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Grain price stabilization in India: Evaluation of policy alternatives

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Abstract

Stabilization of prices is an important element of food policy in India as in most other countries — both developing and developed. However, since the magnitude of grain stocks held for this purpose as well as the costs of physical storage have become prohibitively high, there is now a need for finding cost-effective alternatives including non-interventionist and market-oriented methods for price stabilization. In this paper we consider the case of rice and wheat which are staple foodgrains in India. We make a comparison between alternative price stabilization policies including that of holding buffer stocks in terms of their impact on domestic price stability, producer and consumer welfare and government costs. A multi-market equilibrium framework is used where private storage, consumption, supply and prices of rice and wheat are determined simultaneously. Indian exports and imports are assumed to affect world prices. The alternative price stabilizing mechanisms are ranked according to both the criteria, welfare and price stability achieved. The main findings are as follows. The ranking of alternatives varies with the criterion used. Greater price stability need not necessarily imply greater welfare. The option of variable levies on private external trade turns out to be the most inexpensive and that of domestic buffer stocks the costliest in achieving price stability. Further, the efficacy of buffer stocks and subsidy to private storage in stabilizing prices is lower under free trade as compared to the case where the economy is closed to private external trade.

JEL classification: Q17; Q18
Keywords: Price stabilization; Buffer stocks; Canalized trade; Variable levies; Private storage; Free trade; India

1. Introduction

Stabilization of prices is an important element of food policy in India as in most other countries — both developing and developed. Since output continues to depend largely on uncertain monsoons, domestic price stabilization remains one of the key objectives of government's foodgrain policies. This objective is met mainly through holding of buffer stocks by government agencies such as the Food Corporation of India. Government food stocks are also meant to meet the requirements of the Public Distribution System (PDS) which provides grains to consumers at subsidized prices. Of late, the increasing magnitude of grain stocks has proved to be fiscally expensive and this method of price stabilization may become unsustainable in the long run (see, e.g. Reddy and Selvaraju, 1992; Ahluwalia, 1993; Jha, 1995). After examining the experiences of several developing countries Knudsen and Nash (1990) came to the conclusion that in most countries where price stabilization involves

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handling of the commodity by government agencies the costs have been extremely high. In the case of India Gulati et al. (1996) suggest that per unit costs of public storage operations are substantially higher than those of private traders. Some empirical studies have also suggested that the current levels of public stocks in India are far in excess of optimal levels and part of the funds spent for this purpose could easily be diverted to productivity-enhancing investments in agriculture (e.g. Ray, 1994). Thus, alternative policies need to be explored in order to achieve, at lower costs, the objectives of providing appropriate production incentives and improved consumption levels through price stability. This has become all the more important ever since India launched its economic reforms program with the objective of rationalizing its expenditure and improving efficiency through market liberalization and deregulation.

Thus a major objective of this study is to analyze the cost-effectiveness of various options for price stabilization, especially those which do not require physical storage of grain by the government. In particular, we compare public buffer stocks with the alternatives of import and export of foodgrains by government agencies, variable levies on private external trade and subsidy to private storage. For each of these alternative scenarios we work out the impacts on government costs and producer and consumer welfare. We use a multi-market equilibrium framework where market outcomes such as equilibrium outputs, stocks and prices are determined simultaneously and private storage behavior is modeled explicitly. Private storage agents are assumed to be risk-neutral and having rational price expectations. Analysis of international trade takes into account the sensitivity of world prices to changes in Indian exports and imports (the 'large country' effect). Domestic price variability, caused by stochastic variability in world prices and domestic production, influences both public and private storage. The interactions between rice and wheat markets are captured not only through demand substitution effects, but also through the introduction of an aggregate public storage constraint.

The rest of the paper is organized as follows. In Section 2 we provide a description of the model used including the behavior of various agents in the economy and the important parameters such as demand and supply elasticities used in the simulations. In this section we also discuss the ways in which various features are implemented in the model. Section 3 reports and analyzes the results obtained from stochastic simulation exercises. A summary of the results obtained and conclusions derived is provided in Section 4.

2. Description of the model

In this section we present a description of the different aspects of the model used to analyze price stabilization policies.

