	31,951	6,687	8,238	0	7,760	9,310	96.9	
1982	34,123	7,410	8,380	0	6,790	7,760	95.4	
1983	35,704	7,927	8,488	0	6,229	6,790	95.6	
1984[a]	35,009	7,565	8,779	0	5,015	6,229	99.3	
1985[a]	36,226	7,865	9,092	794	4,582	5,015	101.5	
1986	38,519	8,627	9,165	591	4,636	4,582	100.2	
1987	40,210	9,198	9,272	216	4,779	4,636	99.5	
1988[a]	39,523	8,839	9,557	873	4,933	4,779	103.2	
1989[a]	40,746	9,141	9,867	784	4,992	4,933	105.4	
1990	43,070	9,932	9,984	87	5,028	4,992	104.0	
1991	44,716	10,470	10,055	0	5,442	5,028	103.2	
1992	46,031	10,862	10,191	0	6,113	5,442	103.6	
Average	37,852	8,464	9,015	239	6,158	6,470	99.1	

[a] It is assumed that a drought occurs in this year.

Table 13—Wheat model: summary of projections, 1979-92 averages

Projection/Scenario	Output (Q)	Opening Stock (SO)	Procurement (PR)	Imports (IM)	Issues (IS)	Closing Stock (SC)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)	Issues Per Capita
			(1,000 metric tons)					(Rs billion)	(kilograms)
Consistent projections									
Basic	38,891	12,012	8,895	646	8,698	12,855	96.7	104.9	11.42
Drought	37,847	10,732	8,466	1,006	8,834	11,370	99.5	95.7	11.60
Drought and exchange shortage	37,847	8,379	8,466	644	8,834	8,656	99.5	75.2	11.60
Programming projections									
No exports, minimum SO half of IS									
Basic	38,896	10,580	8,883	0	8,697	10,765	96.7	83.2	11.49
Drought	37,852	6,470	8,464	239	9,015	6,158	99.1	53.6	11.84
Drought and exchange shortage	37,852	6,470	8,464	239	9,015	6,158	99.1	53.6	11.84
No exports, minimum SO one fourth of IS									
Basic	38,896	10,580	8,883	0	8,697	10,765	96.7	83.2	11.49
Drought	37,852	5,487	8,464	59	9,015	4,995	99.1	44.5	11.84
Drought and exchange shortage	37,852	5,487	8,464	59	9,015	4,995	99.1	44.5	11.84
Exports permitted, minimum SO half of IS									
Basic	38,896	4,891	8,883	570	8,697	4,506	96.7	42.9	11.49
Drought	37,852	5,301	8,464	166	9,015	4,916	99.1	46.7	11.84
Drought and exchange shortage	37,852	5,564	8,464	166	9,015	5,179	99.1	47.8	11.84
Exports permitted, minimum SO one fourth of IS									
Basic	38,896	2,981	8,883	-752	8,697	2,414	96.7	29.2	11.49
Drought	37,852	3,352	8,464	-13	9,015	2,785	99.1	32.7	11.84
Drought and exchange shortage	37,852	3,871	8,464	-15	9,015	3,303	99.1	35.2	11.84
Exports permitted, minimum SO one fourth of IS, stable consumption									
Basic	33,896	2,981	8,883	-752	8,697	2,414	96.7	29.2	11.49
Drought	37,085	4,927	8,314	849	9,721	4,369	96.7	43.7	12.76
Drought and exchange shortage	37,085	5,766	8,314	849	9,721	5,208	96.7	47.8	12.76

Figure 1 — Cumulative cost of government operations and per capita consumption of wheat in different scenarios, 1979-92



Note: The numbers in parentheses are average (1979-92) issues and absorption per capita per year in kilograms.

drought and exchange shortage with about 30-35 percent of the present operational loss, if inventory and trade policies are rationalized.

The shadow prices associated with the constraints of the main programming run (Table 9) are shown below.[50]

Constraint	Shadow Price (Rs/ton)
Opening stock	516.0
Procurement	356.5
Imports	148.6
Issues	0.0

They suggest that the present value of the total loss between 1979 and 1992 may be reduced if the constraints are relaxed marginally: the relaxation of the minimum inventory requirement will give the biggest reduction, followed by the easing of the minimum procurement and the maximum import requirements. The shadow price associated with the minimum issue constraint is zero; the model would reduce costs by increasing issues, but other constraints do not allow this.

It can be noted that average consumption does diminish somewhat in the drought and drought and exchange shortage scenarios,

[50] The reported shadow price is the change in PVC associated with a one-ton change in the constraint level.

from 44.6 to 44.4 kilograms per capita per year (Table 7). And the average index of the real market price does rise from 96.7 to 99.1 (Table 12). Suppose that the government desires no reduction whatever in total consumption and no rise in the real price of wheat when drought or an exchange shortage occurs. An additional constraint, requiring stable consumption, can then be included in the program. The solution values for this simulation are shown in Table 14 and the bottom of Table 13. The extra stability requirement raises average imports and inventory. The concessional sales in the drought and drought and exchange shortage scenarios then rise to 12.76 kilograms per capita per year. And PVC rises 33.6 percent in the drought scenario and 35.8 percent in the drought and exchange shortage scenario, compared to the lowest-cost case, without the stability constraint (Table 9). Still, the cost would be 46 percent of the cost in the consistent projection with the drought scenario. Thus even consumption and price stability in years of shortage can be attained with less than half of the likely loss under current policies if government operations are rationalized.

It is difficult to indicate the policy option that might be preferred by policymakers. The choice would depend on the relative importance attached to the objectives mentioned earlier. The option of Table 9 (with 25 percent minimum inventory requirements and exports allowed) promises the maximum reduction of the basic cost (72 percent). But if policymakers are averse to the notion of having exports and reducing inventory,[51] they may prefer the simulations prohibiting exports which reduce the basic cost by only 21 percent (Table 13). If, on the other hand, they attach the heaviest weight to consumption and price stability, the most preferred case is the one where stable consumption is assumed. It allows exports but ensures that consumption and real prices do not change even when shortages occur, though at some extra cost; the cost is 25-33 percent higher than in the option of Table 9.

[51] The simulations in this report are based on the assumption that the official inventory figures represent real stocks. It has been reported that the actual stocks may be smaller because storage losses are heavy.

Table 14—Wheat model: programming projections with exports allowed, minimum opening stocks one fourth of issues, and stable consumption, 1979-92

Scenario/ Year	Output (Q)	Procurement (PR)	Issues (IS)	Imports (IM)	Closing Stock (SC)	Opening Stock (SO)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
			(1,000 metric tons)					(Rs billion)
Basic								29.23
1979	32,986	7,423	7,309	-6,491	4,111	10,488	85.9	
1980	33,048	7,278	7,110	-2,058	2,221	4,111	90.4	
1981	33,848	7,468	7,720	88	2,057	2,221	92.4	
1982	34,825	7,713	8,230	566	2,107	2,057	92.9	
1983	35,920	8,016	8,428	307	2,001	2,107	94.8	
1984	37,030	8,323	8,006	-176	2,142	2,001	95.9	
1985	38,178	8,663	8,542	0	2,264	2,142	96.8	
1986	39,259	8,961	9,054	138	2,308	2,264	97.8	
1987	40,385	9,274	9,234	-149	2,200	2,308	98.8	
1988	41,517	9,588	8,799	-657	2,332	2,200	99.8	
1989	42,680	9,933	9,327	-483	2,455	2,332	100.7	
1990	43,797	10,243	9,819	-382	2,496	2,455	101.6	
1991	44,949	10,563	9,985	-524	2,550	2,496	102.5	
1992	46,124	10,912	10,200	-712	2,550	2,550	103.3	
Average	38,896	8,883	8,697	-752	2,414	2,981	96.7	
Drought								43.67
1979	32,986	7,423	7,309	-1,563	9,039	10,488	85.9	
1980[a]	31,108	6,669	8,206	0	7,502	9,039	90.4	
1981[a]	31,559	6,749	9,013	540	5,778	7,502	92.4	
1982	33,268	7,224	9,109	1,242	5,135	5,778	92.9	
1983	34,861	7,683	9,026	1,527	5,320	5,135	94.8	
1984[a]	34,370	7,488	9,509	1,275	4,575	5,320	95.9	
1985[a]	35,399	7,791	10,112	1,213	3,466	4,575	96.8	
1986	37,369	8,368	10,122	1,312	3,025	3,466	97.8	
1987	39,101	8,871	9,960	1,470	3,406	3,025	98.8	
1988[a]	38,704	8,705	10,389	1,429	3,150	3,406	99.8	
1989[a]	39,796	9,028	10,956	1,510	2,732	3,150	100.7	
1990	41,836	9,627	10,927	1,253	2,685	2,732	101.6	
1991	43,615	10,145	10,739	587	2,678	2,685	102.5	
1992	45,217	10,627	10,712	85	2,678	2,678	103.3	
Average	37,085	8,314	9,721	849	4,369	4,927	96.7	
Drought and exchange shortage								47.78
1979	32,968	7,423	7,309	0	10,602	10,488	85.9	
1980[a]	31,108	6,669	8,206	158	9,223	10,602	90.4	
1981[a]	31,559	6,749	9,013	438	7,397	9,223	92.4	
1982	33,268	7,224	9,109	1,124	6,637	7,397	92.9	
1983	34,861	7,683	9,026	1,392	6,686	6,637	94.8	
1984[a]	34,370	7,488	9,509	1,120	5,785	6,686	95.9	
1985[a]	35,399	7,791	10,112	1,034	4,498	5,785	96.8	
1986	37,369	8,368	10,122	1,106	3,850	4,498	97.8	
1987	39,101	8,871	9,960	1,233	3,994	3,850	98.8	
1988[a]	38,704	8,705	10,389	1,155	3,465	3,994	99.8	
1989[a]	39,796	9,028	10,956	1,195	2,732	3,465	100.7	
1990	41,836	9,627	10,927	1,253	2,685	2,732	101.6	
1991	43,615	10,145	10,739	587	2,678	2,685	102.5	
1992	45,217	10,627	10,712	85	2,678	2,678	103.3	
Average	37,085	8,314	9,721	849	5,208	5,766	96.7	

