INDIAN AGRICULTURAL PRICE POLICY REVISITED*

by

David G. Abler and Vasant Sukhatme**

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**Assistant Professor, Department of Agricultural Economics and Rural Sociology, Pennsylvania State University, and Associate Professor, Department of Economics, Macalester College, respectively. Both authors are former students of Gale Johnson. Sukhatme did his graduate work under Johnson during 1972-77. Abler was an undergraduate student of Sukhatme during 1978-82 and went on for graduate work under Johnson during 1982-87.

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In common with nearly all developed and developing countries, government intervention in Indian agriculture is widespread and many decades old. There have been enormous public investments in irrigation, research, and extension. On the price front, there is a procurement system for the major grains under which the government buys a percentage of output at a set price, usually below the market price. There are also significant implicit and explicit subsidies on purchased inputs; there are controls on international trade in grains and fertilizer; and there is an extensive public distribution system for procured grains ostensibly designed to provide a food safety net to the poorest groups in society.

Price policy issues have been among the most researched topics in Indian agriculture. Many of the leading names in Indian academia, along with scholars from the U.S., U.K., and Japan, have made contributions to this area. Unlike his several works on agriculture in the Soviet Union and China, Gale Johnson, at least to our knowledge, has not published any specific piece on Indian agriculture per se. However, as is naturally to be expected of Gale, he has been a thoughtful and perceptive observer of the Indian agricultural scene. His writings contain many references to the Indian situation and he has drawn on Indian data to illustrate his arguments on numerous occasions. We refer to some of these below.

The objective of this paper is to attempt a fresh look at Indian agricultural price policy. Several features of Indian agricultural price policy have often come under attack for their adverse effects on production incentives. Frankly, we do not like most of the defenses that we see in the current literature. The "prices do not matter" argument has surfaced many times over the years, although it is no longer considered fashionable to state it so directly. Instead, the current popular argument is that the impact of price on supply, while positive, is outweighed by the impact of irrigation and other types of infrastructure. Others have argued that the procurement system actually helps farmers. True, some fraction of a farmer's output is bought at a below-market price. However, the system reduces supply in the open market and thereby increases the market price. The argument is that this increase in the market price may be large enough to raise the average price received by a farm on all its output. This paper is primarily a critique of these two lines of argument.

As we will argue in greater detail below, we feel that the prices vs. infrastructure argument is probably true, as far as it goes. However, the proponents of this argument fail to acknowledge that infrastructure is not created in a vacuum. The incentives for both public authorities and individual farms to invest in irrigation, develop and adopt new seed varieties, and make other improvements in farming techniques depend on price. That infrastructure is important does not mean that prices are unimportant. As we will indicate below, the procurement-average price argument hinges critically on an unrealistic assumption about who receives procured grain and who must buy grain on the open market. The literature presumes that the procurement system forces well-off consumers with inelastic demands onto the open market. For such consumers, a small decrease in open market supplies could lead to a large increase in the open market price. However, as we will show, the reality is much different.

We begin in section I with a description and brief history of the major policies for wheat, rice, and other foodgrains. Section II contains a detailed discussion and critique of the two lines of argument mentioned above. We recognize that the strength of our critique is an empirical issue: for example, how large is the response of infrastructure to price? Accordingly, section III constructs a simple simulation model to quantify such responses. We do not undertake full-blown econometric estimation of the model's parameters but instead rely mostly on estimates from the literature. Simulation results are presented in Section IV, while conclusions are presented in Section V.

I. INDIAN FOODGRAIN PRICE POLICY*

Through the years Indian foodgrain price policy has had several objectives, among them attaining food self-sufficiency, assuring low prices and ample supplies for urban consumers, assuring renumerative prices to farmers, and achieving food price stability. Inevitably, though, there have been conflicts among the objectives and some have been given greater weight than others. This section describes the key foodgrain policies. Procurement is discussed in part A, the public distribution system (PDS) in part B, infrastructure and input subsidies in part C, government stockholding policy in part D, and linkages between domestic and international foodgrain markets in part E.

*The descriptive material in this section is based on variety of sources in addition to those specifically mentioned. More detailed descriptions of Indian foodgrain price policy are in Chopra (1988), Kahlon and George (1985), Kahlon and Tyagi (1983), Krishnaji (1990), and Wall (1978).

A. Procurement

Under the procurement system, the government purchases a fraction of foodgrain output at a set price, usually below the market price. Procurement has always been confined almost entirely to wheat and rice. These crops are procured by the Food Corporation of India (FCI), state civil supplies corporations, and cooperative marketing agencies. The FCI, which was established in 1965, is the central government's principal agency for food policy. It also handles storage, public distribution, and all international trade in foodgrains. Procurement and public distribution began as emergency measures during World War II, although procurement was negligible throughout the 1950s and 1960s. Only since the late 1960s has procurement grown to large proportions, both in total and as a percentage of production.

Several different methods of procurement have evolved, reflecting differences in the ways that foodgrains are marketed, the administrative expertise of local procurement personnel, and other factors. In general, five methods have been used: (1) outright acquisition of stocks from private traders; (2) monopoly purchases, under which the government is the sole legal purchaser of grain from farmers; (3) levies on farmers, traders, and/or millers requiring them to give a proportion of their output or turnover to the government; (4) preemptive purchases, with the government able to buy any lot of grain sold in the market at the going price; and (5) open-market purchases at the going price without compulsion. Levies are often progressive, with the proportion of grain taken by the government increasing as the amount of grain produced or handled increases. Until 1977, procurement was facilitated by restrictions on the free interstate movement of grain by private traders under the so-called zonal system. This system depressed market prices in surplus states by "bottling up" production, making procurement prices look more attractive.

Experience has shown the self-defeating nature of monopoly purchases, high levies, and other overly stringent procurement methods (Krishna and Chhibber, 1983). Such methods have only led to hoarding of grain by private traders in anticipation of better prices later, illegal markets in grain, and corruption on a large scale. Only more modest procurement methods have succeeded in providing grain for the public distribution system.

Data for 1967-87 on wheat and rice procurement and production are plotted in Figures 1 and 2. The total amount procured has risen tremendously over this period, especially for wheat, as both production and the percentage procured have increased. On average, total foodgrain procurement has been rising about twice as fast as production. Data for 1983-87 are shown in more detail in Table 1. About 20% of total wheat production and 15% of total rice production were procured during this period. Wheat procurement is concentrated in the states of Punjab and Haryana, which together usually have about 45-50% of their output procured and supply 75-85% of all-India procurement. The same is true for rice; generally, 60-80% of their rice output is procured and they supply over half of all-India procurement.

Procurement prices are recommended to the government by the Commission for Agricultural Costs and Prices (CACP), formerly known as the Agricultural Prices Commission (APC). The APC, established in 1965, was charged with recommending prices "in the perspective of the overall needs of the economy and with due regard to the interests of the producer and the consumer." As we will see, its decisions definitely have been weighted toward consumers. The CACP is only an advisory body, but in practice the actual procurement prices have been close to (if slightly higher than) those suggested. Ostensibly, when recommending prices, the CACP considers production costs, domestic market prices, world prices, effects of price changes on living costs and industrial production costs, and the desire to maintain some predetermined inter-crop price parity. However, there is no formula per se. Regressions of the procurement price on the lagged open-market price and the lagged average cost of production (e.g., Gulati and Sharma, 1990), find that both matter positively, with the latter somewhat more important than the former.