2.1. Consumption demand

Demand for rice and wheat in each period is specified as a linear function of both their prices and income. Aggregate income is assumed to be constant and consumption demand non-stochastic. Total consumption demand is made up of consumption from subsidized sources (PDS ration shops) and that from the open market. We assume that subsidized ration quota is fully utilized (i.e. total consumption is greater than the PDS quota) so that the marginal price faced by a consumer equals the open market price. The effect of subsidized food distribution on total consumption demand is then obtained by adding the subsidy arising through PDS to the income term (see Chetty and Jha, 1986 for a theoretical derivation of this result). This subsidy is calculated as the difference between the open market and subsidized prices times the quantity purchased at the subsidized price. The amount of grain to be distributed through PDS is determined by the government and is explained below in the section on government behavior. Demand equations are expressed as linear functions of income and prices and calibrated using the elasticities estimated by Radhakrishna and Ravi (1994).

$$c_{\mathrm{R}} = 70.23 - 0.0386p_{\mathrm{R}} + 0.0104p_{\mathrm{W}} + 0.000059(m + T) \quad (1a)$$

$$c_{\mathrm{W}} = 70.23 + 0.0118p_{\mathrm{R}} - 0.0698p_{\mathrm{W}} + 0.000026(m + T) \quad (1b)$$

c_{R}, c_{W} and p_{R}, p_{W} are consumption demands and open market prices of rice and wheat, respectively, and m is the income variable. In the simulation exercises

Table 1
Parameter values used in the model and base year data

	Rice	Wheat
Parameter values		
Own price elasticity of demand	−0.51	−0.58
Cross price elasticity of demand	0.072	0.19
Income elasticity of demand	0.48	0.41
Price elasticity of supply	0.16	0.09
Elasticity of world price w.r.t. Indian exports	−0.14	−0.001
Elasticity of world price w.r.t. Indian imports	0.14	0.001
Import margins (percent of border price)	15.0	36.7
Export margins (percent of border price)	5.0	9.0
Marginal cost of private storage (Rupees/quintal)	52.0	52.0
Discount rate used by private storage agents	0.1	0.1
Alternative price bands (floor and ceiling prices) used by the government (Rupees/quintal)	(850, 950)	(450, 550)
	(871, 950)	(465, 550)
	(871, 889)	(465, 475)
Capacity constraints on total buffer stocks	30 million tonnes	
Data for the base year (1995–1996)		
Market price (Rupees/quintal)	880.4	470.1
Ration price (Rupees quintal)	537.0	402.0
World (border) price (Rupees/quintal)	1100.0	450.0
Domestic consumption (million tonnes)	67.5	55.4
Production	74.2	56.7
Public storage	14.8	14.5
Exports (million tonnes)	5.6	-–

Note: One tonne equals 1000 kg or 0.9842 tons, one quintal is the same as 100 kg and one crore is equivalent to 10 millions '–' denotes a negligible amount.

income is given exogenously so that consumption demand is essentially a function of prices. T is the implicit subsidy due consumption of PDS grain and is given by the expression

$$T = (p_R - r_R)d_R + (p_W - r_W)d_W \quad (2)$$

where d_R and d_W are the quantities of rice and wheat supplied through PDS; p and r are the open market and ration prices, respectively. Table 1 gives the various parameter values used in the model.

2.2. Supply

Farmers plan to produce only that much output at which the marginal expected revenue is equal to the marginal cost incurred. This decision process is captured by a supply function that relates production to expected future price, where producers are assumed to have rational price expectations. ($E_t(p_{t+1})$), the expected price used in the estimation of the supply equations, is approximated by the 1-year-ahead forecasts obtained from the ARIMA model fitted to the price series. This has been termed as 'quasi-rational expectations' approach by Marc Nerlove. The estimated ARIMA equations are

$$\text{Rice}: \quad z_t = 0.97z_{t-1} + u_t - 0.55u_{t-1} + 1.15 \quad (3a)$$

$$\text{Wheat}: \quad z_t = 0.86z_{t-1} - 0.73z_{t-2} + u_t - 0.71u_{t-1} + 0.90u_{t-1} + 9.91 \quad (3b)$$

where z denotes the first difference of price.

Based on data from 1960–1961 to 1994–1995 the following supply functions are estimated.

$$\text{Rice}: \quad q_R = -26084 + \underset{(3.0)}{26.6}[E_t(p_{t+1})]_R + \underset{(4.6)}{844}\,t, \quad \bar{R}^2 = 0.92, \ \text{DW} = 1.96 \quad (4a)$$

$$\text{Wheat}: \quad q_W = -77129 + \underset{(2.1)}{15.8}[E_t(p_{t+1})]_W + \underset{(14.6)}{1321}\,t, \quad \bar{R}^2 = 0.98, \ \text{DW} = 1.75 \quad (4b)$$

Figures in parentheses are t-values and DW stands for Durbin–Watson statistic. The elasticities of supply with respect to expected price at mean values implied by these equations are 0.16 for rice and 0.09 for wheat. Although the empirical estimations of this relationship included a time trend, in the model simulations it is assumed that crop yields are stable with no technological change and the constant term is suitably adjusted.