Note: Availability for both the drought scenarios is the same as in the basic scenario.

[a] It is assumed that a drought occurs in this year.

8

CONCLUDING REMARKS

The wheat revolution tripled India's wheat output from about 11 million tons in the early 1960s to 34 million tons in the five years ending in 1982. It has brought about drastic changes in the operation of the dual-market system. Concessional sales remained between 4.5 and 8 million tons a year (as in most years since 1964). But imports, which ranged between 3 and 8 million tons in all but two years in the 1960s and early 1970s, were negligible in the five years ending in 1981. And the closing stock, which seldom exceeded 3 million tons before 1975, rose above 10 million tons during 1977-79.

The adjustments made to the new situation can only be regarded as partial and passive. For without an abnormal increase in the concessional offtake, the government has simply let the inventory grow. As a result the annual cost of the wheat operation has escalated to at least Rs 4 billion.

The behavioral model of the dual-market system estimated here projects the demand for concessional sales to be about 8-9 million tons a year over the next decade in both normal and drought years. The need for the government to meet this demand is likely to remain because the low rate of growth of national income per capita (an average of only 1.3 percent a year) is not likely to increase, the growth rate of the population has not decelerated, and the incidences of poverty (at least 50 percent) and malnutrition (at least 23 percent) remain undiminished.[52]

With the current operating rules this need will be met at a heavy cost: Rs 96-105 billion of present value (PVC) over 1979-92 (Table 6, basic and drought scenarios). But programming simulations show that, given the prevailing production and price trends, this cost can be reduced by 30-35 percent (to Rs 29-33 billion; see Table 9, basic and drought scenarios) if the government rationalizes the small amounts of imports that may be required in some years and cuts average inventory down to about one fourth of its present size, though never to less than one fourth of issues. This inventory ratio will be large enough to meet issue requirements in normal and in bad years.

According to the model, the excess inventory in some years can be exported. But it would be better to use it to support a food-for-work program and a supplemental nutrition program.[53]

The crucial conditions for the success of the new operating rules, implicit in the assumptions underlying the projections, are that the wheat irrigation ratio continues to grow by 0.8-0.9 percentage points each year and that real (deflated) procurement and issue prices are kept stable around recent levels.

Optimal solution values for all the decision variables can be computed, with the kind of dynamic programming model presented in this paper, for every coming calendar year, using the crop and foreign exchange forecasts and information about changes in exogenous quantities, which are normally available to the government by November. The parameters of the model itself can be revised as more observations become available, and its specifications can be improved to reflect structural changes.

One of the by-products of model simulations of the kind presented here is that they indicate the demands that a rational grain management system of a country is likely to make on world supplies. Estimates of the grain import requirements of major importing countries are best made with models that reflect the peculiarities of their dual regimes. With rational management of wheat policy, India may need to import, in the next decade, only between half a million and a million tons of wheat in normal years, and little more than a million tons in drought years.

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[52] Raj Krishna, *India's Sticky Economy* (Ahmedabad: Vikram A. Sarabai Ama Memorial Trust, 1981); and P. V. Sukhatme, *Nutrition and Poverty*, Ninth Lal Bahadur Shastri Memorial Lecture (New Delhi: Indian Agricultural Research Institute, 1977)

[53] A part of the loss from the wheat operation will thus be converted into planned outlays on formation of rural material and human capital

APPENDIX 1:
SOME EARLIER GRAIN MODELS FOR INDIA

In the corpus of econometric research on Indian agriculture during the last two decades, a large number of single-equation relationships have been estimated for individual crops or groups of crops.[54] At least five multi-equation grain models have also been estimated.[55] The model presented in this report builds and improves upon the specifications that proved their merit in these studies.[56]

The models by Mann, Barnum, and Rogers, Srivastava, and Heady were reviewed and improved upon by Blandford and von Plocki. The models by Blandford and von Plocki and by Gupta remain the best available cereal models so far. It may be useful to review the specifications and limitations of these two models as background to the structure of the wheat model presented in this report.

The Blandford and von Plocki Model

The equations of the Blandford and von Plocki model are[57]

$$A = f_1 (A_{t-1}, P_{t-1}, R, N), \qquad \text{(BVP1)}$$

where

A = area sown with cereals,

P = the deflated wholesale price index for cereals,

R = the rainfall index, and

N = population.

$$Y = f_2 (R, T), \qquad \text{(BVP2)}$$

where

Y = cereal yield, and

T = time trend.

$$QDC = f_3 (P, PS, IC), \qquad \text{(BVP3)}$$

where

QDC = per capita demand for cereals,

PS = the deflated price index of consumption substitutes for cereals, and

IC = real per capita consumer income.

$$I = f_4 (QS, QI), \qquad \text{(BVP4)}$$

where

I = total real consumer income,

QS = total domestic cereal supply, and

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[54] In some of these studies, area or output response functions were estimated (for example, in I. J. Ahluwalia, *Behavior of Prices and Outputs in India* [Delhi: Macmillan and Co., 1979]; and Krishna and Raychaudhuri, *Some Aspects of Wheat and Rice Policy*). In others, demand equations were estimated. (Examples are S. Birla, "Regional Demand Analysis of Major Foodgrains in India" [Ph.D. thesis, University of Illinois, 1970]; and Pandey, "The Analysis of Demand for Foodgrains".) Marketed surplus functions and price determination functions were also estimated (examples of the former are in Raj Krishna, "The Marketable Surplus Function for a Subsistence Crop," *Economic Weekly*, February 1965; and Pranab K. Bardhan and Kalpana Bardhan, "Price Response of Marketed Surplus of Foodgrains," *Oxford Economic Papers* 50 [No. 2, 1963], examples of the latter are in R. Thamarajakshi, "Determinants of Wheat Prices," *Agricultural Situation in India* 14 [May 1970]: 120-136; and N. Krishnaji, "Wheat Price Movements," *Economic and Political Weekly*, June 30, 1973, pp. A-42 – A-53, both were also estimated in Ahluwalia, *Behavior of Prices and Outputs*).

[55] Jitendar S. Mann, "The Impact of Public Law 480 Imports on Prices and Domestic Supply of Cereals in India," *American Journal of Agricultural Economics* 49 (February 1967): 131-146; Howard Barnum, "Simulation of the Market for Foodgrains in India," *American Journal of Agricultural Economics* 53 (May 1971): 269-274; Keith D. Rogers, Uma K. Srivastava, and Earl O. Heady, "Modified Price, Production, and Income Impacts of Food Aid Under Market Differentiated Distribution," *American Journal of Agricultural Economics* 54 (May 1972): 201-208; Gupta, *Public Distribution of Foodgrains*; and Blandford and von Plocki, "Evaluating the Disincentive Effect."

[56] All of these studies are on cereals and foodgrains; but a disaggregated study of wheat is essential because, though rice dominates Indian grain output, wheat has been the mainstay of government operations. It accounts for 48 percent of government procurement, 58 percent of concessional sales, 62 percent of government stocks, and 17 percent of grain imports. (These ratios are averages for five years [1973-77].) Besides, four of the five studies used time series only up to 1968 and one (Gupta, *Public Distribution of Foodgrains*) used only ten observations (1966-75).