The overriding concern for researchers has been whether procurement prices cover production costs. A related concern has been how to calculate production costs. There are differences across farms in managerial skills and other factors that translate into differences in the average cost of production. While some economists have actually claimed that costs of family labor and family-owned resources (land, livestock, etc.) should not be included in production costs, they are included by using a simple average over all farms. In the early 1950s the procurement price for wheat did not cover the estimated average cost of production, but since the mid 1960s the procurement price has been slightly above average cost. For rice, the procurement price usually has been slightly above average cost. The immediate and seemingly obvious conclusion has been that the procurement system has not had any serious disincentive effects on farmers.

However, comparing the procurement price (or any price) with average cost is meaningless for the purpose of examining effects on producer incentives. Saying the procurement price is close to average cost amounts to nothing more than saying that Indian agriculture is a competitive industry more or less in equilibrium. In a competitive industry, price cannot fall below average cost for any significant period of time. If it does, resources employed in that industry will be withdrawn and rents to factors of production will decrease, thereby reducing average cost. Similarly, if the price is in excess of production costs, competition among sellers will bid price down to average cost. With a few exceptions, these simple economic facts have gone unrecognized in the literature.

In a different context, Gale Johnson (1950) was one of the first to recognize the linkages between farm output prices and prices of farm inputs. In explaining why U.S. agricultural output failed to decline during the Great Depression despite a 50% decline in output prices during 1929-33, he noted that, owing to inelastic input supply curves, input prices fell just as rapidly during this period. Gale's pathbreaking work in this area has had a major impact on the agricultural economics profession (Johnson and Hoover, this volume). More recently, Gale (1981) has criticized setting U.S. target prices in relation to production costs because, among other problems, costs vary with price. Unfortunately, as illustrated here, his insights on this subject have often been ignored.

Trends in wheat and rice prices during 1967-87 are shown in Figures 3 and 4, while a closer look at the 1983-87 period is provided in Table 2. The interesting differences between domestic and world prices are discussed in part E below. Procurement prices have been consistently below domestic open market prices, with the gap usually somewhat bigger for rice than wheat. During 1983-87 the gap was on the order of 10-15% for both crops. The gap was large in the mid 1970s, when increases in domestic market prices (which were themselves much less than world price increases) were not passed along to procurement prices.

B. Public Distribution System (PDS)

Government price policy fundamentally has led to the creation of two segments in the Indian foodgrain market: the open market, and the public distribution system (PDS). Grain procured from farmers, imported, or released from government stocks is rationed to consumers at subsidized prices through PDS. Grain presently is distributed through about 325,000 "fair price" shops. As one would expect, there are often long waiting lines at the fair price shops.

Although the objective of PDS has sometimes been couched in terms of protecting the poor, there have been no serious efforts to target PDS toward the poor until recently. Firm data at the national level on the division of PDS supplies between the poor and the nonpoor or between rural and urban areas are not available. However, George (1985) estimates that about 85% of all PDS grain goes to urban areas. In contrast, as in other developing countries, the vast majority of India's poor (over 80% in 1983/84) live in rural areas. Even within urban areas, PDS often does not help the poor because eligibility is deliberately set wide, leading to a small ration per household. Only the states of Kerala, Gujarat, and (to a lesser extent) Tamil Nadu have extended PDS to rural areas and succeeded in targeting it to the poor. Data on PDS supplies and poverty are shown in Table 3. They underscore the fact that PDS supplies have not been allocated among states on the basis of poverty, total population, or even urban population.

Trends in PDS consumption and total consumption per capita during 1967-87 are shown in Figures 5 and 6. PDS consumption relative to total consumption has tended downward for wheat, although in absolute terms it has risen significantly. For rice, the importance of PDS has, on the whole, risen since the late 1960s. It may be noted that during the mid 1970s, when market prices were high, PDS was not expanded to help provide consumption security; PDS rations of wheat actually fell. One of the stated goals of PDS has always been to provide a buffer against open-market fluctuations. More detailed quantity and price data for 1983-87 are provided in Tables 1 and 2 above. During this period, the PDS price of wheat was about 15-20% less than open-market consumer prices while the gap was 20-30% for rice.

C. Input Support

The government supports inputs into foodgrain production in a variety of ways: through research and extension on hybrid seed varieties and other improved techniques; investments in infrastructure, including surface irrigation systems, transportation, and communication; and subsidies for several inputs, including surface irrigation, electricity, credit, and fertilizer. Our primary focus here is on irrigation infrastructure, because it is the largest and most important of the government's infrastructure investment activities, and on input subsidies related to irrigation.

Farmers and the government have made massive investments in irrigation. Starting at 21 million hectares in 1950, the total area irrigated for all crops in India has more than doubled since then. Government canals consistently have accounted for 37-38% of total irrigation, while private tubewells have risen from insignificance in 1950 to over 25% of the total today. The percentage of wheat area irrigated has risen from about one-third in 1950 to over 75% today. The percentage of rice area irrigated also stood at about a third in 1950 but is only somewhat above 40% today. To some extent, the achievements in irrigation are not as impressive as the numbers indicate because of problems with the irrigation systems (Dhawan, 1989). Canals have been plagued by poor drainage, which has led to waterlogging, widespread wastage of irrigation water, and corruption on a grand scale. Wade (1982) estimates that 25-50% of the works budget on a typical canal project leaks out in kickbacks to politicians and irrigation officials.

Subsidies for irrigation come primarily in the form of canal water, electricity, and credit (Gulati, 1989). For the sake of administrative convenience, canal water rates are usually linked to area rather than to the volume used; the rates charged are too low to recover the full costs of operating and maintaining the canal system. Similarly, electricity rates for agriculture are below the cost of production and distribution. In North India, a farmer hooking up an electric pumpset for a tubewell pays a one-time charge and then nothing thereafter, regardless of the amount of electricity used. Medium- and long-term institutional farm credit, which is used to purchase irrigation and other farm equipment, is offered to farmers at below-market interest rates. Some farmers also default on their loans, and as a rule serious efforts are not made to penalize them.

Data for 1983-87 on government investments in irrigation, irrigation-related subsidies, and other input subsidies are shown in Table 4. Irrigation investments are defined as the annualized capital costs of developing a hectare of surface irrigation potential, multiplied by the area irrigated by canals and other surface systems (Landes, 1990). For wheat and rice together, these investments amounted to 20% of annual product value, a substantial figure. Irrigation subsidies and other input subsidies each amounted to about 4% of total wheat and rice product value. The credit subsidy in the "other" category includes short-term credit and medium/long-term credit used for purposes other than irrigation. The fertilizer subsidy includes subsidies on both domestically-produced and imported fertilizers; both arise from government control of domestic fertilizer prices (see Gulati, 1989, 1990).