2.3. Private storage

Storage agents are assumed to be risk- neutral and their inter-year storage decisions are based on rational price expectations. The amount they store is determined through expected profit maximization from the carry-over of grains using a Dynamic Programming approach. Optimal private storage thus satisfies the following arbitrage conditions:

$$p_t + k > (1+\rho)^{-1} E_t(p_{t+1}),\ S_t = 0 \qquad (5a)$$

$$p_t + k = (1+\rho)^{-1} E_t(p_{t+1}),\ S_t > 0 \qquad (5b)$$

where p_t is the current price, k the marginal cost of storage (assumed constant), ρ the discount rate and S the amount of private storage. These complementarity conditions imply that storage will be zero so long as the expected gain from holding an additional unit of grain stock falls short of the cost of holding it. Storage is positive only when the expected gain exceeds or equals the cost. Competitive market conditions, however, ensure that profits are not positive.

The basic storage model is a part of the larger model where prices and other endogenous variables are determined to clear the markets. Since it is a stochastic dynamic programming problem the solution is not just one value for the carry-over of stocks, but an equilibrium storage rule which expresses the relationship between storage and current availability of grain (harvest plus previous year's storage). It is generally impossible to analytically obtain the reduced form equation for this rule and hence numerical procedures are used.

2.4. Government

Intervention in the cereals market by the government serves two main purposes: provision of food security to consumers with the help of PDS, the subsidized food distribution scheme and stabilization of prices to provide price support to farmers and protect consumers from unduly high prices. In order to simplify the model we assume that procurement of grain for PDS and price stabilization purposes is made at market prices although in reality the government has a procurement policy whereby it procures grains at prices different from market prices.[1]

The PDS prices are fixed exogenously at suitably low levels so that they are always below market prices. The need for subsidized food is more during periods of poor crop output since it leads to lower employment and purchasing power (see, e.g. Narayana et al., 1991; Ahluwalia, 1993). In our simulations we therefore assume the quantity of grain distributed through PDS to be negatively related to production. A linear function fitted to data yields the following relation between PDS quantity and production.

$$d_{\mathrm{R}} = -17.0 - \underset{(-1.2)}{0.05}\, q_{\mathrm{R}} + \underset{(6.3)}{0.315}\, t$$

$$\bar{R}^2 = 0.87, \mathrm{DW} = 1.66 \qquad (6a)$$

$$d_{\mathrm{W}} = -26.3 - \underset{(-3.9)}{0.334}\, q_{\mathrm{W}} + \underset{(4.5)}{0.545}\, t$$

$$\bar{R}^2 = 0.47,\ \mathrm{DW} = 1.47 \qquad (6b)$$

As before the values in parentheses are t-values. In the simulation model the time trend is combined with the constant term in the above equations as was done in the case of supply equations.

This paper concentrates on the second objective of the government and analyzes the cost-effectiveness and welfare implications of alternative price stabilization mechanisms. The various alternatives considered include buffer stocks, import and export of grain by government through its agencies (usually referred to as canalized trade) and variable levies on private external trade. In all these cases the government is assumed to be attempting to keep prices within a band consisting of a floor and a ceiling price. The use of *buffer stocks* implies that the government prevents

[1] In the case of rice, procurement has been at below market price in the form of a levy on millers. Wheat procurement, however, has been mostly at support prices.

price from falling below a floor level by buying grain from the market and adding to its stocks. If the price goes beyond the ceiling price, then the government sells grain in the market by depleting its stocks until the price is driven down to the ceiling level. The combined storage capacity for rice and wheat is fixed as 30 million tonnes. If there is a need to defend the floor prices of both rice and wheat when the capacity constraint is binding then one of the cereals needs to be given priority over the other. In the simulations reported here rice was given first priority. The scenario where private external trade is restricted and trade takes place only through public agencies is referred to as the case of *canalized trade*. In this case government agencies import grains when price tends to go above the ceiling price and export when it tends to fall below the floor level. In the case where private external trade is permitted, *variable trade levies* (taxes/subsidies) are used for the same purpose. That is, prices are prevented from going above the ceiling level by either subsidizing imports or taxing exports depending on the trade status. Similarly, prices are stopped from falling below the floor level by either taxing imports or subsidizing exports depending on whether net imports are positive or negative.