[57] The subscript (t) is suppressed. But the subscript (t-1) is retained where a variable is lagged.

QI = an index of industrial production.

$$M = f_5 (QG, FX), \qquad (BVP5)$$

where

M = commercial imports,

QG = the expected "food gap," and

FX = effective level of foreign exchange reserves.

$$W = f_6 (QG, S, PR), \qquad (BVP6)$$

where

W = withdrawals,

S = beginning period stocks, and

PR = internal procurement of cereals by the government.

$$QS = A \times Y. \qquad (BVP7)$$

$$QD = 0.875\ QS + M + W + PL480, \qquad (BVP8)$$

where

QD = total consumer demand for cereals, and

PL480 = total food aid imports.

$$QDC = QD/N. \qquad (BVP9)$$

$$IC = I/N. \qquad (BVP10)$$

$$QG = QM - 0.875\ QS - PL480, \qquad (BVP11)$$

where

QM = the physiologically necessary minimum requirement of cereals.

This model can be usefully amended in several ways. There is no direct government purchase equation or a direct concessional sales equation in the model; these can be included. A proxy for technological change needs to be entered in the area function (BVP1) instead of population, for farmers' land-allocation decisions depend on expected profit that, in turn, depends on expected productivity as well as expected prices. Relative price and lagged yield variables need to be added to the yield function (BVP2), for input use responds to prices with a lagged adjustment. Since the major demand substitution in the wheat market is the one between the open market and the concessional market, deflated prices in both markets need to be entered in the demand (or absorption) function (BVP3). The income-generation equation (BVP4) is evidently too simplified. The processes of national income generation are too complex to be endogenized in a sector model. Therefore aggregate income is better kept exogenous in a commodity study.

The Gupta Model

The four equations of the Gupta model are:

$$QP = f_1 (PR_{t-1}, A_{t-1}, T), \qquad (G1)$$

where

QP = net grain production per capita,

PR = the ratio of the grain price index to the nongrain crop price index,

A = the area index, and

T = the yield index.

$$QPG = f_2 (PPD_{t-1}, QPD_{t-1}, PFG, QP), \qquad (G2)$$

where

QPG = grain procurement per capita,

PPD = the deflated government issue price index,

QPD = concessional sales per capita, and

PFG = the deflated grain price index.

$$QOM = f_3 (PPD, Y, QPD, PFG), \qquad (G3)$$

where

QOM = open-market grain demand per capita, and

Y = real income per capita.

$$QP = QPG + QOM. \qquad (G4)$$

This model, too, can be improved. Concessional sales and import equations need to be added. The government issue price is

used unnecessarily in the procurement equation as a proxy for the government purchase price although purchase-price series are available. The ratio between the two has varied. Also, an important determinant of procurement, namely, output, needs to be included in the procurement equation. Concessional sales influence purchase requirements, but actual procurement depends inter alia on output. Since output is simply the product of current area and current yield, it is not appropriate to specify it as a function of lagged area, current yield, and the relative price. It is better to specify output (or area and yield separately) as a function of relative prices, technology proxies, rainfall, and the lagged dependent variable. Lastly, it is not necessary to include both concessional sales and the concessional sale price as explanatory variables in the open-market demand equation, for the two are closely correlated.

APPENDIX 2: SUPPLEMENTARY TABLES

Table 15—Government supplies and total availability of all foodgrains and wheat, 1951-80

Calendar Years	Foodgrains			Wheat		
	Government Supplies	Total Availability	Ratio of Government Supplies to Total Availability	Government Supplies	Total Availability	Ratio of Government Supplies to Total Availability
	(million metric tons)		(percent)	(million metric tons)		(percent)
1951-55	4.6	57.6	8.0	2.0	6.6	30.3
1956-60	3.9	66.8	5.8	2.8	10.8	25.9
1961-65	6.5	77.9	8.3	4.6	14.3	32.2
1966-70	11.1	81.9	13.6	6.4	18.1	35.4
1971-75	10.4	93.3	11.1	6.1	23.6	25.8
1976-80	11.5	105.1	10.9	6.9	28.6	24.1

Sources. Centre for Monitoring the Indian Economy, *Basic Statistics Relating to the Indian Economy* (Bombay: CMIE, 1980); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 16—Share of wheat in total foodgrain availability and concessional sales, 1951-80

Calendar Years	Concessional Sales: Ratio of Wheat to Foodgrains	Availability: Ratio of Wheat to Foodgrains
	(percent)	
1951-55	43.5	11.5
1956-60	71.8	16.2
1961-65	70.8	18.4
1966-70	57.7	22.1
1971-75	58.7	25.3
1976-80	60.0	27.2

Sources. Centre for Monitoring the Indian Economy, *Basic Statistics Relating to the Indian Economy* (Bombay: CMIE, 1980); and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 17—Procurement of wheat and all foodgrains, 1951-81

Year	Wheat Procurement	Foodgrain Procurement	Ratio of Wheat Procurement to Foodgrain Procurement
	(million metric tons)		(percent)
1951	799	3,826	20.88
1952	792	3,477	22.78
1953	212	2,094	10.12
1954	...	1,429	...
1955	...	15	...
Average	361	2,168	16.65[a]
1956	...	37	...
1957	...	294	...
1958	...	525	...
1959	265	1,807	14.67
1960	395	1,275	30.98
Average	132	788	16.75[a]
1961	20	541	3.70
1962	...	479	...
1963	5	750	0.67
1964	90	1,430	6.29
1965	379	4,018	9.43
Average	99	1,444	6.86[a]
1966	219	4,009	5.46
1967	779	4,462	17.46
1968	2,373	6,805	34.86
1969	2,417	6,381	37.88
1970	3,183	6,714	47.41
Average	1,794	5,674	31.62[a]
1971	5,088	8,857	57.45
1972	5,024	7,665	65.54
1973	4,531	8,424	53.79
1974	1,885	5,645	33.39
1975	4,098	9,563	42.85
Average	4,125	8,031	51.36[a]
1976	6,618	12,853	51.44
1977	5,171	9,974	51.84
1978	5,470	11,098	49.29
1979	8,000	13,846	57.78
1980	5,866	11,168	52.53
Average	6,225	11,788	52.81[a]
1981	6,585	12,729	51.73

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

[a] This figure was derived as the ratio of the average tonnage for the period

Table 18—Imports of wheat and all foodgrains, 1951-81

Year	Wheat Imports	Foodgrain Imports	Ratio of Wheat Imports to Foodgrain Imports
	(million metric tons)		(percent)
1951	3,063	4,801	63.80
1952	2,551	3,926	64.98
1953	1,711	2,035	84.08
1954	198	832	23.80
1955	440	513	85.77
Average	1,593	2,421	65.80[a]
1956	1,104	1,372	80.47
1957	2,879	3,620	79.53
1958	2,709	3,210	84.39
1959	3,543	3,851	92.00
1960	4,376	5,119	85.49
Average	2,922	3,434	85.09[a]
1961	3,090	3,486	88.64
1962	3,249	3,629	89.53
1963	4,071	4,536	89.75
1964	5,621	6,252	89.91
1965	6,572	7,439	88.35
Average	4,521	5,068	89.21[a]
1966	7,827	10,311	75.91
1967	6,400	8,659	73.91
1968	4,766	5,671	84.04
1969	3,090	3,824	80.81
1970	3,406	3,547	96.02
Average	5,098	6,402	79.63[a]
1971	1,811	2,010	90.10
1972	-492	-498	98.80
1973	2,413	3,587	67.27
1974	4,203	4,827	87.07
1975	7,016	7,407	94.76
Average	2,990	3,467	86.24[a]
1976	5,832	6,515	89.52
1977	547	555	98.56
1978	...	...	100.00
1979	...	...	100.00
1980	...	...	100.00
1981	777	777	100.00
Average	1,193	1,308	91.21[a]

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

[a] This figure was derived as the ratio of the average imports for the period.