D. Government Stocks

Following a precipitous drawdown of government foodgrain stocks during the early 1970s, and poor harvests in 1974, the Indian government initiated an active stock accumulation program in 1974. Large stocks were built up through procurement and, for wheat, imports as well. Total wheat and rice stocks during 1983-87 averaged about 21 million MT, or about 20% of annual consumption. The ostensible purpose was to ensure adequate food supplies during years of domestic production shortfalls. However, the figures above clearly show that total Indian consumption has fluctuated along with production, although perhaps by not quite as much. The program undoubtedly has affected private stocks, but continuous, national-level data on private stocks are not available.

Gale Johnson has been a forceful critic of Indian stockholding policy. In *World Agriculture in Disarray, Revised*, he lays out the case for relying on international trade instead of stocks to make up differences between procurement and PDS. His data indicate the cost of grain storage during 1974-79 was 40 billion (1985) Rs., whereas a policy of importing during bad years and exporting during good ones would have actually netted the government a 33 billion (1985) Rs. gain. This puts the total cost at 73 billion Rs., or more than 6% of total government expenditures during 1974-79. Gale notes that the government made the mistake of building up stocks during 1974-76, a period of high world prices. The situation might have been different if stocks had been accumulated during a period of low prices, but identifying such a period in advance would clearly require a great deal of luck.

E. Linkages with World Markets

For India, international agricultural trade is by and large a government operation. Foreign trade in cereal grains is controlled by FCI (Food Corporation of India), while trade in many other agricultural products is controlled by another government monopoly, the State Trading Corporation of India. Imports and exports of rice have always been negligible. For wheat, imports were significant throughout the 1960s under food aid programs and again in the mid 1970s as government stocks were built up. Imports reached modest levels in the early 1980s, being devoted to stock accumulation, but otherwise have been quite small since 1976. Exports have always been very limited, but they have exceeded imports in some recent years. The government's goal of self-reliance in food explains most of these trade patterns.

On this subject of self-reliance in food at least one comment can be made. Researchers in general have ignored linkages between international prices and domestic Indian prices. Sah and Srinivasan (1988), for example, conduct their analysis of the welfare impacts of the procurement-rationing program under the assumption of no foreign trade in food. This assumption is based on their explicit recognition and acceptance of India's "unambiguous commitment" to achieving food self-sufficiency. This is curious piece of reasoning. Government pronouncements with respect to the objectives of food self-sufficiency do not imply that a closed economy framework is the appropriate analytical framework to employ.

Government control over trade has generated large differences between domestic and world prices, as the data in Table 2 and Figures 3-4 above indicate (see also Sukhatme, 1983). For rice, the world price has almost always been above the domestic open-market and procurement prices, with the gap reaching huge proportions during the mid 1970s. More recently, though, a large drop in world prices has narrowed the difference; during 1983-87, the world price (using the officially-set exchange rate and including transportation costs to Indian production points) was about 10% above the open market producer price and 25% above the procurement price. For wheat, an interesting shift in pricing policy occurred during the mid 1970s. Prior to then, domestic prices exceeded world prices; since then, the opposite has been the case. With domestic production growing rapidly under the green revolution, the government apparently was unwilling to pass the large world price increases of the mid 1970s on to domestic markets. During 1983-87, the world price (once again at the legal exchange rate) was about 40% above the open-market producer price and about 55% above the procurement price.

The differences between domestic and world prices are even larger if one uses illegal (or black-market) exchange rates, as the data in Table 2 demonstrate. Illegal trading in hard currency is just one aspect of a thriving underground economy in India commonly estimated at 20-100% of officially-reported national income (*World Currency Yearbook*; Acharya, 1983). Periodic efforts to crack down on the black market in hard currency have all failed completely.

To some extent, input subsidies offset the disincentive effects of output price policies. However, their impact is definitely limited. Producer and consumer subsidy equivalents (PSEs and CSEs) for wheat, rice, and competing crops have been estimated by Landes (1990) and are shown in Table 5. Only when one includes investments in irrigation infrastructure do the PSEs for wheat and rice approach zero, and the appropriateness of treating these investments like direct subsidies is doubtful. Separate estimates of effective protection in Indian agriculture by Gulati *et al.* (1990) are largely consistent with Landes (1990). Both these studies agree that oilseeds receive much more favorable treatment than wheat or rice. Bringing domestic prices into line with world prices would shift land and other resources into wheat and rice, crops for which India has more of a comparative advantage.

Are world prices the relevant benchmark? The Indian government's answer has generally been no. Gale Johnson (1978), however, has been a forceful advocate of international trade and world prices as the benchmark. Largely as a result of Gale's influential work (1975), it is now well-accepted that domestic agricultural price policies in developed countries have stabilized internal prices at the expense of international price instability. Despite these interventions, however, Gale has often noted that world prices come much closer to reflecting the actual opportunity costs of various commodities than the prices in India and other developing countries. The benefits of free international agricultural trade constitute one of major themes of Gale's early work (Johnson and Hoover, this volume). In the Indian case, the data in Table 2 suggest that open-market consumer prices are already close to world prices, whereas the gaps between producer prices and world prices are much larger. Moving to world prices (while possibly retaining food subsidies) could offer real benefits to producers without unduly harming consumers.

II. THE PRICE POLICY LITERATURE

In this section we take a closer look at two of the common themes of the Indian agricultural price policy literature: (1) while prices may have an impact on supply, irrigation and other types of infrastructure are much more important; and (2) while the procurement price is less than the open market price, the procurement system operates so as to raise the average price received by a farm on all its output. We critique the former argument in part A and the latter in part B.

A. Prices vs. Infrastructure

The importance of infrastructure over price on supply has been alleged by so many researchers that it is hard to single out anyone. A typical quote comes from de Janvry and Subbarao (1986, p. 92), who reject a "monetarist" viewpoint for a "structuralist" one. They claim that "aggregate supply response in agriculture is low, price-support programs imply high private and social costs, price incentives fundamentally result in income transfers to the large farmers, and output must be increased by promoting a well-balanced package of government instruments including technology, infrastructure investments, and production subsidies."

No one doubts the importance of infrastructure or technology. Their critical role in supply has been demonstrated conclusively within both the Indian context (e.g., Antle, 1984) and an international context (e.g., Binswanger *et al.*, 1987). However, this hardly means that prices are unimportant. Gale Johnson (1978) was one of the first to see the prices vs. infrastructure argument as a variant on the old "prices do not matter" argument.

Many, many studies of supply response with respect to prices and infrastructure have been done for India. A selective list of recent studies is presented in Table 6. A few studies specify a Nerlovian partial adjustment equation for supply and so yield both short- and long-run supply elasticities. The other studies, which use yearly data and do not contain lags in adjustment, are probably capturing short-run effects. Given this, "consensus" short-run own-price supply elasticities for wheat and rice are each about 0.4. The short-run supply elasticity with respect to irrigation varies a lot from one study to another; some are significantly greater than the own-price elasticity while others are about the same or even less. On the whole, however, irrigation appears to be more important. To this extent, at least, the prices vs. infrastructure argument is corroborated. A consensus short-run elasticity with respect to irrigation for wheat and rice combined is about 0.6. There appears to be no firm difference between short- and long-run elasticities, although on average the long-run elasticities are about double their short-run counterparts.