In addition to the alternatives described above, the government could also consider *subsidizing private storage* to bring about price stabilization. The main costs for private storage agents are those incurred in physical holding of stocks (handling costs, rental value of storage space, etc.) and the foregone interest earnings on the funds invested in them. Thus, subsidy can be administered directly on the per unit storage cost or through a subsidy on interest rate. We consider the former type of subsidy in our simulations.[2] The implicit assumption behind the government's attempt to stabilize prices, irrespective of the method adopted, is that private agents store sub-optimal levels of grain due to market failures of different kinds. For example, certain positive externalities from increased price stability do not get reflected in the private agents' profits. These include distributional and social benefits in the form of prevention of under-nourishment among the poor and avoidance of national emergencies (famines etc.). There can also be disincentives to adequate private storage due to government price controls that prevent the storage agents from reaping 'windfall' profits during extreme shortages. A detailed discussion of various possible reasons for the sub-optimality of private storage is provided in Gardner (1979).

In the first three of the price stabilization alternatives, namely, buffer stocks, canalized trade and variable levies, the width of the price band is varied to achieve various degrees of price stability. Three different sets of price bands are used to analyze government price stabilization policies (see Table 1). The basis for the exact specification of these bands is explained in the section on model implementation. In the case of buffer stocks, the government faces a capacity constraint in the form of an upper bound on physical storage of grain. Also, the closing stocks are constrained to be non-negative. Prices go out of the price band when either of these two storage constraints becomes binding. In the cases of canalized trade and variable levies, we assume that there are no constraints in keeping prices within the specified band. In the alternative of subsidy-to-private storage, it is not easy to link the amount of subsidy to any price band. The amount of subsidy can, however, be varied to bring about different degrees of price stability. In the three scenarios considered, the government is assumed to bear respectively, 50, 100 and 150% of the storage costs of private agents.

There are some other alternatives such as commodity options and futures contracts that can provide price and income support to farmers. If the government encourages use of these instruments, farmers could be protected against price and income risk without much need for the holding of buffer stocks. But a study in the case of the US has shown that 'government programs to expand use of such contracts by farmers generally would not raise or stabilize market prices or farmers' incomes unless subsidies are involved' (Heifner and Wright, 1989). It has also been observed that such subsidies are difficult to administer. Commodity options, however, could improve market efficiency by providing useful information regarding intra-year price movements. Gardner (1977) observes that "the public good aspect of information generated by quoted option prices suggests that options trading on organized exchanges should be encouraged." Crop insurance can be another way of spreading risk among

[2]Interest rate subsidies have been demonstrated to be inefficient in stabilizing market prices as compared to a direct subsidy (see Gardner and Löpez, 1996).

farmers.[3] Analyzing these alternatives, however, is beyond the scope of this study.

2.5. External trade

During normal weather years with no crop failures, production levels of both rice and wheat are sufficient to meet domestic demand. Thus, India is likely to be an irregular participant in world trade when trade is liberalized. The direction of trade is therefore determined endogenously in our model. In addition, unlike in the case of a small open economy where world prices are taken exogenously, we assume that Indian exports and imports affect world prices. This would especially be the case for rice since the world rice market is thin and Indian exports have been substantial in recent years. In order to capture this effect, the short-run elasticity of world price with respect to increases in India's exports/imports is assumed to be −0.14 for rice and −0.001 for wheat. The elasticity for rice is based on the estimates from IFPRI's (International Food Policy Research Institute's) IMPACT model which gives the percentage decrease in world rice price due to 1 million tonnes of additional Indian rice exports as 4.7% (as reported by Gardner and Rosegrant, 1996). −0.14 is the elasticity computed at the point where Indian rice exports are equal to 3 million tonnes. In the case of wheat the elasticity is based on the assumption that the elasticity of excess demand for wheat exports with respect to price is unity (Mitchell, 1996). Since Indian wheat exports form around 0.1% of world exports this translates into an elasticity of −0.001 at current levels of exports. In our simulations we have assumed import elasticities to be the same as export elasticities.