Table 19—Shares of procurement, imports, and stock depletion in the concessional sales of wheat, 1961-78

Year	Procurement	Ratio of Procurement to Concessional Sales	Imports	Ratio of Imports to Concessional Sales	Stock Reduction	Ratio of Stock Reduction to Concessional Sales	Concessional Sales
	(1,000 metric tons)	(percent)	(1,000 metric tons)	(percent)	(1,000 metric tons)	(percent)	(1,000 metric tons)
1961	20	0.67	3,090	103.59	-127	-4.26	2,983
1962	0	0.00	3,249	100.67	-28	-0.87	3,221
1963	5	0.13	4,071	106.68	-260	-6.81	3,816
1964	90	1.33	5,621	82.84	1,074	15.83	6,785
1965	375	6.31	6,573	110.67	-1,009	-16.98	5,939
1966	219	2.69	7,784	95.60	139	1.71	8,142
1967	779	10.58	6,348	86.18	239	3.24	7,366
1968	2,352	40.88	4,766	82.81	-1,363	-23.69	5,755
1969	2,417	46.52	3,090	59.48	-312	-6.00	5,195
1970	3,183	59.53	3,425	64.05	-1,261	-23.58	5,347
1971	5,088	114.21	1,814	40.72	-2,447	-54.93	4,455
1972	5,024	86.57	314	5.41	465	8.02	5,803
1973	4,531	63.55	2,414	33.86	185	2.59	7,130
1974	1,885	33.25	4,203	74.14	-419	-7.39	5,669
1975	4,098	54.31	7,016	92.99	-3,569	-47.30	7,545
1976	6,618	131.96	5,832	116.29	-7,435	-148.25	5,015
1977	5,171	80.85	547	8.55	678	10.60	6,396
1978	5,470	79.79	300	4.38	1,085	15.83	6,855

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 20—Ratio of wheat procurement to production, 1959/60-1979/80

Marketing Year	Ratio of Procurement to Output
1959/60	2.98
1960/61	3.53
1961/62	1.82
1962/63	...
1963/64	0.84
1964/65	0.95
1965/66	3.78
1966/67	1.90
1967/68	7.84
1968/69	13.89
1969/70	12.80
1970/71	15.89
1971/72	21.40
1972/73	18.96
1973/74	18.32
1974/75	8.98
1975/76	16.80
1976/77	22.89
1977/78	17.80
1978/79	17.25
1979/80	22.51

Sources: Raj Krishna and G. S. Raychaudhuri, "Some Aspects of Wheat Price Policy in India," *Indian Economic Review* (October 1979), and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Note: The marketing year ends in March. The average ratio for 1959/60-1966/67 was 1.97; for 1967/68-1974/75, 14.76, and for 1975/76-1979/80, 19.45.

Table 21—Procurement of wheat in Punjab and Haryana and in all India, 1967-77

Year	Procurement in Punjab and Haryana	All-India Procurement	Ratio of Procurement in Punjab and Haryana to All-India Procurement
	(1,000 metric tons)		(percent)
1967	630	799	78.8
1968	1,572	2,373	66.2
1969	2,145	2,417	88.7
1970	2,845	3,183	89.4
1971	3,647	5,088	71.7
1972	3,997	5,024	79.6
1973	3,293	4,531	72.7
1974	1,332	1,885	70.7
1975	2,794	4,098	68.2
1976	3,849	6,618	58.2
1977	4,142	5,170	80.1
Total	30 246	41,186	73.4

Source: R. N. Chopra, *Evolution of Food Policy in India* (Delhi: MacMillan and Co., 1981).

Table 22—Average difference between the wholesale and procurement prices of wheat, selected states and years

State	Period	Number of Years	Difference Between the Wholesale and Procurement Prices of Wheat
			(percent)
Bihar	1951/52-1953/54	3	28.7
	1965/66-1975/76	10	29.3
Gujarat	1951/52-1952/53	2	32.4
	1965/66-1974/75	10	27.3
Madhya Pradesh	1952/53-1953/54	2	9.1
	1965/66-1975/76	11	17.2
Rajasthan	1951/52-1953/54	3	16.1
	1967/68-1975/76	9	19.9
Uttar Pradesh	1951/52-1952/53	2	16.1
	1966/67-1975/76	10	18.5
Punjab (Mexican varieties)	1967/68	1	0.0
	1968/69	1	0.0
	1969/70	1	0.0
	1970/71	1	0.0
	1971/72	1	5.0
	1972/73	1	9.0
	1973/74	1	4.0
	1974/75	1	10.0

Sources: Raj Krishna and G. S. Raychaudhuri, "Some Aspects of Wheat Price Policy in India," *Indian Economic Review* (October 1979). The figures for Punjab are from D. S. Sidhu, *Price Policy for Wheat in India* (New Delhi: S. Chand and Co., 1979).

Table 23—Difference between the cost of production and the procurement price of wheat, various states, districts, and years

State/District/Crop	Period	Average Proportion by Which the Procurement Price Exceeds the Cost of Production
		(percent)
Haryana		
Karnal, Rohtak, and Jind Tehsil of Sangrur	1961/62 – 1963/64	
Unirrigated wheat		-23.3
Irrigated wheat		-28.6
Bihar		
South Monghyr	1957/58 – 1959/60	-27.0
Shahabad	1960/61 – 1962/63	-37.9
Rajasthan		
Pali	1962/63 – 1964/65	-29.2
Punjab		
Amritsar and Ferozepur	1954/55 – 1956/57	
Unirrigated wheat		-14.0
Irrigated wheat		-1.5
Ferozepur	1967/68 – 1969/70	
Desi wheat		+11.0
Mexican wheat		+30.0
Uttar Pradesh		
Meerut and Muzaffarnagar	1955/56 – 1956/57	
Unirrigated wheat		-21.0
Irrigated wheat		+8.0
Deoria	1966/67 – 1968/69	
Unirrigated wheat		+39.6
Irrigated wheat		+21.0
Muzaffarnagar	1966/67 – 1968/69	
Unirrigated wheat		+41.0
Irrigated wheat		+66.0

Source: P. J. Krishna and G. S. Raychaudhuri, "Some Aspects of Wheat Price Policy in India," *Indian Economic Review* (October 1979).

Notes: The cost data are from samples taken from districts selected in farm management studies as representative of states or regions. They are averages of the two or three crop years of the period. The sample, taken each year, usually covered 200 farms, with the number of farms in each size class proportional to the number of farms in that class in the district.

Table 24—Procurement price and cost of production of high-yielding wheat, Punjab, 1967/68-1977/78

Production Year	Average Cost[a]	Procurement Price in Marketing Year	Proportion by Which the Procurement Price Exceeds the Average Cost
	(Rs/quintal)		(percent)
1967/68	50.02	76.00	51.94
1968/69	67.45	76.00	12.68
1969/70	62.69	76.00	21.23
1970/71	60.96	76.00	24.51
1971/72	59.71	76.00	27.28
1972/73	67.10	81.00	20.72
1973/74	74.34	105.00	41.24
1974/75	87.76	113.00[b]	28.76
1975/76	99.45	113.00[b]	13.62
1976/77	101.39	110.00	8.49
1977/78	108.45	112.50	3.74

Source: D. S. Sidhu, *Price Policy for Wheat in India* (New Delhi: S. Chand and Co., 1979), p. 75.

Notes: The production year runs from July to June and the marketing year from April to March. Thus the output of crop year 1967/68 would be marketed in the marketing year 1968/69.

[a] These figures include family-supplied inputs valued at market prices.

[b] This figure includes the imputed value of a special fertilizer subsidy (Rs 8 per quintal of wheat).

Table 25—Number of fair price and ration shops, 1961-78

Year	Number of Shops
1961	47,370
1962	50,052
1963	59,554
1964	103,198
1965	109,881
1966	135,997
1967	142,815
1968	140,402
1969	138,777
1970	122,038
1971	121,032
1972	165,031
1973	200,655
1974	221,975
1975	240,210
1976	236,196
1977	238,622
1978	238,727

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 26—Annual availability and concessional sales of foodgrains per capita, 1961-78

Year	Availability	Concessional Sales
	(kilograms)	
1961	171.1	8.99
1962	168.2	9.65
1963	162.0	11.21
1964	165.4	18.35
1965	175.3	20.89
1966	149.0	28.56
1967	146.5	26.11
1968	168.4	19.83
1969	162.5	17.81
1970	166.1	16.41
1971	171.1	14.18
1972	170.7	18.61
1973	154.2	19.82
1974	165.1	18.34
1975	148.7	18.73
1976	166.5	14.96
1977	158.8	18.74
1978	172.4	15.95
Mean	163.4	17.62
Minimum	146.5	28.56
Maximum	175.3	8.99

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 27—Total absorption and concessional sales of wheat per capita, 1961-78

Year	Absorption	Concessional Sales
	(kilograms)	
1961	28.75	6.79
1962	30.78	7.17
1963	28.94	8.32
1964	32.74	14.47
1965	34.09	12.39
1966	34.83	16.62
1967	33.16	14.71
1968	35.06	11.25
1969	36.64	9.93
1970	37.05	9.99
1971	37.13	8.14
1972	42.81	10.35
1973	42.48	12.44
1974	39.14	9.68
1975	41.14	12.60
1976	38.80	8.19
1977	42.70	10.22
1978	45.20	10.71
Mean	36.75	10.78[a]
Minimum	28.75	6.79
Maximum	45.20	16.62

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

[a] The mean excluding the abnormal years 1964, 1965, and 1966 is 9.88 kilograms.

