The Impact of Two-Tier Producer and Consumer Food Pricing in India

Maurice Schiff

India's government buys wheat, rice, and sugar at below the market price and then sells it in ration shops in the urban and rural areas. The rest is sold in the open market. This creates a two-tier price system for consumers and producers. Supporters of the government's procurement policy claim that it raises the open-market price so much that it increases the sales-weighted average of the rationed price and the open-market price; in that case, both the farm sector as a whole and low-income urban consumers with access to the ration shops gain, and high-income urban consumers who buy at the open-market price lose. This view has provided an intellectual basis for the policy.

This article examines a variety of cases: with and without rationing; with rationing through ration cards or queuing; with and without access by the urban rich to the ration shops; with or without free trade; and with a marketable surplus having either positive, negative, or zero price elasticity. The impact of the policy on the average price is in general ambiguous or negative. Under the most plausible assumptions, it is negative, implying that farmers as a whole lose from the procurement policy.

Governments in developing countries generally discriminate against agriculture. Export crops are taxed to transfer resources to the rest of the economy, and food crops are often taxed to provide cheaper food to urban consumers. To attain the latter objective, several countries have instituted a procurement policy: the government buys food commodities from producers at below-market prices and then sells them to low-income consumers through ration shops. The governments thus impose a producer levy on the output they buy. Producers may supply additional demand at any price the market will bear. This policy results in a two-tier price system for producers and consumers. In the Punjab, India,

2. However, Schiff and Valdés (1992) report that when food is imported, most developing countries tax the imports and protect the producers. In those cases, the cheap-food motive is dominated by the self-sufficiency and revenue motives.

Maurice Schiff is in the Policy Research Department of the World Bank. The author would like to thank participants at a World Bank seminar sponsored by the Agriculture Division, India Department; at the Agricultural Policy Workshop organized by the World Bank and the Indira Gandhi Institute for Development (New Delhi, January 1993); and at a seminar at the University of Namur (Belgium, August 1993); as well as three anonymous referees, for useful comments.

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wheat procurement has averaged about 50 percent of output and rice between 60 and 80 percent of output since the late 1960s.

India's food procurement policy applies essentially to wheat, rice, and sugar. Procurement is carried out at the local market for wheat and at the mill for rice and sugar. For wheat, the government has closed surplus states following droughts to depress the procurement price. Imports were increased in times of drought in the 1970s, less so in the 1980s when large stocks had been accumulated (Subbarao 1992; Gulati 1987).

Wheat farmers in India's surplus states have recently refused to sell their output to the government procurement agencies. The boycott was intensified after a call by the India Farmers Union to boycott the procurement agencies as a protest against low procurement prices and severe restrictions on selling wheat to other states (The Times of India, May 8, 1992; The Economic Times, May 7, 1992). But Dantwala (1967, 1986); Mellor (1968); and Hayami, Subbarao, and Otsuka (1982) have argued that farmers do not suffer from the procurement policy. They claim that since procurement increases the open-market price, the average of the procurement price and the open-market price is no less than the price farmers would have obtained without procurement. In fact, Hayami, Subbarao, and Otsuka formally model markets with government procurement and conclude that a procurement policy leads to an increase in the average price received by farmers both in the short and the long run. That conclusion contradicts the behavior of wheat farmers, who resisted selling their output to the procurement agencies.

Assuming that production occurs in a competitive industry, farmers cannot on their own achieve price discrimination between various consumer groups to increase profits. The question is whether the public procurement and distribution policy can result in a price discrimination scheme that actually raises farm profits. Dantwala (1967); Mellor (1968); and Hayami, Subbarao, and Otsuka (1982) argue that farm profits unambiguously increase. I argue that farm profits increase only under somewhat questionable assumptions (no rationing and no access by the rich to the ration shops) coupled with restrictive conditions (that the policy only be applied infinitesimally). Under reasonable assumptions producers will suffer from the policy.

This issue is examined in Schiff (forthcoming) for two cases involving rationing, a positive price elasticity of marketable surplus, a closed economy, and, alternatively, with or without market segmentation between rich and poor. This article examines the issue under more general conditions. For instance, trade liberalization in agricultural products is presently being discussed by the government of India (and has been carried out to a large extent in several other

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3. There are several limitations to Hayami, Subbarao, and Otsuka's (1982) analysis. For instance, they describe the policy as entailing queues by the urban poor to obtain the rations at the fair-price shops, but their model includes no cost of waiting and assumes no rationing. They also state that the access to the ration shops is general, but their model assumes market segmentation with the access restricted to the poor (pp. 655-56).
developing countries). Hence, the free trade case is examined here. The procurement and distribution policy is analyzed under the following conditions: with and without market segmentation between urban rich and poor; with and without rationing; with rationing through ration cards and through queuing; under free trade and for a closed economy; for a positive, zero, or negative price elasticity of marketable surplus; and for the short run and long run. These conditions were not all considered in previous analyses. The results are summarized in table 1.

The remainder of the article is organized as follows. Section I presents the model and discusses a number of issues in preparation for the analysis in section II of the cases of free trade, closed economy with no rationing, closed economy with rationing and market segmentation, and closed economy with rationing and no market segmentation. Section III concludes.

I. THE MODEL

The analysis is carried out in a partial equilibrium framework. For simplicity, the model abstracts from administrative costs and marketing margins. This simplification does not affect the results as long as these costs are the same for the private and public sectors. This assumption biases the results in favor of those obtained by Hayami, Subbarao, and Otsuka (1982), since public sector costs are likely to be larger than private sector costs. The implication of differential costs is discussed in the concluding section.

If the authorities use public funds to subsidize the operation, the average farm price will be larger than the average consumer price. Farmers as a whole and consumers will benefit more from the policy than they would if there were no subsidies. This article assumes that the procurement and distribution policy is self-financed. In other words, no budgetary resources are used to provide explicit subsidies. This enables the results to be compared with those of others (for example, Hayami, Subbarao, and Otsuka 1982).

Farmers typically produce more than one product. It is precisely because of the existing substitution possibilities with other farm products that the supply curve in equation 1 has a positive slope. Assuming that there are no distortions in the other product markets, the analysis focuses exclusively on the impact of procurement and distribution policies on the product in question. That also enables comparison of the results with those of others.

The model assumes that there are three sets of demands, $D_R$ of the urban rich, $D_P$ of the urban poor, and $D_F$ of residents in rural areas. It also assumes that output depends on current price and abstracts from dynamic considerations that result from production lags or storage.