Our problem with the prices vs. infrastructure argument is that it presumes the two are, or ought to be, independent or competing policy levers. As Gale Johnson (1978) recognized, prices complement infrastructure and technology rather than compete with them. To a farmer contemplating whether to dig a tubewell for irrigation, buy a new electric or gasoline pump, get hooked up to the local electric power line, purchase irrigation water from the local government canal, or use a new high-yielding seed variety, prices clearly do matter. Prices affect the income the farmer can expect to receive from these investments and, therefore, the incentive to make the investments.

Do prices affect the incentives of public authorities to invest in irrigation, other types of infrastructure, and new techniques? Politicians and administrators make decisions based on a variety of considerations, some or most of which may have nothing to do with incentives. To the extent that incentives do matter, however, the answer is yes. To the extent that farmers benefitting from infrastructure and new techniques have enough clout to see that their interests are not ignored entirely, the answer is also yes. Many researchers argue that farmers in North India, and others who have taken advantage of irrigation and high-yielding seeds (the so-called "rich farm" lobby), have too much political clout (e.g., Krishnaji, 1990). On the whole, farmers probably have a fair amount of political clout but less than that enjoyed by urban consumers and other major interest groups.

The general tendency in the literature is to treat infrastructure and technology as exogenous. There is little empirical evidence that can be brought to bear here. Thus, one objective of the simulation exercises in sections III and IV below is to fill this gap by quantifying the response of infrastructure to price. Evenson (1983) found that an increase in the price of rice or coarse cereals did indeed stimulate investments in irrigation, electricity, and roads. The wheat price and the price of other crops had negative impacts, although omitted technology variables positively correlated with infrastructure and negatively correlated with prices could be the culprit. Sukhatme (1983) found that adoption of high-yielding rice varieties was a positive function of the price of rice, although he reported no effect for wheat.

B. Procurement and the Average Farm Price

The argument that procurement could actually raise the average price received by a farm on all its output was originally outlined by Dantwala (1967). Mellor (1968, p. 34) stated it as follows: "Levy takes a significant portion of the supply, and in effect gives it disproportionately to the lower income consumers with the more elastic demand. The free market is then left to those persons with higher incomes with highly inelastic demand. The effect then is to concentrate the shortage among the consumers with the most inelastic demand." In short, procurement supposedly allows the government to engage in price discrimination and, as is well known, the group with the more elastic demand receives the lower price.

This argument was developed more fully by Hayami *et al.* (1982), who constructed a partial equilibrium, closed economy model of the Indian procurement/PDS system. They considered two cases, effective implementation (in which the price elasticity of demand for PDS consumers is greater in absolute value than that of open-market consumers) and ineffective implementation (both price elasticities equal). Under effective implementation, the average farm price is indeed higher so long as the price elasticity of supply is less than the absolute value of the price elasticity of demand for open-market consumers. When the supply elasticity exceeds the open-market demand elasticity, they predict that prices will diverge through oscillation. However, this result is an artifact of the adaptive price expectations and Cobweb-type dynamics assumed in their model. Under ineffective implementation, the average farm price is basically the same as with no procurement.

For the reasons given in section I.B above, we feel that the ineffective implementation case is the most apt description of reality. In practice, PDS has not segmented the market into low- and high-income consumers, but rather rural and urban consumers. The rural poor, who are by far the largest group of poor people, generally have little access to PDS. In urban areas, efforts to target PDS to the poor are the exception rather than the rule and the poor must generally get most of their food in the open market. In Andhra Pradesh, for example, PDS supplies the poor with only one-third or less of their rice (Subbarao, 1990).

PDS could still be a perverse form of price discrimination if price elasticities of demand were significantly lower (in absolute value) in rural areas than in urban areas. The only two studies to our knowledge that provide separate demand elasticity estimates for rural and urban consumers are Coondoo and Majumder (1987) and Radhakrishna and Murty (1980). The former finds demand to be more elastic for rural consumers, while the latter reaches the opposite conclusion. In any event, such price discrimination would put the burden of high prices on the poorer group, rural consumers.

One of the objectives of the simulation model sections III and IV is to quantify the impacts of procurement on the average farm price and other variables, starting with the assumption of ineffective implementation. We do this first assuming that other government policies are given and then allowing other policies to change in response to procurement. So far as we know, no one has analyzed the impact of procurement on other government policies. Econometric models of the Indian grain market (e.g., Krishna and Chhibber, 1983) typically treat procurement and other policies as levers that can be manipulated independently of each other. As we will see, the impact of procurement on producers is sensitive to this assumption.

III. THE SIMULATION MODEL

In this section, we develop a static, partial equilibrium, single commodity model to quantify the effects of various procurement and infrastructure policy regimes. The commodity is superior cereals, a combination of wheat and rice. For the purposes of investigating the arguments discussed above, this level of aggregation seems acceptable. Infrastructure is defined as irrigation and is measured by government expenditures on irrigation (both investments and subsidies). The base period is 1983-87, drawing on the data in Tables 1-5 above. Part A covers supply, B covers demand, C lays out the market equilibrium conditions, D specifies the government policy variables, while part E models the determinants of government policy.

A. Supply

The profit (π) from production of superior cereals is assumed to be a function of the supply price (p^s) and infrastructure (z):

$$(1) \quad \pi = \alpha_o p^s + (\alpha_p/2)(p^s)^2 + \alpha_z p^s z,$$

with $\alpha_p > 0$ and $\alpha_z > 0$. Output supply (q^s) is obtained from Hotelling's lemma:

$$(2) \quad q^s = \partial\pi/\partial p^s = \alpha_o + \alpha_p p^s + \alpha_z z.$$

As explained below, government subsidies for electricity and irrigation are counted as part of the cost of investing in irrigation infrastructure. Other input subsidies (for fertilizer and credit used to purchase items other than irrigation equipment) are not included in the model in order to keep it simple and clearly focused on procurement and infrastructure.

The supply price of superior cereals is a weighted average of the procurement price and the open-market, farm-level wholesale price (p^f). The respective weights are θ and $1 - \theta$, where θ is procurement as a fraction of total supply. Define the procurement price as $(1 - \tau)p^f$, where τ is the implicit tax on procured grain. Then

$$(3) \quad p^s = (1 - \theta\tau)p^f.$$

As noted above, there are many, many studies on elasticities of wheat and rice supply with respect to price and infrastructure. A list of some of these studies is in Table 6 above. The "consensus" short-run elasticities with respect to price and irrigation appear to be about 0.4 and 0.6, respectively. Consensus long-run elasticities appear to be about double the short-run elasticities, or 0.8 for price and 1.2 for irrigation. For the simulations below, we base α_p and α_z on averages of the short- and long-run elasticities. α_0 is chosen so that equation (2) replicates base-period data.