Table 28—Ratios of the issue price to the procurement price and to the import price of wheat, 1961-79

Year	Ratio of the Issue Price to the Procurement Price	Ratio of the Issue Price to the Import Price
1961	1.1134	1.1131
1962	1.0769	1.0651
1963	1.0000	1.0393
1964	1.0000	0.9330
1965	0.9222	1.2270
1966	0.9266	1.2559
1967	0.6416	0.7847
1968	0.9365	1.2025
1969	0.9989	1.3116
1970	1.0263	1.3151
1971	1.0263	1.3218
1972	1.0263	0.8067
1973	1.0526	0.7099
1974	1.0354	0.7251
1975	1.1905	0.7345
1976	1.1905	0.7702
1977	1.1364	0.6786
1978	1.1148	0.6765
1979	1.1148	0.6215

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 29—Ratios of the wheat import price to the domestic wholesale price, to the unit value of imports, and to the procurement price, 1961-78

Year	Ratio of the Import Price to the Domestic Wholesale Price	Ratio of the Import Price to the Unit Value of Imports	Ratio of the Import Price to the Procurement Price
1961	0.9321	1.0204	1.0003
1962	0.9422	1.1117	1.0111
1963	0.9698	1.1041	0.9622
1964	0.8381	1.2051	1.0718
1965	0.660.	1.0615	0.7516
1966	0.7095	0.8467	0.7378
1967	0.8626	1.3088	0.8174
1968	0.7819	1.2567	0.7787
1969	0.7418	1.2184	0.7616
1970	0.7408	1.2482	0.7804
1971	0.7667	1.3366	0.7764
1972	1.1892	2.0942	1.2721
1973	1.3258	1.7149	1.4827
1974	1.0820	1.2291	1.4279
1975	1.2764	1.2785	1.6208
1976	1.3692	1.2286	1.5456
1977	1.5022	1.5573	1.6745
1978	1.5235	1.5238	1.6478

Sources: Centre for Monitoring the Indian Economy, *Basic Statistics Relating to the Indian Economy* (Bombay: CMIE, 1980), and India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin of Food Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 30—Wheat zoning and price variation, 1951/52-1974/75

Year	Coefficient of Variation of State Prices	System	Average for Zoning System
1951-52	19.26	L	
1952-53	13.68	L	
1953-54	8.30	L	
1954-55	13.10	L	13.59
1955-56	10.46	F	
1956-57	9.14	F	9.80
1957-58	14.46	S	
1958-59	15.55	S	
1959-60	19.99	S	
1960-61	12.15	S	15.54
1961-62	13.14	F	
1962-63	10.09	F	
1963-64	7.63	F	10.29
1964-65	30.39	S	
1965-66	32.43	S	
1966-67	23.27	S	28.70
1967-68	20.31	L	20.31
1968-69	21.12	S	
1969-70	10.72	S	15.92
1970-71	16.94	F	
1971-72	15.03	F	15.99
1972-73	14.97	S	
1973-74	22.33	S	
1974-75	15.64	S	17.65

Source: Raj Krishna and G. S. Raychaudhuri, "Some Aspects of Wheat Price Policy in India," *Indian Economic Review* (October 1979).

Notes: L stands for a large-zone system, in which movement within a group of states is free. S stands for a single-state system, in which movement outside a state requires a license. F stands for a system in which movement is not restricted.

Table 31—Annual growth rates of income, expenditure, and wheat absorption, and ratios of absorption growth to income and expenditure growth, 1961-78

Variable	Growth Rate	Ratios of Growth Rate	
	(percent/year)		
Consumption expenditure (X)	3.16	D ÷ X	1.58
Consumption expenditure per capita (XPC)	0.90	DPC ÷ XPC	2.99
Aggregate income (YC)	3.69	D ÷ YC	1.36
Aggregate income per capita (YPC)	1.45	DPC ÷ YPC	1.86
Aggregate wheat absorption (D)	5.00		
Aggregate wheat absorption per capita (DPC)	2.69		

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years); India, Central Statistical Organisation, *National Accounts Statistics*, various issues (Delhi: Controller of Publications, various years).

Table 32—Wheat imports and aid utilized, 1961-78

Year	Value of Wheat Imports	Aid Utilized	Ratio of the Value of Wheat Imports to Aid Utilized
	(Rs million)		(percent)
1961	775.5	5,320	14.58
1962	918.6	6,990	13.14
1963	1,028.6	9,290	11.07
1964	2,419.2	11,390	21.24
1965	2,647.3	12,160	21.77
1966	4,230.4	11,320	37.37
1967	3,784.7	11,770	32.16
1968	2,594.9	9,130	28.42
1969	1,843.3	8,370	22.02
1970	1,733.7	7,800	22.23
1971	1,026.0	8,210	12.50
1972	481.6	6,050	7.96
1973	3,461.0	8,030	43.10
1974	6,981.8	9,680	72.13
1975	12,072.2	14,360	84.07
1976	8,071.0	12,480	64.67
1977	935.8	10,760	8.70
1978	660.7	10,940	6.04

Sources: The values of wheat imports are from United Nations, Economic and Social Commission for Asia and the Pacific, *Statistical Yearbook for Asia and the Pacific* (Bangkok: ESCAP, 1978). The figures for aid utilized are from the Reserve Bank of India, *Report on Currency and Finance*, various issues (Bombay: Reserve Bank of India, various years).

Table 33—Concessional and total imports of wheat, 1961-78

Year	Total Imports	Concessional Imports	Ratio of Concessional Imports to Total Imports
	(1,000 metric tons)		(percent)
1961	3,090	3,090	100.00[a]
1962	3,249	2,433	74.88
1963	4,071	3,567	87.67
1964	5,621	4,509	80.22
1965	6,573	6,297	95.80
1966	7,784	7,649	98.27
1967	6,348	5,086	80.12
1968	4,766	4,766	100.00[a]
1969	3,090	2,700	87.38
1970	3,425	2,649	77.34
1971	1,814	1,814	100.00[a]
1972	314	314	100.00[a]
1973	2,414	119	4.93
1974	4,203	81	1.93
1975	7,016	995	14.18
1976	5,832	581	9.96
1977	547	547	100.00[a]
1978	300	88	29.33
Average	3,525	2,627	74.52[b]

Sources: The figures for total imports are from India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years). The figures for concessional imports were provided by Barbara Huddleston of the International Food Policy Research Institute.

[a] In this year concessional imports exceed total imports. They are, however, shown as equal to total imports.

[b] This was derived as the ratio of average imports.

Table 34—Wheat model: projections of exogenous variables, 1979-92

Year	Aid Utilized (ADU)	Foodgrain Deficit for Issues (DEF) Basic Scenario	Foodgrain Deficit for Issues (DEF) Drought Scenario	Foodgrain Deficit for Imports (DEFM) Basic Scenario	Foodgrain Deficit for Imports (DEFM) Drought Scenario	Irrigation Ratio (IRW)	General Price Index (1970/71=100) (PALL2)
	(Rs billion)	(1,000 metric tons)				(percent)	
1979	11	10,584.4	10,584.4	-12,755.72	-12,755.72	66.7	204.4
1980	11	10,680.5	16,772.2	-12,755.72	-5,201.00	67.5	224.8
1981	11	10,776.7	13,822.5	-12,755.72	-8,978.36	68.4	247.3
1982	11	10,872.8	10,872.8	-12,755.72	-12,755.72	69.3	270.0
1983	11	10,969.0	10,969.0	-12,755.72	-12,755.72	70.2	299.2
1984	11	11,065.0	17,156.7	-12,755.72	-5,201.00	71.1	329.2
1985	11	11,161.2	14,207.0	-12,755.72	-8,978.36	72.1	362.1
1986	11	11,257.4	11,257.4	-12,755.72	-12,755.72	73.0	398.3
1987	11	11,353.5	11,353.5	-12,755.72	-12,755.72	74.0	438.2
1988	11	11,449.6	17,541.3	-12,755.72	-5,201.00	74.9	482.0
1989	11	11,545.8	14,591.6	-12,755.72	-8,978.36	75.9	530.2
1990	11	11,641.9	11,641.9	-12,755.72	-12,755.72	76.9	583.2
1991	11	11,738.0	11,738.0	-12,755.72	-12,755.72	77.9	641.5
1992	11	11,834.1	11,834.1	-12,755.72	-12,755.72	78.9	705.7