4. The case where the procurement price is higher than the market price and acts as a price floor (which has happened in some bumper crop years) is not considered. Also, the analysis abstracts from the impact of the policy on price variability. Hayami, Subbarao, and Otsuka (1982) find that procurement policy increases the likelihood of unstable market prices.
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Note: The procurement policy sets the procurement price below the open-market price. In the table, $P_o$ denotes the procurement price, $P_m$ the open-market price, and $P$ the average price.

a. The results of the case of no trade also hold if trade is controlled by the government and is independent of price.

b. If the market is segmented between rich and poor, the rich have no access to the rationed units at price $P_0$, but the poor do have access to the units sold in the open market at price $P_m$. There can be no case of no rationing and an unsegmented market because in that case all consumers buy at $P_0$, resulting in excess demand that must be rationed (unless $dM/dP$ is so negative that farmers exactly release the increase in urban demand, but that raises problems of multiple equilibria and stability).

c. This holds only for a “small” reduction in $P_0$ and if $|E_P| > |E_R|$, where $E_j$ is the price elasticity of demand of group $j$ ($P$ [poor], $R$ [rich]). Available evidence on India indicates that $|E_P| > |E_R|$.

d. This holds if $E_P Y / (P_m - P_0) Q_0$, where $E_P$ is the income elasticity of demand of urban consumers, $Y$ is urban income, and $(P_m - P_0) Q_0$ is the value of the property rights to the rationed units, $Q_0$. Evidence indicates that this condition is easily satisfied.

e. $P$ falls as long as $dM/dP > (dD_u/dP_m)/(1 - q)$. 

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Before proceeding to a full analysis of the various cases, four issues are examined: urban market segmentation, the marketable surplus, ration cards and queues, and the procurement price below the market price.

**Urban Market Segmentation**

Subbarao (1992), writing about the excessive cost and ineffectiveness of India's Public Distribution System, claims that no serious efforts were made to limit access to the system to only the most vulnerable groups. In fact, all urban consumers are issued ration cards (which are even used for identification). Hence, the urban rich have access to the ration shops. If they do not consume the product that is procured because of its poor quality (or because of the inconvenient location of the ration shop), then only the urban poor's demand for the procured product should be considered in the analysis.

If the urban rich do consume products that are procured and have equal access to the ration shops, the question remains as to whether they will choose to buy at the ration shops if queues are present. The value of time of the urban rich is higher than that of the urban poor; for the urban rich, then, the full cost of buying at the fair-price shops, including the value of their time, might be larger than the open-market price. However, the urban rich typically use the urban poor (servants) to stand in line for them and can thus obtain the procured output at the same cost as the urban poor. This is particularly true in India. The analysis thus considers both the case of perfect urban market segmentation between rich and poor (or perfect targeting) and the case of no market segmentation.

If farmers can adjust the quality of their products so as to sell a lower quality at the ration shops, then the gain to the poor of having access to the ration shops will fall, and so will the cost to the farmers. At the limit, if farmers are able to costlessly adjust quality to the lower, ration-shop price, then farm profits remain unchanged. And if low-income consumers are indifferent between better quality at the higher price (without the procurement policy) and lower quality at the lower price, then consumer welfare remains unchanged. In that case, the policy is totally ineffective. Of course, this requires that the quality-price tradeoff for consumers equal the quality-cost tradeoff for producers, and this is unlikely to hold over a large range. Thus, the ability to adjust quality will generally partially reduce the policy's effectiveness.

The same is true with evasion. If it can be done without cost, the policy will be ineffective. If it entails a cost, however, evasion will reduce the effectiveness of the policy, as when authorities close surplus states to interstate trade to limit evasion in times of drought. The analysis abstracts from the two issues of quality differences and evasion to keep the problem manageable and to enable a comparison with the findings of others, but the above qualifications should be kept in mind.

**The Marketable Surplus**

The marketable surplus, $M$, equals output, $S$, minus rural demand, $D_F$, or

\[ M = S(P) - D_F(P,\pi) \]
where $P$ is the price received by farmers and $\pi$ is the farmers' profits. Then

$$
\frac{dM}{dP} = \frac{dS}{dP} - \frac{dD_F}{dP} = \frac{dS}{dP} - \left( \frac{\delta D_F}{\delta P} + \frac{\delta D_F}{\delta \pi} \cdot \frac{\delta \pi}{\delta P} \right)
$$

since, by Hotelling's lemma, $\delta \pi/\delta P = S$.

Assuming the good to be normal, the effect of an increase in $P$ is positive, and it is possible that $dD_F/dP > 0$. It is even possible that $dM/dP < 0$ if $\delta D_F/\delta \pi > 0$.

For subsistence crops in India, Krishna (1962) reports values for $d\log M/d\log S$ of 1.04 and 1.06. Since $d\log M/d\log S = (d\log M/d\log P)/(d\log S/d\log P) > 0$ and since the denominator $(d\log S/d\log P)$ is positive, $dM/dP > 0$. Most studies on developing countries also obtain positive values for $dM/dP$. Here the cases in which $dM/dP$ is negative, zero, and positive are considered, but the price elasticity of marketable surplus is assumed to be larger than the price elasticity of urban demand in order to ensure that the equilibrium is both unique and stable.

### Ration Cards and Queues

Assuming that the procured amount is not sufficient to satisfy the demand at the below-market price and that the procured amount is rationed through ration cards, then those who have access to the procured output benefit from an intramarginal income gain. The relevant price (at the margin) for them (as well as for those who have no access to the rationed output) is the market price. This point is important for formulating the demand functions in the cases of a closed economy with and without market segmentation (see next section).

An alternative is the case of rationing by queuing. Supplies at the ration shops may not be sufficient to satisfy the rationed demand. This is relevant in several Indian states. For instance, Subbarao (1992) claims that in Andhra Pradesh, where coverage is wide, the public distribution system met only 34 percent of the minimum rice requirements of the poorest. For all grains, 2.5 million tons were required to fill the ration quotas of the poorest, but the state government provided only 1.7 million tons, and some of it went to other groups. By contrast, the states of Gujarat, Kerala, and Tamil Nadu have been quite successful in targeting the poor. Thus, the analysis without queuing may be more relevant for

5. For small farmers for whom $M \neq 0$, $dM/dP > 0$.

$$
\frac{dD_F}{dP} = \frac{\delta D_F}{\delta P} + \frac{\delta D_F}{\delta \pi} \cdot \frac{\delta \pi}{\delta P}
$$

The first term on the right is the substitution effect and is negative. Thus, if $M \leq 0$, $dD_F/dP < 0$ and $dM/dP > 0$. 

targeting the poor. Thus, the analysis without queuing may be more relevant for those states. However, the situation is worse in some other states (Bihar, Rajasthan, Madhya Pradesh, and Uttar Pradesh), which account for a large share of India’s poor but receive only a small share of supplies for the Public Distribution System. This has resulted in long queues. Hence, the analysis in the presence of queues is relevant for these states.