B. Demand

There are two groups of consumers, rural (r) and urban (u). Consumers in each group i (= r or u) purchase superior cereals on the open market (q^i)

and through PDS (d^i). PDS purchases are rationed by the government, with the PDS price (h^i) less than the open-market retail price (p^i):

$$(4)\quad h^i = (1 - \sigma)p^i,$$

where σ is the subsidy rate on PDS consumption.

The indirect utility function for each group is assumed to be a function of the open-market price and the consumer savings on PDS purchases, measured on a per-unit basis by the difference between the open-market and PDS prices:

$$(5)\quad v^i = -\gamma_i p^i + (\beta_i/2)(p^i)^2 + \delta_i(p^i - h^i)d^i,$$

with $\gamma_i > 0$, $\beta_i > 0$, and $\delta_i > 0$. If $\delta_i = 1$, consumers benefit by the full amount of the difference between open-market and PDS prices. In this case, as we will show in a moment, PDS consumption displaces open-market consumption on a one-for-one basis.

From Roy's identity, open-market demands are

$$(6)\quad q^i = -\partial v^i/\partial p^i = \gamma_i - \beta_i p^i - \delta_i d^i,$$

so that $\partial q^i/\partial d^i = -\delta_i$. (To obtain equation (6), the marginal utility of income is normalized to unity.)

Estimates of demand elasticities on which to base the model's parameters are not as plentiful as for supply elasticities. A list of some recent studies is presented in Table 7. On the whole, these studies suggest an own-price elasticity of demand for superior cereals of about -0.3. As noted above, evidence is conflicting on whether demand is more price elastic in rural or urban areas. Thus we base both β_r and β_u on a price elasticity of -.3. γ_r and γ_u are chosen so that equation (6) replicates base-period data.

Estimating δ_r and δ_u is more difficult. If PDS and open-market grain were perfect substitutes, and if PDS were inframarginal (that is, the amount of grain given to consumers through PDS were less than what they would have purchased anyway on the open market), then PDS would be tantamount to a pure income transfer. In this case, $\delta_i = 1 - MPC^i(1-h^i/p^i) \approx 0.97$ to 0.99, where MPC^i is the marginal propensity of group i to consume superior cereals. However, PDS and open-market grain are not perfect substitutes, since the quality of PDS grain is generally recognized to be lower. Moreover, low-and middle-income households with access to fair price shops purchase the bulk of their grain through PDS (George, 1985). This suggests that PDS might not be inframarginal for many of these households. Since such a large fraction (about 85%) of PDS supplies to urban areas, PDS is probably less likely to be inframarginal in urban areas than in rural areas. Based on these considerations, we set $\delta_u = 0.7$ and $\delta_r = 0.9$.

C. Market Equilibrium

There are two market-clearing conditions, one for the open market and the other for the government-controlled market. In the open market, supply must equal demand:

$$(7) \quad (1 - \theta)q^s = q^u + q^r.$$

Private stocks would be included in equation (7) but, as noted above, data are unavailable. In the controlled market, PDS consumption must equal procurement plus net imports and net reductions in government stocks. Let μ represent net imports and net stock reductions as a fraction of procurement. Let λ be the fraction of PDS supplies going to urban areas. Market equilibrium then requires

(8) $d^u = \lambda(1 + \mu)\theta q^s$,

(9) $d^r = (1 - \lambda)(1 + \mu)\theta q^s$,

so that $d^u + d^r = (1 + \mu)\theta q^s$.

In the open market, each retail price is equal to the farm-level price plus a fixed marketing margin (m^i, i = u or r):

(10) $p^i = p^f + m^i$.

Price data in Table 2 imply $m^u = m^r = 500$ Rs/MT in the base period.

D. Government Policy Variables

The government has six policy variables: irrigation infrastructure (z); procurement as a fraction of supply (θ); the implicit tax rate on procured grain (τ); the subsidy rate on PDS grain (σ); the fraction of PDS supplies going to urban areas (λ); and imports/stock reductions as a fraction of procurement (μ). Comparative statics with respect to the policy variables are discussed in Section IV below.

E. Determinants of Policy

Some would say that the comparative statics with respect to the policy variables are the end of the story. However, the arguments in Section II on the impacts of prices and procurement hinge on the response of other policy variables to these two policy levers. In order to quantify these responses, it is necessary to model the determinants of policy. We assume that the Indian government has a revealed political preference function (Peltzman, 1976; Gardner, 1987) that depends on the welfare of four broad interest groups: producers of superior cereals; urban consumers of superior cereals; rural consumers of superior cereals; and a group consisting of taxpayers and other claimants on government revenues. The fourth group benefits from PDS sales but must finance their procurement, net imports/stock changes, and investments in irrigation infrastructure.

Producer welfare is measured by profits (π), consumer welfare by utility (v^i), and the fourth group's welfare by (minus one times) the welfare costs of the programs listed above. Welfare costs are measured by expenditures on these programs plus the deadweight costs of raising taxes to finance these expenditures. Following equation (10) in Browning (1987), we can estimate the deadweight costs of taxes on labor supply. We need data on average and marginal income tax rates (available in *Statistical Outline of India*), as well as an estimate of the elasticity of labor supply, available for rural India in Rosenzweig (1984). The implied deadweight losses at the margin are on the order of 50% of tax revenue. Welfare costs of other tax methods might be more or less, but this seems like a plausible number.

Government expenditures on irrigation are simply measured by z, while procurement expenditures are $(1 - \tau)p^f\theta q^s$. Net of marketing costs, government revenues from PDS sales are $(1 - \sigma)p^f(d^u + d^r) = (1 - \sigma)p^f(1 + \mu)\theta q^s$. Imports are made at the world price (p^w). The opportunity cost of selling stocks on the domestic market through PDS is also the world price. Thus import/stock costs are $p^w\mu\theta q^s$. Total welfare costs (t) are

$$(11)\quad t = (1 + \epsilon)\{z + (\sigma - \tau)p^f\theta q^s + [p^w - (1 - \sigma)p^f]\mu\theta q^s\},$$

where ϵ (= 0.5) is the marginal deadweight cost of each Rupee spent. The world price at production points evaluated at the illegal exchange rate is used in the simulations below. In reporting on the results of these simulations, the second term inside the braces in equation (11) is referred to as procurement/PDS expenditures. The third term is referred to as import/stock expenditures.

The government's objective function is a weighted sum of the welfare measures for the four interest groups:

$$(12)\quad G = \omega^s\pi + \omega^u v^u + \omega^r v^r - t,$$

where $\omega^s > 0$, $\omega^u > 0$, and $\omega^r > 0$ are weights on producer, urban consumer, and rural consumer welfare. The weight on government expenditures is normalized to unity because it is only relative weights that matter. The weights are treated as constants for simplicity only. In fact, as Gardner (1987) demonstrates, the weight given a group should increase as its welfare relative to other groups is reduced and vice versa. Equation (12) can be viewed as a local approximation to the "true" preference function. We have a garden-variety social welfare function when $\omega^s = \omega^u = \omega^r = 1$.