Year	Lagged Ratio of the Price Index of Barley and Gram to the General Wholesale Price Index (PBG21)	Ratio of the Price Index of Cereals Other than Wheat to the General Wholesale Price Index (PCS)	Issue Price (PI)	Issue Price (PILL2)	Import Price (PM)
			(Rs/quintal)	(constant 1961 Rs/kilogram)	(Rs/quintal)
1979	1.0538	2.00	137.97	0.6750	164.37
1980	1.0538	2.00	151.74	0.6750	182.54
1981	1.0538	2.00	166.93	0.6750	187.32
1982	1.0538	2.00	182.25	0.6750	172.03
1983	1.0538	2.00	201.96	0.6750	176.80
1984	1.0538	2.00	222.21	0.6750	197.83
1985	1.0538	2.00	244.42	0.6750	218.86
1986	1.0538	2.00	268.85	0.6750	234.45
1987	1.0538	2.00	295.79	0.6750	251.14
1988	1.0538	2.00	325.35	0.6750	269.01
1989	1.0538	2.00	357.89	0.6750	288.17
1990	1.0538	2.00	393.66	0.6750	308.70
1991	1.0538	2.00	433.00	0.6750	329.39
1992	1.0538	2.00	476.35	0.6750	329.39

Year	Import Price Index (1961=100) (PM)	Index of the Deflated Import Price of Wheat (1961=100) (PMM)	Population (POP)	Procurement Price (PP)	Deflated Procurement Price (1961 Prices) (PP2)
			(million)	(Rs/quintal)	(Rs/kilogram)
1979	598.8	148.8	654.59	123.66	0.6055
1980	665.0	150.2	669.52	136.00	0.6055
1981	682.4	140.2	684.78	149.62	0.6055
1982	626.7	117.0	700.39	163.35	0.6055
1983	644.1	109.3	716.36	181.02	0.6055
1984	720.7	111.2	732.70	199.17	0.6055
1985	797.3	110.1	749.40	219.07	0.6055
1986	854.1	107.0	766.49	240.97	0.6055

(continued)

Table 34—Continued

1987	914.9	103.9	783.96	265.11	0.6055
1988	980.0	100.9	801.84	291.61	0.6055
1989	1,049.8	98.0	820.12	320.77	0.6055
1990	1,124.6	95.2	838.82	352.84	0.6055
1991	1,200.0	92.2	857.94	388.10	0.6055
1992	1,200.0	83.5	877.51	426.95	0.6055

Year	Output of Foodgrains (QFG)	Rainfall Index (Normal=100) (RAW)	Marketing Cost (ST)	Unit Value Index of All Imports (1958=100) (UVIM)	Aggregate Consumption Expenditure (1970/71 Prices) (X)	Consumption Expenditure Per Capita (1970/71 Prices) (XPC)
	(million metric tons)		(Rs/quintal)		(Rs 10 million)	(Rs)
1979	133.2	100.00	32.85	394.35	35,791.05	546.77
1980	136.4	100.00	35.30	433.79	36,864.78	550.62
1981	139.7	100.00	38.00	477.16	37,970.73	554.50
1982	143.1	100.00	40.80	524.88	39,109.85	558.40
1983	146.5	100.00	43.90	577.47	40,283.14	562.33
1984	150.1	100.00	47.20	635.10	41,491.64	566.29
1985	153.7	100.00	50.70	709.62	42,736.39	570.27
1986	157.5	100.00	54.50	782.62	44,108.48	574.29
1987	161.3	100.00	58.50	863.13	45,339.03	578.33
1988	165.2	100.00	62.80	951.91	46,699.20	582.40
1989	169.2	100.00	67.50	1,049.84	48,100.18	[illegible]
1990	173.3	100.00	72.50	1,157.83	49,543.19	590.[illegible]
1991	177.5	100.00	77.90	1,274.94	51,029.48	594.78
1992	181.8	100.00	83.70	1,408.30	52,560.36	598.97

Notes: ADU: Foreign aid utilized is kept constant in nominal terms at about its value in 1978 (Rs 11 billion).

DEF: The grain deficit for issues is projected directly with an equation estimated with the 1961-78 DEF series with rainfall and time as variables.

DEFM: The grain deficit for imports is projected with an equation estimated with the 1961-78 DEFM series with rainfall and time as variables. The time-trend contribution is assumed to be zero in the future.

IRW: The wheat irrigation ratio was 66 percent in 1978. Sanderson and Roy projected it to rise to 76.9 percent in 1990. The ratios for intermediate years are interpolated.

PALL2, UVIM: General domestic prices and the unit value of all imports are assumed to rise 10 percent a year from the base year 1978.

PBG21: The ratio of the price index of barley and gram to the general wholesale price index is assumed to remain constant at its 1978 value.

PCS: The ratio of the price index of consumption substitutes (cereals other than wheat) to the general wholesale price index is kept constant at 2.00, its value in 1978.

PM: The World Bank projections of the world price of wheat (in current dollars) are used (World Bank, "Biennial Review of Commodity Price Forecasts," Washington, D.C., May 1982 [mimeographed]). To compute the 1981 rupee price, the 1978 price is inflated by the percentage by which the World Bank price for 1981 exceeds the World Bank price for 1978. Rupee prices for other years are projected similarly. Prices for years for which World Bank projections are not made are interpolated. The 1978 PM was Rs 1,510 per ton.

PMM: This is the import price of wheat deflated by the unit value of all imports.

POP: The population growth rate assumed is the same as in the decade 1971-81 (2.28 percent a year).

PP, PF, PP2, PILL2: Deflated procurement and issue prices (PP2 and PILL2) remain constant in real terms. Nominally they (PP and PI) rise 10 percent a year. The nominal PP and PI series are also given: computed as PP = PP2 × PALL2 and PI = PILL2 × PALL2.

QFG: The output of foodgrains is assumed to grow (in normal years) 2.42 percent a year. This is the growth rate projected by Sanderson and Roy.

RAW: In the basic scenario, rainfall is kept normal at 100. In the drought scenario, rainfall is assumed to be 20 percent below normal in 1980, 1984, and 1988, and 10 percent below normal in 1981, 1985, and 1989. Except in 1966 the dip in rainfall has varied between 12 and 20 percent.

X: Aggregate consumption expenditure is projected with a trend equation fitted to the 1961-78 series. The rainfall variable is included in the trend equation, so that it projects a trend value of X in normal years and a value below the trend in drought years.

XPC: Consumption expenditure per capita = X/POP.

Gross output lagged one year (Q1), the lagged ratio of the open-market wholesale price (PW) to PALL2, that is, PW21, and the opening stock (SO) are endogenously generated for each year as the solution values of the preceding years' gross output (Q), ratio of PW to PALL2 (PW2), and closing stock (SC).

Table 35—Ratio of opening stock to issues of wheat, 1961-78

Year	Ratio	Average
1961	0.58	
1962	0.53	0.52
1963	0.44	
1964	0.27	
1965	0.09	
1966	0.17	0.17
1967	0.16	
1968	0.17	
1969	0.42	0.43
1970	0.44	
1971	0.74	0.82
1972	0.90	
1973	0.27	
1974	0.21	0.22
1975	0.18	
1976	1.00	
1977	1.92	1.54
1978	1.69	

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, *Bulletin on Food Statistics*, various issues (Delhi: Controller of Publications, various years).

APPENDIX 3: DICTIONARY OF SYMBOLS

Symbol	Variable	Unit
A	Coefficient matrix of endogenous variables in 3SLS equations.	...
AC	Area under wheat.	Million hectares
AC1	AC lagged one year.	Million hectares
ADU	Total foreign aid utilized.	Rs 10 million
B	Coefficient matrix of predetermined variables in 3SLS equations.	...
C	Net aggregate cost of government operations.	Rs billion
D	Total demand (absorption).	1,000 tons
DEF	Foodgrain deficit for issues = DFG* - SPFG + PRFG.	1,000 tons
DEFM	Foodgrain deficit for imports = DEF - SOFG - PRFG = DFG* - SPFG - SOFG.	1,000 tons
DFG*	Desired total demand (absorption) for foodgrains computed as 163.4 kilograms per capita per year, the average for 1961-78.	1,000 tons
DEFPC	Foodgrain deficit for issues per capita.	1,000 tons
DPC	Total demand (absorption) per capita.	Kilograms per year
E	Column vector of endogenous variables.	...
FE	FEA deflated by the UVIM index; 1958 = 100.	Rs billion
FEA	Foreign exchange available (total aid utilized plus exchange reserves plus export receipts).	Rs 10 million
G	Column vector of predetermined variables.	...
IM	Total imports.	1,000 tons
IS	Government issues (concessional sales).	1,000 tons
ISPC	Government issues per capita.	Kilograms per year
IRW	Irrigation ratio: the ratio of wheat area under irrigation to total wheat area.	Percent
PALL2	Wholesale price index for all commodities; 1970/71 = 100.	...
PB	Wholesale price index of barley; 1970/71 = 100.	...