If queues are long enough to bring the effective price of rationed food (including the waiting cost) up to the open-market price, then under plausible conditions (positive price elasticity of marketable surplus and trade controls), the open-market price will rise and the average price will fall (see table 1). Then both consumers and producers will lose.

The Procurement Price and the Open-Market Price

Procurement for rice and sugar is generally carried out at the trader-processor level and is proportional to the marketable surplus that is sold by the farmer to the trader or processor. The price farmers receive is then a weighted average, \( \bar{P} \), of the procurement price, \( P_0 \), and the open-market price, \( P_m \). \( \bar{P} \) is also the marginal incentive, because procurement is proportional. Then output, \( S \), marketable surplus, \( M \), and rural demand, \( D_F \), are all a function of \( \bar{P} \) and not of \( P_m \). This assumes that all farmers have a positive marketable surplus.

It has been argued that procurement is better modeled by assuming that a fixed amount is procured (rather than a fixed proportion), particularly for wheat. Then, the marginal incentive for farmers is \( P_n \) the open-market price. Since procurement lowers \( P_0 \), \( P_m \) will always increase more than the average price, \( \bar{P} \) (or will decrease less). Therefore, with a positive price elasticity of marketable surplus \( M \), the impact on \( M \) will be larger when a fixed quantity is procured than when a fixed proportion is procured (assuming the amount procured to be the same in both cases). Thus, \( \bar{P} \) will always be lower when a fixed quantity (rather than a fixed proportion) is procured. The analysis in the next section assumes procurement is proportional. This results in an upward bias in the solution for \( \bar{P} \) compared with the assumption of fixed-quantity procurement, or in a bias in favor of the Dantwala (1967) and Hayami, Subbarao, and Otsuka (1982) result.

The distribution of gains and losses by farm size has been examined by Sah and Srinivasan (1988). The formal model abstracts from farm size and landless laborers, but these issues are examined in each case in the next section. Small farmers might have a negative marketable surplus, that is, they might be net buyers, and so would landless laborers. The relevant price at the margin would then be the open-market price or the procurement price, depending on the market to which the small farmer or landless laborer would have access. If purchases in the rural areas are made in the same proportion as in the urban areas, then the relevant price is also \( \bar{P} \).

If the procurement policy depresses the average price, \( \bar{P} \), then producers as a whole lose. However, small farmers who are net buyers gain, as do landless
laborers. And they especially gain if they have access to the ration shops in a proportion that is larger than in the urban areas, that is, if they pay less than the average price. However, to be net buyers, small farmers must earn extra income and be employed on other (larger) farms or must work in the nonfarm rural sector. Rural employment opportunities are generally related to agricultural incentives. A lower average producer price will depress rural employment opportunities. Hence, the impact on small farmers, and landless laborers, of a procurement policy that results in a lower average price will depend on the impact of the policy on rural wages.

II. Public Procurement and Distribution under Alternative Assumptions

The effects of public procurement and distribution under alternative assumptions are analyzed for the following general cases: free trade, a closed economy with no rationing, a closed economy with rationing and market segmentation, and a closed economy with rationing and no market segmentation.

Free Trade

The procurement policy has generally been examined in a closed-economy setting. The issue of extending the process of industrial trade liberalization to the agricultural sector in India is part of the current policy debate. Such a process has already taken place in several developing countries. For free trade in a specific product and under the small-country assumption, the analysis is simple. The market price, $P_m$, is independent of the procurement policy. Therefore, the average price, $\bar{P}$, in the case of procurement is lower than the market price without procurement, because part of the crop is procured at a price $P_0 < P_m$.

Thus, farmers as a whole lose. Small farmers who are net buyers and landless laborers gain, unless the lower average price leads to lower rural wages, in which case the effect is ambiguous. Those urban consumers who have access to the procured output gain. No consumers lose. These results hold both in the short run (output $S$ given) and in the long run, with or without rationing, and with or without market segmentation between the urban rich and poor. However, with rationing by queuing, arbitrage may lead to such a long queue that the cost (inclusive of time) will be $P_m$ in both markets. (The reason for that is discussed below for a closed economy with rationing and market segmentation.) Then, no consumers gain (and net rural buyers who also must queue do not gain, and they lose if rural wages fall).

These results are summarized in the following.

Proposition 1. Under free trade and the small-country assumption, procurement has no impact on the open-market price ($P_m$), the average price ($\bar{P}$) falls, farmers as a whole lose (although small farmers and landless laborers who are net buyers may gain, depending on the impact of the price fall on the rural wage), no consumers lose, and those with access to the
procured output gain. However, if procured output is rationed by queuing, consumers may not gain (and it is more likely that net rural buyers lose).

With drought and managed trade, the open-market price, $P_m$, rises. Governments have often closed the surplus states (to prevent them from exporting to the deficit states) to keep the procurement price low so that they can purchase the quantity needed. Governments have also often allowed larger imports in response to droughts when stocks were low or have sold stocks when they were large. Thus, the procurement policy has been applied most intensely precisely when supply has been most responsive (through imports or reduction in stocks), and the market has thus tended to be more open. Under these circumstances, the impact of such a policy is more likely to be a fall in the average producer price, $\bar{P}$.

The analysis above assumes that the law of one price prevails. However, there is a gap between the free on board (f.o.b.) and cost, insurance, and freight (c.i.f.) prices at the port (say Bombay for wheat) and even more so in the interior (say, the Punjab). Pursell and Gulati (1993) have estimated these margins for 1985-87. The difference in the c.i.f. and f.o.b. prices of rice was 5 percent at the port and 25 percent in the main surplus area (Punjab); the difference for wheat was 17 percent at the port and 43 percent in the main surplus area. Thus, even under free trade, the products might behave as nontradables within a certain price range. Then, the open-market price might increase with procurement, and the effect on the average price would be ambiguous. This is less likely to happen at the port where the price range is smaller (5 percent for rice) than in the hinterland.

The analysis proceeds under the assumption of a closed economy for the product analyzed. The results also hold when international trade in the product is managed by the government and is independent of the procurement policy.

A Closed Economy with No Rationing

Without rationing, there must be market segmentation between rich and poor. Otherwise, all consumers can buy at the procurement price, $P_0$, resulting in excess demand that will have to be rationed. Thus, the poor have unlimited access to the procured output at price $P_0$, and the rich can buy only in the open market, at price $P_m$. In this case, the procurement price is set by the authorities, but the quantity procured is determined endogenously by the fact that the authorities must meet the poor's demand.