Equation (12) can be maximized with respect to some or all of the policy variables. Suppose we want to know how procurement and the tax rate on procurement affect other government policy choices. Then (12) is maximized with respect to the other variables, taking θ and τ as a given, and these policy choices become contingent on θ and τ. Suppose we want to know the politically "optimal" choices for all the policies. Then (12) is maximized with respect to all policy variables, yielding solutions contingent only on the model's parameters and exogenous variables.

To our knowledge, no prior studies have applied a revealed political preference approach to Indian agricultural price policy. Consequently, we have no prior estimates of the weights in the objective function (12). However, following Oehmke and Yao (1990) and others, we can deduce the weights from observed government behavior during the base period. The six first-order conditions for a maximum of (12), $0 = \partial G/\partial \mathbf{x}$ for the vector $\mathbf{x} = \{z\ \theta\ \tau\ \sigma\ \lambda\ \mu\}$, would usually be viewed as determining the optimal policies. They can also be viewed, though, as determining the weights that permit the model to reproduce base-period policy choices. The weights are conditional on other parameters/variables. In addition, the matrix $\partial^2 G/\partial \mathbf{x}\partial \mathbf{x}'$ of second derivates must be negative definite for the observed policy vector $\mathbf{x}$ to constitute a global maximum of (12), so that the nth principal minor of this matrix (n=1 to 6) should have sign $(-1)^n$. We should therefore also try to pick weights that ensure the second-order conditions for a maximum of (12) are satisfied.

With only three weights, it is not possible to pick values that satisfy all six first-order conditions and all six second-order conditions. We undertook a grid search at intervals of 0.25 for the weights that would do the "best" job, restricting ourselves to values we felt were intuitively plausible. We settled on $\omega^s = 0.5$, $\omega^u = 2.0$, and $\omega^r = 1.5$. With these weights, the government values producer welfare by about 50% less than taxpayer welfare. Urban consumer welfare is about twice as politically important as taxpayer welfare, while rural consumers are about 50% more politically powerful than taxpayers.

Aside from the fact that not all conditions for a maximum of (12) are satisfied, there are several other caveats on our procedure. First, as noted above, the weights are in reality not constants; large changes in the policy variables could generate large changes in the weights. Second, by inspection we have found that the weights are sensitive to the parameter values. Third, and more generally, no one has yet shown that an equation such as (12) can be derived from a more general model of political behavior (e.g., Becker, 1983). Fourth, the weights are chosen on the assumption that the observed policies maximize (12), so that one cannot test this conjecture. Fifth, the government chooses many other policies that affect producers, consumers, and/or taxpayers jointly with those included in the model. Finally, the weighted objective function (12) is used here to explain government behavior but should not be used to evaluate social welfare (see Harberger, 1978).

IV. SIMULATION RESULTS

In this section we use the simulation model to address the arguments critiqued in section II. We examine the influence of price on irrigation infrastructure in part A. The Indian government has no policies that permit it to directly set the farm price; we therefore focus on its most direct price policy instrument, the procurement price. In part B, we examine the impact of procurement on the average farm price and other variables.

A. Procurement Prices and Irrigation

Within the context of our model, the Indian government's control over the procurement price is through the tax rate on procurement. Elasticities with respect to the procurement tax rate are shown in Table 8. There are three policy scenarios: all other policies fixed (the usual comparative statics case); all policies except procurement allowed to change in response to the procurement tax; and all policies, including procurement, allowed to change. The latter two policy scenarios draw on the determinants of policy in section III.E above. Particular attention focuses on the response of irrigation to the procurement tax.

By itself, the procurement tax has little effect. Open-market prices increase, but only negligibly; the farm average supply price and total supply decrease, but the effects are nil. Only government procurement/PDS expenditures show any significant responsiveness to the tax. The other two scenarios, however, are a much different story. As the procurement tax increases, investments in irrigation decline, just as expected. The elasticity of irrigation with respect to the tax is -0.1 when all policies except procurement are flexible and -0.2 when all policies change. Paradoxically, in response to this decrease in irrigation, market prices increase to the point where the weighted average farm price actually increases. The elasticity of the farm average price with respect to irrigation (other policies constant) is -1.1. Within the context of our simulations, then, the original impact of the procurement tax on the average farm price is overwhelmed by the response of other policy variables to the tax. The net effect on supply is still negative, but the impact is negligible. All three scenarios agree in this regard.

On the consumer side, though, the three scenarios differ. Consumers are not affected much by the tax when all other policies are fixed. With flexible policies, market price increases have more significant impacts. Consumer expenditures increase even as urban consumption decreases. The conclusion is that consumers are the main losers from the tax. Consumer losses are held in check to some extent by an increase in imports/stock releases. For urban consumers, who enjoy more political clout than rural consumers, there is also an offsetting increase in the urban share of total PDS supplies. On the other hand, an increase in market prices implies an increase in total government PDS subsidy expenditures for any given PDS subsidy rate. To reduce these expenditures, the government cuts the PDS subsidy, harming consumers. Other models of the procurement/PDS system typically assume that the procurement tax rate and PDS subsidy rate move in lockstep or are actually equal (e.g., Sah and Srinivasan, 1988). Our results suggest that this need not be the case.

Our results confirm that the procurement price can have a significant impact on investments in irrigation. However, they may not seem as "firm" as desired. The root of the problem is that the procurement price is not a strong tool with which to influence the average farm price. The base-period contribution of the procurement price to the average farm price is only about 17%, while the market price contributes the remaining 83%.

B. Procurement and the Average Farm Price

Elasticities with respect to the fraction of output procured are shown in Table 9. Once again, there are three policy scenarios: all other policies fixed; all policies except the procurement tax rate allowed to change in response to procurement; and all policies, including the procurement tax, allowed to change. The latter two policy scenarios draw on the determinants of policy in section III.E above. Special attention focuses on the response of the farm average price to procurement.

By itself, an increase in procurement causes minor increases in market prices and a negligible change in the farm average price. This follows from the assumption of ineffective implementation of PDS rationing, and agrees with the results of Hayami *et al.* (1982). Open-market demands decrease moderately, a result of both the additional procurement (and thus PDS supplies) and the open-market price increases.

Much more dramatic results occur when other policies can respond to procurement. Imports/stock reductions as a fraction of procurement decrease by more than 50%, as the government relies instead to some extent on the additional procurement to supply PDS. This decrease in imports/stock reductions, by itself, puts upward pressure on domestic prices. However, to take advantage of the higher rate of procurement on each unit of output, policymakers increase production by investing more in irrigation. The elasticity of supply with respect to irrigation (other policies constant) is about 0.25. This increase in irrigation overwhelms other effects on prices, causing significant reductions in market prices and the farm average price. We thus arrive at a conclusion similar to the one above concerning the procurement tax: within the context of our simulations, the original impact of procurement on the farm average price (which is nil) is overwhelmed by the response of other policies, especially irrigation, to procurement.