Symbol	Variable	Unit
PBG21	Ratio of the price index of major production substitutes of wheat, that is, barley and gram, to the general wholesale price index, lagged one year; 1970/71 = 100.	...
PCS	Ratio of the price index of the consumption substitutes of wheat (cereals other than wheat) (1961/62 – 100) to the general wholesale price index (1970/71 = 100).	...
PG	Wholesale price index of gram; 1970/71 = 100.	...
PI	Government issue price.	Rs per quintal
PI'	Government issue price.	Rs per ton
PILL2	Issue price (deflated): PI/PALL2.	Rs per quintal
PM	Import price; 1961 = 100.	...
PMM	Import price (deflated): PM/UVIM.	...
POP	Population.	Million
PP	Procurement price.	Rs per quintal
PP'	Procurement price.	Rs per ton
PP2	PP/PALL2.	Rs 100 per quintal
PQR	Wheat procurement/output ratio.	Percent
PR	Procurement.	1,000 tons
PVC	Present value of cost C over the projection period (1979-92).	Rs billion
PW	Open market wholesale price; 1961/62 = 100.	...
PW2	PW/PALL2.	...
PW21	PW2 lagged.	...
Q	Gross output.	1,000 tons
Q1	Q lagged one year.	1,000 tons
RAW	Rainfall index for wheat; normal = 100.	...
SC	Closing stock with the government.	1,000 tons
SO	Opening stock with the government.	1,000 tons
SOFG	Opening stock of all foodgrains with the government.	1,000 tons
SP	Supply available for human consumption from the output of wheat; 0.879 Q.	1,000 tons

Symbol	Variable	Unit
SPFG	Net production or supply available for human consumption from foodgrain output; 87.5 percent of output.	1,000 tons
ST	Average carrying cost.	Rs per quintal
URXR	Ratio of urban consumption expenditure per capita to rural consumption expenditure per capita (XUPC/SRPC).	...
UVIM	Unit value index of imports; 1958 = 100.	...
WAP	Weighted average of the market wholesale and concessional issue prices of wheat (1970/71 prices) weighted by the proportions of commercial and concessional absorption in total absorption, and deflated by the general wholesale price index.	Rs per quintal
X	Aggregate real consumption expenditure; 1970/71 prices.	Rs 10 million
XPC	Aggregate real consumption expenditure per capita; 1970/71 prices.	Rs 10
XRPC	Rural consumption expenditure per capita.	Rs
XUPC	Urban consumption expenditure per capita.	Rs
YC	National income; 1970/71 prices.	Rs 10 million
YD	Yield.	Kilograms per hectare
YD1	YD lagged one year.	Kilograms per hectare
YPC	National income per capita; 1970/71 prices.	Rs 10

APPENDIX 4: INTERCEPT ADJUSTMENTS

For computing the projections, the intercepts of the estimated reduced form equations were adjusted to reflect some structural changes in the last few years of the estimation period. The major structural changes were a drastic reduction in concessional imports after 1970 and a sharp decline in nonconcessional imports in 1977, 1978, and 1979.

Therefore the intercept in the import equation was adjusted to reduce total imports by 3.5 million tons. This adjustment generated realistic imports for the early years of the projection period.

The intercept in the deflated wheat price (PW2) equation was also adjusted so that the value of PW2 in 1979 (in the basic scenario) came to be 1.56, in line with its actual value in 1979 and 1980.

Adjustments were also made in the intercepts of the procurement (reduced by 1 million tons) and issues (raised by 1 million tons) equations.

APPENDIX 5: MARKETING COSTS

Procurement cost figures available from the FCI and Garg averaged 15 percent of the procurement price between 1969/70 and 1979/80.[58] This ratio is applied to the procurement price to get the cost per unit procured.

Distribution cost figures made available by the FCI averaged 15.6 percent of the procurement price between 1969/70 and 1975/76. This ratio is applied to the procurement price to get the distribution cost per unit of issues. The distribution cost for imported grain is assumed to be the same as for domestic grain.

The port clearance cost for imported grain is calculated as a proportion of the distribution cost—the proportion being the average between 1969/70 and 1975/76 in the data supplied by the FCI (0.50). Since the distribution cost is 15.6 percent of the procurement price, the port clearance cost is 7.8 percent of the procurement price.

Thus in the expression for aggregate cost, the following marketing costs enter in addition to the basic purchase/import costs:

procurement cost	= 0.15 × procurement price × procurement,
distribution cost	= 0.156 × procurement price × issues,
port-clearance cost	= 0.078 × procurement price × imports, and
storage cost	= (storage cost ST) × 0.50 × (opening stock + closing stock).

[58] Food Corporation of India, New Delhi, correspondence; Garg, *State in Foodgrain Trade*.

APPENDIX 6:

AN ALTERNATIVE SIMULATION WITH TOTAL GRAIN DEFICIT IN THE WHEAT ISSUE EQUATION

Two specifications of the issue equation were presented in Chapter 4.

$$IS = f_4(PW2, PILL2, X), \quad (4)$$

and

$$IS = f(PILL2, PW2, DEF). \quad \text{(Table 2, equation [8])}$$

The estimated OLS coefficients of these equations are given in Tables 1 and 2.

For the main simulations of Chapters 6 and 7, only the first specification has been used. But some reviewers suggested that the simulations might be different if concessional sales of wheat were regarded as linked with the overall grain deficit (apart from the relevant relative prices). Therefore 3SLS parameters with equation (8) from Table 2 were estimated (Table 36) and used to simulate the main programming case, in which exports are allowed and stocks are a minimum of 25 percent of issues (Tables 36 and 37).

The estimated coefficients of the issue equation with the DEF variable change significantly in the 3SLS system in comparison with the OLS values. In fact, both the price coefficients that are not significant in the OLS equation (Table 2, equation [8]) become significant in the 3SLS equation (Table 36, equation [4]). And the price elasticity rises from -0.2 to -1.1.

Comparing the averages for the projection period of the cases with and without a deficit variable (Table 38), it can be noted that the differences between projected outputs and purchases in the two sets of projections are small. But average sales are higher by 2.0-2.6 percent and imports and closing stocks are significantly higher when a deficit variable is included, particularly in the drought and drought and exchange shortage scenarios. In these scenarios, instead of average net exports, the DEF specification projects average imports of about 300,000 tons a year. And the average stocks are 10 percent higher (at 3.1 million tons) in the drought scenario with the DEF specification.

The average real market price level is marginally lower (by 0.1-0.3 percent), and the present value of the cost of government operations is 5-9 percent higher (Table 38).

But these differences are well within the range of outcomes under alternative assumptions, even if the issue equation includes X (see Table 13). The average stock, even with the DEF specification, is less than a third of the initial level in 1979; and imports are less than a third of a million tons, or about equal to the lowest levels in the 1961-78 period.

Average concessional consumption per capita is somewhat higher with the new issue equation: in the basic scenario, it is 11.66 kilograms with DEF and 11.49 kilograms with X in the issue equation, in the drought scenarios it is 12.18 kilograms with DEF and 11.84 kilograms with X in the issue equation (Tables 7 and 39). But as was noted in Chapter 7, average concessional sales per capita, even with X in the issue equation (11.5 kilograms), are 11 percent higher than the average in the past. The inclusion of DEF in the issue equation only raises it and the associated loss.

Thus the expectation that the DEF specification will produce radically different and preferable projections has not been fulfilled.