When private external trade is permitted, exports take place whenever domestic price p, falls below the export trigger price $\hat{p}^x$ which is obtained by deducting export margins (port charges etc.) from border price. Similarly, imports take place if domestic price rises above the import trigger price $\hat{p}^m$, which is obtained by adding import margins to border price. At the export trigger price the trader is indifferent between selling the marginal unit in the domestic or the world market. If the domestic price is lower than this level then the grain is sold in the world market. Similarly, at the import trigger price the trader is indifferent between buying from domestic and international markets. If domestic price is higher than this level then grain is imported.

2.6. Commodity balance

At equilibrium the supply of grain in any period should exactly meet the demand for grain in that period. The available supply in any period t is composed of production (y) in that period plus carry-over of private (PS_{t-1}) and public (GS_{t-1}) stocks from the previous period and import (m) of grains from the rest of the world in that period. Total demand for grain in period t consists of consumption (c), storage ($PS_t + GS_t$) and exports (x). Commodity balance therefore implies

$$y_t + PS_{t-1} + GS_{t-1} + m_t = c_t + PS_t + GS_t + x_t \quad (7)$$

Equilibrium prices and quantities are thus obtained by matching current availability with domestic consumption and storage demand (public and private) plus export demand.

3. Model implementation

The various parameter values used in the empirical implementation of the model are given in Table 1. In practice there is no explicit price band specified by the government. But there are policies aimed at stabilizing prices. In our model since we use price bands the choice of these should be such that the magnitudes of prices and quantities that the model generates should be close to reality. Thus the model is tuned by a 'trial and error' process such that outcomes are close to actual values observed for the base year (1995–1996). This is especially important in the case of rice export because its magnitude was sizeable in the base year compared to other years. Thus we have to make sure that the price bands under the free trade scenario leads to similar amounts of exports. The first set of price bands is therefore an outcome of the trial and error process used to obtain realistic model outcomes. The second set of price bands is obtained by choosing the

[3] Due to informational and other problems the costs of administering a crop insurance program are very high and such programs apparently are not cost-effective in reducing risk even in developed countries like the USA.

Table 2
Frequency distribution of domestic yields and world prices

Deviation from expected output (million tonnes)		Probability	Percentage deviation from trend values of border price		Probability
Rice	Wheat		Rice	Wheat	
6.8	6.0	0.12	36.0	30.0	0.39
−9.5	−6.7	0.15	−31.0	−25.0	0.39
0.0	0.0	0.34	0.0	0.0	0.00
6.8	0.0	0.18	36.0	0.0	0.03
−9.5	0.0	0.06	−31.0	0.0	0.03
6.8	−6.7	0.00	36.0	−25.0	0.06
0.0	−6.7	0.06	0.0	−25.0	0.00
−9.5	6.0	0.03	−31.0	30.0	0.10
0.0	6.0	0.06	0.0	30.0	0.00

lower bounds closer to the prices observed in the base year while maintaining the upper bounds at the previous level. In the third set, the lower and upper bounds are placed symmetrically around the price observed in the base year, the lower bounds being the same as in the second set.

Equilibrium outcomes are computed for 1000 different random realizations of domestic yields and world market prices. These random realizations are obtained using a random number generator given the estimated frequency distribution of occurrence of different states of nature. The randomness in domestic yields is expressed by a joint (for rice and wheat) discrete probability distribution of deviations of actual from expected output and is estimated based on historical data (1960–1961 to 1995–1996). Similarly, the joint probability distribution of deviations of border prices of rice and wheat from their corresponding trend values is obtained using past data (1964–1965 to 1994–1995) on world prices (Table 2). The 9-point discrete distribution is a simplification since the data-points are small in number. The distributions of world prices and domestic output are assumed to be independent. Since trade in foodgrains has been restricted until very recently in India the observed correlation between fluctuations in world prices and domestic output is weak. This would, however, change with the freeing of trade by India. Planned or expected output (the supply equation) for the base period is obtained as a function of the price expected for that period. The realized production is obtained by adding randomly generated deviation to the expected output. Similarly, given the trend value of the border price for the base year the realized border price is obtained by applying the randomly realized percentage deviation from trend value.