Market equilibrium is given by

$$M = S(P) - D_P [\bar{P}, \pi (\bar{P})] = D_U (P_0, Y_P) + D_R (P_m, Y_R)$$

6. A possible exception is the case where the price elasticity of the marketable surplus is so negative that at the lower producer price, $P_0$, farmers release for urban consumption exactly the increase in urban demand or more. However, this raises problems of multiple equilibria and stability. Here it is assumed that the price elasticity of marketable surplus is larger (less negative) than the price elasticity of urban demand to ensure that the equilibrium is unique and stable. Then, market segmentation must hold with no rationing.
where $\bar{P} = qP_o + (1 - q)P_m$ is the average price received by farmers on their marketable surplus, $M$; $q$ is the proportion of marketable surplus that is procured, $q$ being equal to $DPU / M$ without rationing; $D_U$ is urban demand by group $j$, where $j$ is $P$ (poor) or $R$ (rich); $Y_i$ is the income of urban group $j$; and $\pi$ is rural profits.

The impact of a change in $P_0$ on $P_m$ and $\bar{P}$ is derived in appendix A. The solution is given by equations A-3, A-5, and A-6. The sign of $d\bar{P} / dP_0$ is ambiguous (see equation A-6). Therefore it follows from equation A-5 that $dq / dP_0$ may be negative, zero, or positive, and it then follows from equation A-3 that $dP_m / dP_0$ may be negative, zero, or positive. Thus, it is not even possible in a closed economy with no rationing to know the effect on the open-market price of a change in the procurement price. These results hold both in the very short run (output given) and in the long run.

If $dM / d\bar{P} = 0$, then $dP_m / dP_0 < 0$ ($P_m$ rises as $P_0$ is reduced), but the sign of $dP / dP_0$ remains ambiguous. In this case, the urban rich lose because they buy only at $P_m$, whereas the urban poor, who can satisfy their entire demand at the low $P_0$, gain. The effect on the producers is ambiguous.

Starting from a situation of no procurement policy ($P_0 = P_m$), under plausible assumptions, if $dM / d\bar{P} \geq 0$, then $dP_m / dP_0 < 0$ and $d\bar{P} / dP_0 < 0$. That is, a "small" application of the procurement policy increases the open-market price and the average price received by farmers. Setting $P_m - P_0 = 0$ in equation A-6,

$$\frac{d\bar{P}}{dP_0} = \frac{(1 - q) \frac{dD_U}{dP_0} - q \frac{dD_R}{dP_m}}{(1 - q) \frac{dM}{d\bar{P}} - \frac{dD_R}{dP_m}} = \frac{A'}{B'}$$

and from equation A-3

$$\frac{dP_m}{dP_0} = \frac{- \frac{dD_U}{dP_0} + q \frac{dM}{d\bar{P}}}{B'}.$$ 

Assuming $dM / d\bar{P} \geq 0$, it follows that $B' > 0$ and $dP_m / dP_0 < 0$. $A'$ can be rewritten as

$$A' = (1 - q) E^P \frac{D_U}{P_0} - q E^R \frac{D_R}{P_m} = \frac{D_R}{M} \frac{E^R D_U}{P_0} - \frac{D_U}{M} \frac{E^R D_R}{P_m} = \frac{D_R}{M} \frac{(E^P - E^R)}{(P_0 - P_m)}$$

where $E^j$ is the price elasticity of demand of group $j$. Because $P_m = P_0$, it follows that if the price elasticity of demand of the urban poor is larger than that of the urban rich, then $A' < 0$ and $d\bar{P} / dP_0 < 0$. In the case of India, Radhakrishna, Murthy, and Shah (1979) have found that $|E^P| = 0.8 > |E^R| = 0.4$, so that $d\bar{P} / dP_0 < 0$. 
Thus, starting from a situation of no procurement policy ($P_0 = P_m$), a “small” (infinitesimal) application of that policy (a “small” reduction in $P_0$) will result in an increase in $P_m$ and $P$ as long as the price elasticity of the marketable surplus is nonnegative and the demand of the urban rich is less elastic than the demand of the urban poor. As is known from the theory of discriminating monopoly, a necessary condition for producers as a whole to gain is that consumers who are charged the higher price (the rich) have a less elastic demand. In this case, the policy leads to a price discrimination that benefits farmers as a whole. Net buyers in rural areas (small farmers and landless laborers) lose, unless the increase in the average producer price results in higher rural wages, in which case the effect is ambiguous. Rich urban consumers lose, and poor urban consumers gain.

These results are summarized in the following.

**Proposition 2.** In a closed economy with no rationing, the impact of procurement on $P_m$ and $P$ is, in general, ambiguous. However, starting from $P_m = P_0$ (no policy), a “small” application of the policy will raise $P_m$ and $P$ if the elasticity of the marketable surplus is nonnegative and the demand of the urban poor is more elastic than the demand of the urban rich. In the latter case, farmers as a whole gain, the urban poor gain, and the urban rich lose. Net rural buyers (small farmers and landless laborers) lose unless rural wages increase, in which case the effect is ambiguous.

The result $\frac{dP}{dP_0} < 0$ holds only locally, that is, around $P_m = P_0$. This is essentially the result obtained by Hayami, Subbarao, and Otsuka (1982), whose model assumes no rationing, market segmentation, and a “small” application of the policy. As noted above, the result is ambiguous in the more general and interesting case where the change in $P_0$ is “large” (for example, in the case of food shortages, where the market price would be significantly higher than the procurement price), unless further restrictions are imposed on parameter values or functional forms, or both.

For instance, assume that the demand of the urban rich is inelastic whereas that of the urban poor is elastic and that the marketable surplus is constant. Then any reduction in $P_0$ will raise producer revenue both because of the larger sales to the poor at the lower ration-shop price $P_0$ (elastic demand) and from lower sales to the rich at the higher price $P_m$ (inelastic demand). Thus, revenue rises in both markets. Because total revenue rises and marketable surplus is given, $P$ must increase. The same result obtains if one of the two demand curves has an elasticity equal to one. However, Radhakrishna, Murthy, and Shah (1979) found an elasticity for the poor smaller than one (0.8). In that case, revenue from selling to the poor falls as the price falls. Thus, the impact on $P$ is ambiguous for discrete applications of the policy when the parameter values that have been reported for India are used. More precise numerical results for the discrete case are presented at the end of this subsection.
Why is the impact on the average price, $\bar{P}$, unambiguously positive in a closed economy with no rationing when the policy is applied infinitesimally but not for a discrete application of the policy? Assuming first that the marketable surplus, $M$, is given and does not vary with price, any increase in the consumption of the urban poor with access to the ration shops is matched by an equal decrease in consumption by the rich. Because the price elasticity of the rich is smaller than that of the poor, marginal revenue is larger for the poor than for the rich without intervention. Revenues are maximized by shifting consumption from the rich to the poor until marginal revenues are equal in both markets.