In spite of the increase in both supply and procurement as a fraction of supply, imports/stock reductions fall by so much that total PDS supplies decrease. When all other policies are flexible, the elasticity of PDS supplies with respect to the fraction of output procured is -1.1. To appease consumers, the government hikes the PDS subsidy rate. In addition, some PDS is transferred from urban areas to rural areas, where the marginal impact on consumer welfare is greater (recall $\delta_r = 0.9$ but $\delta_u = 0.7$). To limit government expenditures, the procurement tax is increased in response to the increase in the PDS subsidy (as well as the increase in irrigation expenditures). In contrast to the simulations in section IV.A above, then, the procurement tax and PDS subsidy move in the same direction. However, they differ in the magnitudes of their changes.

V. CONCLUSIONS

One of the main themes throughout Gale Johnson's writing is that agricultural policies generally do not accomplish their publicly stated objectives. Indian agricultural price policy is a good case in point. The procurement/public distribution system has failed to provide any real measure of consumption security to the poor. Instead, it has appeased politically influential urban constituencies. Nor has procurement provided any benefits to producers, as much of the literature purports to show. Taking into account the reaction of other policies to the procurement system, our simulations suggest that it has significantly reduced farm prices. In the case of Indian agricultural price policy, as in other cases, success or failure is measured in political terms that policymakers are usually reluctant to discuss.

The major success story in Indian agriculture has been investments in irrigation and other types of infrastructure, which have yielded large dividends. However, low procurement prices have to some extent discouraged these investments. Taking into account the reaction of irrigation and other policies to the procurement price, our simulations suggest that there could be some modest gains in this regard. Gains in irrigation might even be larger with a move to free international trade in grains, a much more dramatic policy reform than tinkering with the procurement price. The Indian government made some small moves toward trade liberalization in the mid 1980s, but has since retrenched. Tangible improvements in agricultural infrastructure might be made if the government were to take steps to bring domestic procurement and open-market prices more in line with world prices.

Unfortunately, sustained agricultural policy reforms are unlikely to occur if the recent instability in India's leadership continues. As each new government comes to power, it brings with it a somewhat different set of agricultural policy priorities. This instability filters down through the civil service fairly quickly, affecting, for example, the composition of the Commission for Agricultural Costs and Prices. Political instability also makes it difficult to gain legislative approval for reforms required by the International Monetary Fund and World Bank as a condition for new loans. More lasting reforms will only be possible when a government is in power long enough, and has enough political goodwill, to undertake some politically risky changes in agricultural price policy.

Table 1. Wheat and Rice Quantities, 1983-87 (Million MT, Annual Averages)

Variable	Wheat	Rice	Total
Production	44.5	58.0	102.5
Open Market	35.5	49.5	85.0
Procured	9.0	8.5	17.5
Urban Consumption			
Open Market	12.5	8.5	21.0
PDS	9.5	6.0	15.5
Rural Consumption			
Open Market	23.0	41.0	64.0
PDS	1.5	1.5	3.0
Net Imports	0.5	0.0	0.5
Imports	0.8	0.3	1.1
Exports	0.3	0.3	0.6
Net Decrease in Stocks	1.5	-1.0	0.5

NOTE: Rounded to the nearest 0.5 million MT, except for imports and exports. Sources: *Bulletin on Food Statistics*, *Fertilizer Statistics*, and National Sample Survey data in Evenson (1986).

Table 2. Wheat and Rice Prices, 1983-87 (Thousands of 1985 Rs/MT, Annual Averages)

Variable	Wheat	Rice	Weighted Average
Producer Price			
Open Market	1.8	2.6	2.3
Procurement	1.6	2.3	1.9
Urban Consumer Price			
Open Market	2.4	3.3	2.8
PDS	1.9	2.4	2.1
Rural Consumer Price			
Open Market	2.2	3.1	2.8
PDS	1.9	2.4	2.1
World Price (Using Legal Exchange Rate) at			
Indian Ports	1.9	2.4	2.2
Production Points	2.5	2.9	2.7
Consumption Points	2.6	3.1	2.9
World Price (Using Illegal Exchange Rate) at			
Indian Ports	2.2	2.8	2.6
Production Points	3.0	3.4	3.2
Consumption Points	3.1	3.7	3.4

NOTE: Rounded to the nearest 100 Rs/MT. The weighted averages are computed using the quantities in Table 1. The open-market producer price is the post-harvest wholesale price, while the open-market consumer price is the rural retail price. The world price at production (consumption) points is the price at Indian ports plus transportation costs to major production (consumption) areas. All domestic prices, as well as the world prices at production and consumption points, are production- or consumption-weighted averages of prices in various states/markets. Sources: Landes (1990), *Bulletin on Food Statistics*, *Fertilizer Statistics*, National Sample Survey data in Evenson (1986), *International Financial Statistics*, and *World Currency Yearbook*.

Table 3. PDS Supplies and Poverty, 1983/84

State	Percentage of National Total			
	National PDS Supplies	Urban Population	Total Population	Poverty
Winners				
Kerala	16	3	4	3
West Bengal	15	9	8	8
Union Territories	22	5	2	2
Losers				
Bihar	4	5	10	14
Madhya Pradesh	2	7	8	9
Uttar Pradesh	3	12	16	20
Rest of States	38	59	52	44
All India	100	100	100	100

NOTE: National PDS supplies refers to wheat and rice combined and excludes state efforts. However, state programs are significant only in Andhra Pradesh. Union Territories includes minor states. Population figures are for 1981. Sources: Hanumantha Rao, Ray, and Subbarao (1988) and *Statistical Outline of India*.

Table 4. Agricultural Investments and Subsidies, 1983-87 (Annual Averages, Billions of 1985 Rs)

Variable	Wheat Amount	Wheat % Product Value	Rice Amount	Rice % Product Value	Total Amount	Total % Product Value
Irrigation Investment	22	28	22	15	44	20
Irrigation Subsidies	3.9	5.0	3.9	2.7	7.8	3.6
Surface Systems	0.4	0.5	0.4	0.3	0.8	0.4
Electricity	3.1	4.0	3.1	2.1	6.2	2.8
Credit	0.4	0.5	0.4	0.3	0.8	0.4
Other Subsidies	4.5	5.8	5.1	3.5	9.6	4.3
Credit	2.5	3.2	2.6	1.8	5.1	2.3
Fertilizer	2.0	2.6	2.5	1.7	4.5	2.0

NOTE: Investment amounts are rounded to the nearest one billion Rs and subsidy amounts to the nearest 0.1 billion Rs. Percentages are rounded to the nearest one percent for investment and the nearest 0.1 percent for the subsidies. Product value is based on the data in Tables 1 and 2. The subsidy for surface systems is for operation and maintenance. The irrigation credit subsidy is equal to interest subsidies plus defaults on medium/long-term institutional farm credit, multiplied by the share of irrigation assets in total nonland assets in rural areas (about 0.3). The other credit subsidy is equal to total credit subsidies (including those for short-term credit) minus irrigation credit subsidies.
Sources: Landes (1990), NCAER (1979), and *International Financial Statistics*.