Table 36—Wheat model equations, three-stage least squares, with grain deficit in the issue equation, 1961-78

Equation Number	Dependent Variable	Constant	Independent Variables				
			PBG21	PW21	RAW	IRW	Q1
2	Q	-25,136.7[a]	-2,445.32[c]	6,229.98[a]	0.9767[a]	26.1031[a]	0.6729[a]
		(-6.56)	(-1.69)	(3.81)	(5.87)	(3.39)	(5.66)
			[-0.14]	[0.63]	[0.50]	[0.66]	
			WAP	PCS	X		
3	D	-10,223.2[a]	-10,223.2[a]	3,944.56[a]	1.0984[a]	...	...
		(-3.02)	(-2.96)	(2.97)	(21.62)		
			[-0.41]	[0.46]	[1.51]		
			PILL2	PW2	DEF		
4	IS	5,865.42[b]	-9,402.82[a]	2,644.49[b]	0.1238[a]	...	...
		(2.29)	(-3.16)	(2.35)	(3.93)		
			[-1.08]	[0.89]	[0.07]		
			Q	PP2	PW2		
5	PR	-3,695.77[c]	0.3135[a]	6,550.06[b]	-2,046.86[c]	...	...
		(-2.14)	(14.93)	(2.40)	(-1.60)		
			[2.20]	[1.58]	[-1.45]		
			PMM	ADU	DEFM		
6	IM	7,320.89[a]	-3,530.4[a]	2.8319[b]	0.1814[a]	...	...
		(3.19)	(-3.52)	(2.16)	(3.75)		
			[-1.17]	[0.71]	[0.38]		

Notes. The figures in parentheses are t-values. Those in brackets are the elasticities of the variables at their means.

Q is gross output, D is total demand (absorption). IS stands for government issues (concessional sales) and PR, for procurement. IM is total imports.

ADU is total foreign aid utilized. DEF is the foodgrain deficit for issues, and DEFM is the foodgrain deficit for imports. IRW is the ratio of irrigated wheat area to total wheat area. PBG21 is the ratio of the price index of the major substitutes for wheat in production to the wholesale price index, lagged one year, and PCS is the ratio of the price index of the major substitutes for wheat in consumption to the wholesale price index. PILL2 is the deflated price of issues; PMM is the deflated price of imports. PP2 is the ratio of the procurement price to the wholesale price index for all commodities, and PW2 is the ratio of the open market wholesale price to the wholesale price index for all commodities. PW21 is PW2 lagged 1 year. Q is gross output. Q1 is Q lagged one year. WAP is the weighted average of the market wholesale and concessional issue prices of wheat. X is aggregate real consumption expenditures.

[a] This coefficient is significant at the 1 percent level.

[b] This coefficient is significant at the 5 percent level.

[c] This coefficient is significant at the 10 percent level.

Table 37—Wheat model: programming projections with exports allowed, minimum opening stocks one fourth of issues, and grain deficit linked with issues, 1979-92

Scenario/ Year	Output (Q)	Procurement (PR)	Issues (IS)	Imports (IM)	Closing Stock (SC)	Opening Stock (SO)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
			(1,000 metric tons)					(Rs billion)
Basic								30.71
1979	32,040	7,080	7,875	-5,234	4,458	10,488	88.1	
1980	32,701	7,239	8,191	-703	2,804	4,458	89.2	
1981	33,516	7,377	8,252	126	2,056	2,804	92.0	
1982	34,631	7,632	8,222	599	2,064	2,056	94.2	
1983	35,889	7,978	8,257	298	2,083	2,064	95.3	
1984	37,115	8,313	8,331	57	2,122	2,083	96.3	
1985	38,343	8,672	8,486	-144	2,163	2,122	96.9	
1986	39,483	8,981	8,651	-271	2,221	2,163	98.0	
1987	40,652	9,321	8,883	366	2,294	2,221	98.5	
1988	41,751	9,641	9,176	382	2,376	2,294	99.1	
1989	42,827	9,952	9,506	372	2,451	2,376	99.7	
1990	43,888	10,236	9,806	-358	2,524	2,451	100.8	
1991	45,003	10,537	10,098	366	2,598	2,524	101.8	
1992	46,156	10,850	10,392	-457	2,598	2,598	103.0	
Average	38,857	8,844	8,866	-541	2,487	3,050	96.6	
Drought								35.59
1979	32,040	7,080	7,875	-2,580	7,113	10,488	88.1	
1980*	30,803	6,487	8,830	0	4,769	7,113	93.0	
1981*	31,717	6,633	8,772	151	2,781	4,769	96.3	
1982	33,916	7,340	8,441	887	2,567	2,781	95.8	
1983	35,592	7,885	8,426	1,250	3,277	2,567	95.3	
1984*	35,013	7,566	9,274	1,064	2,632	3,277	98.5	
1985*	36,208	7,846	9,260	1,042	2,260	2,632	100.8	
1986	38,470	8,596	9,034	459	2,276	2,260	99.7	
1987	40,151	9,142	9,105	211	2,525	2,276	99.1	
1988*	39,574	8,847	10,100	1,264	2,537	2,525	101.8	
1989*	40,707	9,084	10,148	1,008	2,481	2,537	104.6	
1990	43,015	9,826	9,926	126	2,507	2,481	104.0	
1991	44,794	10,403	10,029	306	2,575	2,507	103.5	
1992	46,207	10,843	10,300	-542	2,575	2,575	103.5	
Average	37,729	8,398	9,252	288	3,063	3,628	98.8	
Drought and exchange shortage								37.60
1979	32,040	7,080	7,875	-940	8,753	10,488	88.1	
1980*	30,803	6,487	8,830	246	6,163	8,753	93.0	
1981*	31,717	6,633	8,772	-211	3,812	6,163	96.3	
1982	33,916	7,340	8,441	681	3,393	3,812	95.8	
1983	35,592	7,885	8,426	1,013	3,865	3,393	95.3	
1984*	35,013	7,566	9,274	791	2,947	3,865	98.5	
1985*	36,208	7,846	9,260	727	2,260	2,947	100.8	
1986	38,470	8,596	9,039	459	[illegible]	2,260	99.7	
1987	40,151	9,142	9,105	385	2,698	2,276	99.1	
1988*	39,574	8,847	10,100	1,091	2,537	2,698	101.8	
1989*	40,707	9,084	10,148	1,008	2,481	2,537	104.6	
1990	43,015	9,826	9,926	125	2,507	2,481	104.0	
1991	44,794	10,403	10,026	306	2,575	2,507	103.5	
1992	46,207	10,843	10,300	542	2,575	2,575	103.5	
Average	37,729	8,398	9,252	288	3,489	4,054	98.8	

* It is assumed that a drought occurs in this year

Table 38—Wheat model: summary of projections with alternative issue equations, 1979-92 averages

Scenario/ Projection	Output (Q)	Opening Stock (SO)	Procurement (PR)	Imports (IM)	Issues (IS)	Closing Stock (SC)	Index of the Deflated Market Price (1960/61=100) (PW2)	Present Value of Cost (PVC)
		(1,000 metric tons)					(Rs billion)	
Basic								
Exports allowed, minimum SO one fourth of IS	38,896	2,981	8,883	752	8,697	2,414	96.7	29.2
Exports allowed, minimum SO one fourth of IS, and deficit-related IS	38,857	3,050	8,844	541	8,866	2,487	96.6	30.71
Difference (percent)	0.1	2.3	-0.4	28.1	1.94	3.0	-0.1	5.2
Drought								
Exports allowed, minimum SO one fourth of IS	37,852	3,352	8,464	-13	9,015	2,785	99.1	32.7
Exports allowed, minimum SO one fourth of IS, and deficit-related IS	37,729	3,628	8,398	288	9,252	3,053	98.8	35.6
Difference (percent)	0.3	8.2	-0.8	...	2.6	10.0	-0.3	8.9
Drought and exchange shortage								
Exports allowed, minimum SO one fourth of IS	37,852	3,871	8,464	-15	9,015	3,303	99.1	35.2
Exports allowed, minimum SO one fourth of IS, and deficit-related IS	37,729	4,054	8,398	288	9,252	3,489	98.8	37.6
Difference (percent)	0.3	4.7	0.8	...	2.6	5.6	-0.3	6.8

Table 39—Wheat model: projections of total annual absorption and concessional issues of wheat per capita, with grain deficit linked to issues, 1979-92

Year	Absorption		Issues	
	Basic Scenario	Drought and Drought and Exchange Shortage Scenarios	Basic Scenario	Drought and Drought and Exchange Shortage Scenarios
	(kilograms)			
1979	44.24	44.24	12.03	12.03
1980	44.35	43.94	12.23	13.19
1981	44.30	43.84	12.05	12.81
1982	44.50	44.14	11.74	12.05
1983	44.43	44.43	11.53	11.76
1984	44.55	44.34	11.37	12.66
1985	44.73	44.36	11.32	12.36
1986	44.85	44.69	11.29	11.79
1987	45.02	44.97	11.33	11.61
1988	45.19	44.94	11.44	12.60
1989	45.36	44.93	11.59	12.37
1990	45.48	45.19	11.69	11.83
1991	45.60	45.46	11.77	11.69
1992	45.71	45.67	11.84	11.74
Average	44.87	44.65	11.66	12.18
Ratio of average issues to absorption (percent)			25.99	27.28

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