Thus, a small application of the procurement policy will increase total revenue and also the average price (because $M$ is given). However, a discrete application of the policy has an ambiguous effect because it might lead to a shift in consumption that is larger than the shift that maximizes revenues (so that the marginal revenue for the rich becomes larger than for the poor). This might result in lower revenues and a lower average price.

The fact that the marketable surplus increases with the average price cannot reverse these results. Assume the average price increases for a given marketable surplus. The higher average price leads to an increase in marketable surplus. This lowers the average price. However, the new equilibrium average price cannot be lower than without the policy because a lower average price would result in a lower, not larger, marketable surplus. Thus, a positive slope of the marketable surplus will dampen the effect of the procurement policy on the average price but will not reverse it.

Estimated parameter values for India can be used to obtain more precise results for a discrete application of the policy. As noted above, Radhakrishna, Murthy, and Shah (1979) found an elasticity of demand of 0.8 for the poor and 0.4 for the rich. For rice, the procured share has fluctuated between 60 and 80 percent since the late 1960s. Assuming a procured share of 80 percent and assuming linear demand curves for simplicity, the average producer price is maximized when the procurement price is 6.95 percent below the no-intervention price. The maximum average price is only 2.8 percent higher than the no-intervention price. And, when the procurement price is 13.9 percent below the no-intervention price, the average price is exactly equal to its no-intervention value. With a procured share of 60 percent, the maximum average price is 4.4 percent higher than the no-intervention price.

Consequently, if with an 80 percent procurement share the procurement price were set at a level 14 percent or more below the no-intervention price, then the

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7. Given the share procured (and therefore consumed by the urban poor), the price elasticities of demand, and the assumption of linear demand functions, both demand curves can be obtained (up to a scale factor related directly to $M$ and inversely to the no-intervention price). Then, marginal revenue functions can be obtained, and, given a fixed $M$, marginal revenues of the rich and the poor can be equated to obtain the maximum total revenue and maximum average price. That price is a function of the no-intervention price, and the proportional difference between the two can be obtained. Detailed derivations are available from the author.
policy would result in a lower average price, and the farm sector as a whole
would lose. Even if the procurement price were set higher than 14 percent below
the no-intervention price, the policy would at best result in a 2.8 percent in-
crease in the average price. And this number rises to only 4.4 percent with a 60
percent procurement share. These results are obtained under the assumption
that the marketable surplus, $M$, is given. If, as found, $M$ increases with the
average price, then the maximum average price would be even lower than when
$M$ is constant, but the point at which the average price starts falling below the
no-intervention price would be the same.

For wheat, the procured share has averaged about 50 percent since the late
1960s. The maximum average price obtainable would be at most (with a given
marketable surplus) 5.2 percent higher than the no-intervention price. This
would occur when the procurement price is 20.8 percent below the no-
intervention price. (And the average price would be lower than the no-
intervention price when the difference between the procurement and no-
intervention prices became larger than 41.6 percent.) Hence, even if the average
price did increase because of the policy, the amount of increase would at best be
negligible and would probably not reach 5 percent.

A Closed Economy with Rationing and Market Segmentation

In this case, both the procurement price and quantity are exogenous. The
poor’s demand, $D_{U}$, exceeds the supply provided by the ration shops. Hence, $D_{U}$
depends on $P_{m}$, the price of the marginal units, rather than on $P_{0}$. And $D_{U}$
depends not on $Y_{P}$ but on $y_{p} = Y_{P} + V$, which includes the value $V$ of having
access to the rationed units at the lower price. The value $V$ depends on how the
rationed units are distributed. If no more ration cards are distributed to the
target population of urban poor than the supply available at the ration shops,
there is no queuing, and $V = (P_{m} - P_{0})Q_{0}$, where $Q_{0}$ is the procured and
rationed output. If more ration cards are distributed than the supply available at
the ration shops (the rationed demand exceeds the available supply), there are
queues, and the value of the time waiting in line must be subtracted from the
value of access to the rationed goods. The length of the line depends on the
number of ration cards in relation to the available supply. However, the full cost
of obtaining a unit of the product at the ration shop, including the value of
waiting time, cannot be larger than the open-market cost, $P_{m}$. The reason for
that is arbitrage, because the poor always have the choice of buying on the open
market at the price $P_{m}$. The possibility of buying on the open market determines
the maximum length of the queue when the full cost of buying the product is the
same in both markets and $V = 0$ (and $y_{p} = Y_{P}$).

The analysis begins by assuming no queuing. In the absence of queuing, equation 3
becomes

\[ M = S(P) - D_{F}(P, \pi(P)) = D_{F}(P_{m}, y_{p}) + D_{F}(P_{m}, Y_{R}) \]

where $P = qP_{0} + (1 - q)P_{m}$, and $q$ is the proportion of marketable surplus that
is procured and $q = (Q_{0}/M)(Q_{0} < D_{U})$. The total income of the urban poor
(including the value $V$ of the right of access to the rationed output $Q_0$ at the low price $P_0$) is $y_p = Y^p + (P_m - P_0) qM = Y^p + (P_m - P_0) Q_0$.

The derivation of the effect of changes in $P_0$ on $P_m$ and $\bar{P}$ is presented in appendix B. The solution without queuing is given by equations B-3 and B-4. The signs of both $d\bar{P}/dP_0$ and $dP_m/dP_0$ are ambiguous. If $dM/d\bar{P} = 0$, then $dP_m/dP_0 < 0$, but the sign of $d\bar{P}/dP_0$ remains ambiguous. In this case, the urban rich lose while the poor may gain or lose (depending, for the case where $\bar{P}$ rises, on the share they purchase on the open market at the higher price, $P_m$).

With queuing, the longer the queue, the lower the income gain, $V$, to the urban poor. At the limit, $V$ equals zero ($y_p = Y^p$). Then, as shown in equation B-5, $dP_m/dP_0 \leq 0$ as long as $dM/d\bar{P} \geq 0$ or $dM/d\bar{P} \leq (dD_U/dP_m)/(1 - q)$. And, as shown in equation B-6, $d\bar{P}/dP_0 > 0$ as long as $dM/d\bar{P} > (dD_U/dP_m)/(1 - q)$. Thus, with a positive elasticity of marketable surplus, procurement will necessarily lead to a rise in $P_m$ and to a fall in $\bar{P}$. This is the worst scenario, because all three groups (urban rich, urban poor, and farmers as a whole) lose. Even if the elasticity of marketable surplus is negative, procurement can still lead to a fall in the average price received by farmers. And if $dM/d\bar{P} = 0$, then $P_m$ remains unchanged and $d\bar{P}/dP_0 = q$, that is, $\bar{P}$ falls by a proportion $q$ of the fall in $P_0$.