Table 5. Producer and Consumer Subsidy Equivalents, 1983-87 (Annual Averages, Percent)

Commodity	PSE: Without Input Subsidies and Infrastructure	PSE: Without Infrastructure	PSE: All Policies Included	CSE
Superior Cereals				
Wheat	-45	-30	-5	25
Rice	-20	-15	5	5
Coarse Cereals				
Sorghum	-35	-30	-25	15
Maize	-40	-35	-20	20
Oilseeds				
Peanuts	0	0	10	-35
Rapeseed	10	15	25	-45

NOTE: Rounded to the nearest 5 percent. The PSE (producer subsidy equivalent) is $(p^s - p^{ws} + i)/p^s$, where p^s is the domestic supply price, p^{ws} is the world price plus transportaion costs to domestic production points, and i is input subsidies and/or infrastructure. The CSE (consumer subsidy equivalent) is $(p^d - p^{wd})/p^d$, where p^d is the domestic demand price and p^{wd} is the world price plus transportation costs to domestic consumption points. The CSEs for oilseeds are expenditure-weighted averages of figures for oil and meal. Source: Landes (1990).

Table 6. Supply Elasticities, Price and Irrigation

Study	Database	Commodity	Elasticity: Own-Price	Elasticity: Irrigation
Bapna, Binswanger, and Quizon (1984)	Semi-Arid Tropics, District Level, 1955-73	Superior Cereals	0.4	0.3
Evenson (1983)	North India, District Level, 1959-74	Wheat	0.4	1.1
		Rice	0.4	0.3
Gulati and Sharma (1990)	National Level, 1969-86 (Wheat) and 1966-86 (Rice)	Wheat	0.3 *(0.8)*	1.1 *(3.2)*
		Rice	0.3 *(0.3)*	1.5 *(1.7)*
Krishna and Chhibber (1983)	National Level, 1961-78	Wheat	0.6 *(2.0)*	0.7 *(2.0)*
McGuirk and Mundlak (1991)	Punjab, District Level, 1960-79	Wheat	0.1 *(0.8)*	0.4 *(*)*
		Rice	0.1 *(0.2)*	0.1 *(*)*
Krishna and Raychaudhuri (1980)	National Level, 1957-69 (Wheat) and 1957-70 (Rice)	Wheat	0.2	0.2
		Rice	0.5 *(0.9)*	---
Sidhu and Baanante (1981)	Punjab, Farm Level, 1970	Wheat	0.6	0.6

NOTE: Rounded to a single decimal digit. The figures in italics within parentheses are long-run elasticities. For those studies calculating long-run elasticities, the figures in normal type are short-run elasticities. Superior cereals is a combination of wheat and rice. Bapna, Binswanger, and Quizon (1984) estimated several systems of supply equations. The one reported here is their system A (wheat and rice aggregated into superior cereals). For McGuirk and Mundlak (1991), the irrigation elasticities are averages of elasticities for private and public irrigation. Long-run elasticities (*) are not presented because irrigation is endogenous in the long run.

Table 7. Demand Elasticities, Price and Income

Study	Database	Commodity	Elasticity: Own-Price	Elasticity: Cross-Price	Elasticity: Income
Behrman and Deolalikar (1987)	Rural South India, Household Level, 1976-77	Grains	---	---	0.5 to 1.5
Coondoo and Majumder (1987)	National Sample Surveys, 1953-73	Cereals	-0.1	---	0.5
Ito, Peterson, and Grant (1989)	National Level, 1961-84	Rice	---	---	0.1
Krishna and Chhibber (1983)	National Level, 1961-78	Wheat	-0.4	---	1.5
Radhakrishna and Murty (1980)	National Sample Surveys, 1954-65	Cereals	-0.3	---	0.5
Swamy and Binswanger (1983)	State Level, 1956-75	Wheat	-0.3	0.1	1.1
		Rice	-0.7	0.1	0.9

NOTE: Rounded to a single decimal digit. Coondoo and Majumder (1987) estimated several systems of demand equation. Results from the almost ideal demand system (AIDS) are used. For Radhakrishna and Murty (1980), results from their IAS(TC) system are used (pooled monthly, rural-urban data). For both these studies, rural and urban elasticities were weighted using 1981 census population figures to obtain the average elasticities reported here. The cross-price elasticity refers to the impact of the rice price on wheat demand or vice versa.

Table 8. Elasticities with Respect to Procurement Tax Rate (τ)

Variable	All Other Policies Fixed	All Except Procurement (θ) Flexible	All Other Policies Flexible
Policy			
Irrigation (z)	---	-0.1	-0.2
Procurement (θ)	---	---	**
PDS Subsidy (σ)	---	-1.5	-1.8
Urban PDS Share (λ)	---	0.4	0.4
Imports/Stocks (μ)	---	0.5	1.5
Price			
Farm Market (p^f)	*	0.2	0.2
Farm Average (p^s)	**	0.1	0.2
Market Retail (p^u,p^r)	*	0.1	0.2
Quantity			
Supply (q^s)	**	**	**
Urban Open-Market Demand (q^u)	**	-0.2	-0.3
Rural Open-Market Demand (q^r)	**	*	*
Value			
Producer Revenue	**	0.1	0.2
Urban Consumer Expenditures	*	0.3	0.4
Rural Consumer Expenditures	*	0.1	0.2
Procurement/PDS Expenditures	-2.3	-7.2	-7.9
Import/Stock Expenditures	**	-1.3	-0.7

NOTE: Rounded to the nearest 0.1. An * denotes a positive effect less than 0.05, while an ** denotes a negative effect between -0.05 and 0. Consumer expenditures include both open-market and PDS expenditures. Procurement/PDS and import/stock expenditures are defined in equation (11) above.

Table 9. Elasticities with Respect to Procurement (θ)

Variable	All Other Policies Fixed	All Except Procurement Tax (τ) Flexible	All Other Policies Flexible
Policy			
Irrigation (z)	---	3.3	2.5
Procurement Tax (τ)	---	---	6.4
PDS Subsidy (σ)	---	12.9	3.1
Urban PDS Share (λ)	---	-2.5	-0.2
Imports/Stocks (μ)	---	-58.7	-55.4
Price			
Farm Market (p^f)	0.1	-3.2	-2.1
Farm Average (p^s)	*	-3.2	-2.3
Market Retail (p^u,p^r)	0.1	-2.6	-1.7
Quantity			
Supply (q^s)	*	1.1	0.9
Urban Open-Market Demand (q^u)	-0.5	2.7	1.2
Rural Open-Market Demand (q^r)	-0.1	0.3	0.5
Value			
Producer Revenue	0.1	-2.1	-1.4
Urban Consumer Expenditures	0.1	-3.6	-1.8
Rural Consumer Expenditures	*	-2.1	-1.2
Procurement/PDS Expenditures	1.1	40.6	-4.7
Import/Stock Expenditures	0.8	-50.0	-51.0

NOTE: Rounded to the nearest 0.1. An * denotes a positive effect less than 0.05, while an ** denotes a negative effect between -0.05 and 0. Consumer expenditures include both open-market and PDS expenditures. Procurement/PDS and import/stock expenditures are defined in equation (11) above.

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