These results are summarized in the following.

**Proposition 3.** In a closed economy with rationing and market segmentation, if rationing is done without queuing, the impact on $P_m$ and $\bar{P}$ is, in general, ambiguous. If rationing is done by queuing, $P_m$ will rise and $\bar{P}$ will fall if the price elasticity of marketable surplus is positive (a sufficient but not necessary condition) and the queue is long (so that the full cost of buying at the ration shop approximates the open-market price). Then, the farm sector and all urban consumers lose. Net rural buyers (small farmers and landless laborers) would also lose, both because they would have to queue to obtain the rationed units and because the lower average producer price would probably result in lower rural wages.

What is the explanation for these outcomes? In a closed economy with no rationing and market segmentation, the effect on the average price was, in general, ambiguous. We compare that base case with the present one where the procurement price remains unchanged but the procured quantity is reduced (rationing) and there is no queuing. Then, the poor may buy additional units at the open market. In that case, the open-market price and the average price rise because of the higher demand. Also, a larger quantity is sold on the open market. This lowers the open-market price and the average price. Finally, the share sold in ration shops is lower, and the share sold on the open market is higher. This raises the average price. Thus, the net effect on the average price is

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8. If the average price, $\bar{P}$, remains unchanged or falls, then, since the urban rich pay $P_m > \bar{P}$, the urban poor pay on average less than $\bar{P}$ and therefore must gain. However, if $\bar{P}$ rises, the urban poor may gain or lose.
unclear, and, since the effect in the base case was unclear as well, the outcome in
this case is ambiguous. When there is queuing, the longer the queue and the
larger the real income or welfare loss for the poor, the lower their demand and
the lower the open-market price and the average price. At the limit, both the rich
and the poor pay the open-market price. Then all consumers lose and so do the
farmers (as long as the supply response is positive or at least not too backward-
bending).

A Closed Economy with Rationing and No Market Segmentation

In this case, the procured price and quantity are exogenous, and the analysis
only has to consider total urban demand, \( D_U \). Assume rationing is done without
queuing. Then, equations B-3 and B-4 become, respectively,

\[
\frac{dP_m}{dP_0} = \frac{dM}{dP} \left[ 1 - (P_m - P_o) \frac{dD_U}{dy} q \right] + \frac{dD_U}{dy} q \frac{dM}{dP} = A_1 \frac{B_1}{B_1}
\]

and

\[
\frac{dP}{dP_0} = \frac{q \left( \frac{dD_U}{dP_m} + \frac{dD_U}{dy} M \right)}{B_1} = C_1 \frac{B_1}{B_1}
\]

where \( y \) is urban income, including the value to the urban consumers of having
access to \( qM \) units at price \( P_0 \).

If \( dM/dP \geq 0 \), then \( dP_m/dP_0 < 0 \) and \( dP/dP_0 > 0 \). Let us first look at \( C_1 \).
Since \( M = D_U \), the term in parenthesis in equation 6 is simply the compensated
price effect, and thus \( C_1 < 0 \). The sum of the first two terms of \( B_1 \) (the
denominator in equations 5 and 6) is negative, since

\[
\frac{dD_U}{dP_m} + \frac{dD_U}{dy} qM < \frac{dD_U}{dP_m} + \frac{dD_U}{dy} M < 0.
\]

Thus, if \( dM/dP = 0 \), then \( A_1 > 0 \), \( B_1 < 0 \), \( dP_m/dP_0 < 0 \), and, since \( C_1 < 0 \),
\( dP/dP_0 > 0 \).

This result also holds for \( dM/dP > 0 \). First, examine the term

\[
F = (P_m - P_o) \frac{dD_U}{dy} q - 1.
\]

(\( F \) is the bracketed term in \( B_1 \).) This can be rewritten as

\[
F = (P_m - P_o) \frac{dD_U}{dy} \frac{Q_o}{M} - 1 = (P_m - P_o) \frac{dD_U}{dy} \frac{Q_o}{D_U} - 1
\]

\[
= \frac{(P_m - P_o) Q_o}{y} E_U - 1
\]
where $E_Y$ is the income elasticity of demand for the urban consumers. For $F$ to be negative or zero, it must be the case that

$$E_Y \leq \left( \frac{Y}{(P_m - P_o) Q_0} \right) \left( 1 + \frac{Y}{(P_m - P_o) Q_0} \right).$$

Now $Y$ is total urban income and is several times larger than $(P_m - P_o) Q_0$, the value of the property right to the $Q_0$ rationed units. Thus, $E_Y$ could be several times larger than 1, and $F$ would still be negative or zero.

For India, NCAER (1970) and Pandey (1973) report income elasticities, respectively, of 0.489 and 0.71 for foodgrains, and 0.616 and 0.79 for all cereals. Pandey reports an income elasticity for rice of 1.06. The grain, oilseeds, and livestock study of the U.S. Department of Agriculture reports income elasticities of 0.70 for rice and 0.70 for wheat. These results imply that $F < 0$.

Since the sum of the first two terms of $B_1$ (the denominator in equations 5 and 6) is negative, if $F \leq 0$ and $dM/d\bar{y} \geq 0$, then $B_1$ is negative. Since $C_1 < 0$, $d\bar{y}/dP_o > 0$. Also,

$$A_1 = \frac{dM}{d\bar{y}} q(-F) + \frac{dD_u}{dy} qM > 0$$

and thus $dP_m/dP_o < 0$.

Thus, if the policy does not differentiate between the urban rich and the urban poor, and if $dM/d\bar{y} \geq 0$, then the procurement policy, which implies a reduction in $P_o$, will increase the open-market price, $P_m$, but will decrease the average price, $\bar{P}$, received by farmers. Under these circumstances, farmers lose on average and consumers gain on average. If the income elasticity of demand for the procured products is zero and if the urban rich have the same access to the ration shops as the urban poor, then both the urban rich and the urban poor will buy the same proportion at price $P_o$ and at price $P_m$, that is, on average they will both pay $\bar{P}$. Hence, they will both gain. If, as has been found, the income elasticity for these products in urban areas of developing countries is positive, the rich will buy a larger share at $P_m$ than the poor. Hence, the poor will gain, and the rich may or may not gain.

The fall in $\bar{P}$ holds even more strongly if rationing is done by queuing and can hold even for a negative elasticity of marketable surplus (see equation B-6 in appendix B). Thus, farmers as a whole also lose in this case. At the limit, $V = 0$. Then, once the cost of waiting is taken into account, all consumers pay $P_m$, so both the urban poor and the urban rich lose. Hence, in this case, every group loses from the procurement policy.

These results are summarized in the following.

**Proposition 4.** In a closed economy with rationing and no market segmentation, $P_m$ rises and $\bar{P}$ falls if the price elasticity of the marketable surplus is nonnegative. This is true whether rationing occurs with or without queuing. Without queuing, the urban poor gain, and the urban rich may gain or
lose. With long queues, all urban consumers lose. Farmers lose as a whole. However, without queuing, the net buyers (small farmers and landless laborers) gain, unless the lower average price results in a lower rural wage, in which case the effect is ambiguous. With queues, net rural buyers are more likely to lose.

Under India's Public Distribution System, ration cards are distributed to the urban poor as well as to the rich, and buyers at ration shops have to queue. The analysis here indicates that if the rich have equal access to the ration shops, procurement should decrease the average price paid to farmers as long as the price elasticity of the marketable surplus is nonnegative (see lower left corner of table 1).

Sah and Srinivasan (1988) examine the impact of procurement on welfare in a model of utility-maximizing agents with a continuum of farm sizes and urban incomes. They also assume rationing and no market segmentation. They find that the market price increases with a small amount of procurement, but they do not report the impact on the average price. They also show that the urban poor gain and that the rural poor lose. They do not consider the possibility of queuing or of changes in rural wages; rather, they examine the case of tradable rations. In the latter case, and with a linear Engel curve for food, the open-market price is unchanged, the urban poor gain, and the farm sector loses. This result is also obtained by Binswanger and Quizon (1984). They use a general equilibrium model of the Indian economy to simulate alternative price policies. With forced procurement and equal access to the ration shops by all urban groups, they find that the impact on \( P \) is negative.

III. Summary and Conclusions

This article examined the effect of the policy of government procurement of agricultural products on the open-market price and on the average price received by farmers under various circumstances. It analyzed the impact of the policy on the urban rich, the urban poor, and the farmers. Four general cases were analyzed.

So far, India's trade liberalization process has mainly affected industry, but the argument for free trade in agricultural products is being debated by the government. Thus, the first case analyzed was that of free trade. In this case, the open-market price is unaffected by the procurement policy, and the average price falls, irrespective of whether or not the procured output is rationed or targeted to the poor. Farmers as a whole lose, the urban poor gain, and the urban rich gain if they have access to the procured output. These results are weakened if the range between the c.i.f. and the f.o.b. price is large.

The second case was a closed economy with no rationing, in which, if the urban poor can satisfy their demand at the procurement price, the effect of the policy on the open-market price and on the average price is generally ambiguous. However, starting from the open-market price with no procurement policy
and if marketable surplus increases with the average price, then a “small” application of the policy increases the open-market price and the average price as long as the demand of the urban rich is less price-elastic than the demand of the urban poor. Farmers as a whole and the urban poor gain, but the urban rich lose. The rural poor (small farmers who are net buyers and landless laborers) lose if they pay the average price but might gain if they buy mostly at the ration shops and if queues are short. Moreover, the effect depends also on the impact of the higher average price on rural wages. With a discrete application of the policy, the effect on the average price is ambiguous; and if the effect is positive, it probably will not raise the average price by more than 5 percent compared with the no-intervention price.

The third and fourth cases were closed economies with rationing and with and without market segmentation, respectively. If the urban poor cannot satisfy their entire demand at the procurement price and the rationing is with ration cards without queuing, the effect of the policy on the open-market price and the average price is ambiguous. The price effect of the policy is not ambiguous if the policy does not differentiate between the urban poor and urban rich (or unless the rich do not consume the product) and the price elasticity of marketable surplus is nonnegative. Then, the policy increases the open-market price and decreases the average price. Farmers as a whole lose, the rural poor gain (unless the lower average price lowers rural wages, in which case the effect is ambiguous), the urban poor gain, and the urban rich may gain or lose. If rationing is by queuing and the queue is long, then the policy increases the open-market price if the price elasticity of the marketable surplus is positive. The policy causes the average price to fall even if the price elasticity of the marketable surplus is negative. All groups lose in this case.

As long as the procurement policy is not applied infinitesimally, there is no indication that it increases the average price as predicted by Dantwala (1967) and Hayami, Subbarao, and Otsuka (1982). The effect on the average price is ambiguous or negative, except where there is a closed economy with no rationing to the urban poor, perfect market segmentation between urban rich and urban poor, marketable surplus that does not fall with price, price elasticity of demand for the urban poor larger than for the rich, and a procurement policy that is applied infinitesimally. Only under those conditions is the effect on the average price unambiguously positive, although it is very small.

Hayami, Subbarao, and Otsuka (1982) assume the conditions of no rationing to the urban poor and perfect market segmentation between the urban rich and urban poor in their analysis. At the same time, they state that India’s distribution system results in long queues and is unable to differentiate between the urban rich and urban poor (p. 655). If their description of the operation of the policy is correct, then our analysis indicates that procurement decreases the average price (lower left corner of table 1). Thus, a policy that was designed to help the urban poor may very well have hurt the farm sector as a whole, although it may have helped the rural poor.
By setting producer prices equal to consumer prices, we have implicitly assumed that transaction costs are the same in the private and public distribution systems. However, it seems plausible to assume higher costs for the public distribution system. In a recent study on India’s agricultural policies, Sharma (1991) found that, for wheat, the cost of public distribution was twice as high as the cost of private distribution. If so, the probability that the average price paid to farmers rises with the procurement policy is even lower. Moreover, the consumer benefits associated with the procurement policy also fall in this case. The opposite is true if explicit budgetary funds are provided to finance the policy.

Targeting to the urban poor has been mixed, to say the least, with some states more successful than others. In the more successful states (Gujarat, Kerala, and Tamil Nadu), the situation is closer to that of a closed economy with rationing and market segmentation, where the effect of procurement on the average price is ambiguous unless queues are long, in which case the effect is negative. In the states where targeting is less successful (Bihar, Rajasthan, Andhra Pradesh, Madhya Pradesh, and Uttar Pradesh), the situation is closer to that of a closed economy with rationing and no market segmentation, where the effect on the average price is negative (with or without queuing). Thus, under the conditions likely to prevail in India, there is no presumption that procurement will increase the average producer price.

Appendix A. The Impact of a Change in the Procurement Price on the Open-Market Price and the Average Price in a Closed Economy with No Rationing

From equation 3,
\[
\frac{dM}{dP_0} = \frac{dD_U}{dP_0} + \frac{dD_R}{dP_0}
\]
or
\[
\frac{dM}{dP} \frac{dP}{dP_0} = \frac{dD_U}{dP_0} + \frac{dD_R}{dP_m} \frac{dP_m}{dP_0}.
\]

Using the definition of \( \bar{P} \)
\[
\frac{d\bar{P}}{dP_0} = q + (1 - q) \frac{dP_m}{dP_0} + \frac{dq}{dP_0} (P_0 - P_m)
\]
and from equations A-1 and A-2,
\[
\frac{dM}{d\bar{P}} \left[ q + (1 - q) \frac{dP_m}{dP_0} + \frac{dq}{dP_0} (P_0 - P_m) \right] = \frac{dD_U}{dP_0} + \frac{dD_R}{dP_m} \frac{dP_m}{dP_0}.
\]

9. With no rationing, \( q \) is endogenous. It cannot be determined by the government independently of the level of \( P_0 \), because the entire demand of the urban poor \( D_U \) must be satisfied at the price \( P_0 \).
or

\[
\frac{dP_m}{dP_0} = \frac{dD_U}{dP_0} - \left[ q + \frac{dq}{dP_0} (P_0 - P_m) \right] \frac{dM}{dP} \left( 1 - q \right) \frac{dM}{dP} - \frac{dD_m}{dP_m}.
\]

(A-3)

The sign of \( dP_m/dP_0 \) cannot be examined until \( dP/dP_0 \) has been solved, because

\[
\frac{dq}{dP_0} = \frac{d(D_U/M)}{dP_0}
\]

depends on it.

From equations A-2 and A-3,

\[
\frac{dP}{dP_0} = q + (1 - q) \frac{dD_U}{dP_0} - \left[ q + \frac{dq}{dP_0} (P_0 - P_m) \right] \frac{dM}{dP} \left( 1 - q \right) \frac{dM}{dP} - \frac{dD_m}{dP_m} + \frac{dq}{dP_0} (P_0 - P_m)
\]

or

\[
\frac{dP}{dP_0} = (1 - q) \frac{dD_U}{dP_0} - \left[ q + \frac{dq}{dP_0} (P_0 - P_m) \right] \frac{dD_m}{dP_m}.
\]

(A-4)

Since \( q = D_U/M \),

\[
\frac{dq}{dP_0} = \frac{dD_U}{dP_0} M - D_U \frac{dM}{dP_0} = \frac{dD_U}{dP_0} M - D_U \frac{dM}{dP} \frac{dP}{dP_0}.
\]

(A-5)

From equations A-4 and A-5,

\[
\frac{dP}{dP_0} = \frac{(1 - q) \frac{dD_U}{dP_0} + \left[ \frac{(P_m - P_0)}{M} \frac{dD_U}{dP_0} - q \right] \frac{dD_m}{dP_m} }{1 - q \frac{dM}{dP} - \frac{dD_m}{dP_m} - D_U \frac{dM}{dP} (P_0 - P_m) \frac{dD_m}{dP_m}} = \frac{A}{B} \geq 0.
\]

(A-6)
APPENDIX B. THE IMPACT OF A CHANGE IN THE PROCUREMENT PRICE ON THE OPEN-MARKET PRICE AND THE AVERAGE PRICE IN A CLOSED ECONOMY WITH RATIONING AND MARKET SEGMENTATION

From equation 4,

\[ \frac{dM}{dP_0} = \frac{dM_P}{dP_0} + \frac{dM_P}{dP_0} \]

or

\[ \frac{dM}{dP} \frac{dP}{dP_0} = \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} + \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} + \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} \]

or

\[ \frac{dM}{dP} \frac{dP}{dP_0} = \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} + \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} \left[ \left( \frac{dP_m}{dP_0} - 1 \right) M + \left( P_m - P_0 \right) \frac{dM}{dP} \frac{dP}{dP_0} \right] \]

where

\[ D_U = D_U + D_U. \]

Thus,

\[ (B-1) \quad \frac{dM}{dP} \frac{dP}{dP_0} \left[ 1 - \left( P_m - P_0 \right) \frac{dP_m}{dP_0} q \right] = \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} + \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} \left( \frac{dP_m}{dP_0} - 1 \right) M. \]

With rationing, \( q \) can be determined independently of \( P_o \). Assuming that \( q \) is given, and examining the effect of a change in \( P_o \), then

\[ (B-2) \quad \frac{dP}{dP_0} = q + (1 - q) \frac{dP_m}{dP_0}. \]

From equations B-1 and B-2,

\[ \frac{dM}{dP} \left[ q + (1 - q) \frac{dP_m}{dP_0} \right] \left[ 1 - \left( P_m - P_0 \right) \frac{dP_m}{dP_0} q \right] = \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} + \frac{dM_P}{dP_0} \frac{dP_m}{dP_0} \left( \frac{dP_m}{dP_0} - 1 \right) M \]

or

\[ (B-3) \quad \frac{dP_m}{dP_0} = \frac{\frac{dM}{dP} q \left[ 1 - \left( P_m - P_0 \right) \frac{dP_m}{dP_0} q \right] + \frac{dM_P}{dP_0} qM}{\frac{dM_P}{dP_0} \frac{dP_m}{dP_0} + \frac{dM_P}{dP_0} qM + (1 - q) \left[ \left( P_m - P_0 \right) \frac{dP_m}{dP_0} q - 1 \right] \frac{dM}{dP}} \]

\[ = \frac{A_0}{B_0} < 0. \]
From equations B-2 and B-3,

\[ \frac{dP}{dP_0} = q \left( \frac{dD_u}{dP_m} + \frac{dD_v}{dP} M \right) = \frac{C_0}{B_0} > 0. \]  

(B-4)

For rationing by queuing, \( V = 0 \), and \( y_p = Y^p \). Equations B-3 and B-4 then become

\[ \frac{dP_m}{dP_0} = \frac{(dM/dP)q}{dD_u - (1 - q)dM/dP} < 0 \text{ if } dD_u/(1 - q) < dM > 0 \text{ or if } dM < dD_u/(1 - q) \]

and

\[ \frac{dP}{dP_0} = q \frac{dD_u}{dP_m} > 0 \text{ if } dM > dD_u/(1 - q). \]  

(B-5)

(B-6)

If \( dM/dP = 0 \), then \( dP/dP_0 = q \).

REFERENCES

The word “processed” describes informally reproduced works that may not be commonly available through library systems.