3.1. Rational expectations equilibria

Both producers and private storage agents are assumed to have rational price expectations. That is, their price forecasts are consistent with those underlying the given economic model. They use all available information efficiently in making decisions and do not make systematic errors. In our simulation model we assume that there is no inherent growth or seasonality in either supply or demand for grains. This implies that in an infinite horizon setting, the relationship between storage PS_t and availability A_t of grain in that period, is stationary. That is, it does not change from period to period. Once this relationship is derived, the relationships between availability and other endogenous variables are determined indirectly. The numerical procedure used, obtains the relationship between expected future price $E_t(p_{t+1})$ and current storage PS_t. This is because the relation between A_t and PS_t is non-linear (kinked) whereas that between PS_t and $E_t(p_{t+1})$ is smooth. The numerical procedure approximates this relationship by a polynomial and chooses the parameters of this function in such a way that storage agents' expectations are self-fulfilling ('rational') (see Williams and Wright, 1991, Chap. 3). The solution for competitive market equilibrium is obtained using a fixed-point subroutine. The computational process is repeated 1000 times for each of the model scenarios. The outcomes are compared based on the mean values and coefficients of variation generated from these 1000 Monte Carlo simulations.

3.2. Determination of equilibrium prices

Equilibrium prices and quantities are defined as those at which excess demands are zero. That is, at equilibrium prices commodity balances, as defined in Eq. (7), are satisfied. Excess demands z_i (i = rice, wheat) are obtained as total demand (consumption + net exports + net addition to government stocks + net additions to private stocks) less production. Equilibrium prices are determined by solving for the fixed point of the following map for prices.

$$p_i \rightarrow \text{Min}\,\{\text{Max}[(p_i + z_i), \underline{p}_i], \bar{p}_i\} \tag{8}$$

where $\underline{p}_i$ and $\bar{p}_i$ are, respectively, the lower and upper bounds on prices chosen suitably low and high, respectively, so that the fixed point of this map is in the interior. It can be seen easily that when z_is are zero we obtain a fixed point for the above map. Note that the price bounds above are different from the floor and ceiling prices of the government's price stabilization scheme, $\bar{p}_i$ being much higher than the ceiling price and $\underline{p}_i$ being much lower than the floor price.

The various components of the excess demand function are determined as follows. Given a random realization of the deviation ξ from expected or planned output, $\hat{y}$ the realized output y is given as $y = \hat{y} + \xi$ where expected output is a function of the expected price. Consumption demand c is obtained from the demand equations. Since income is fixed these are essentially functions of prices alone. Private stock carry out is determined as a part of the implementation of the Rational Expectations Equilibrium. The mechanisms used to determine change in government stocks, amount of exports and imports and variable levies are described below.

3.3. Determination of changes in government stocks

The magnitude of addition to or depletion of stocks is determined by the following iterative procedure.

1. Set the additions to government stocks, $\Delta GS^+ = 0$ and depletion from stocks, $\Delta GS^- = 0$ (so that net additions to stocks, $(\Delta GS^+ - \Delta GS^-) = 0$) and obtain a set of equilibrium prices using map (8).
2. Check if these prices are within the price bands (i.e. between the floor and ceiling prices). If any of the prices is greater than its respective ceiling price then increment the corresponding ΔGS^- by a small amount δ^- (similarly, if any of the prices is lower than its respective floor price then increment ΔGS^+ by a small amount δ^+) and compute the equilibrium prices again.
3. Repeat Step 2 until one of the following conditions holds. (a) All the prices are within the relevant price bands. (b) The stocks are exhausted for the relevant commodity (i.e. government stocks at the beginning of the period less ΔGS^- is non-positive). (c) The total storage capacity is exceeded (i.e. the sum total of government stocks at the beginning of the period for both the commodities plus ΔGS^+ for both commodities exceeds the maximum combined storage capacity). Since we use a combined storage capacity constraint, if both rice and wheat prices are below their respective floor prices then equilibrium price outcomes depend on which cereal is given a higher priority. We give a higher priority to keeping rice prices within bounds.

Note that with this procedure equilibrium prices would lie outside the price band whenever storage constraints are binding.

3.4. Determination of canalized trade

In the canalized trade case, imports and exports take place only through government agencies. These are chosen such that prices are kept between the ceiling and floor prices, p^{high} and p^{low}. The levels of imports and exports needed for this purpose are determined using the following maps.

$$m_i \rightarrow \text{Max}\ \{\text{Min}[(m_i + (p_i - p_i^{\text{high}})), \bar{m}_i], 0\} \tag{9a}$$

$$x_i \rightarrow \text{Max}\ \{\text{Min}[(x_i + (p_i^{\text{low}} - p_i)), \bar{x}_i], 0\} \tag{9b}$$

where $\bar{m}_i$ and $\bar{x}_i$ are chosen suitably high so that the fixed points for m and x are, respectively, below these levels. Equilibrium levels of trade and prices are determined simultaneously as fixed points of the maps defined in Eq. (8) and (9).

3.5. Determination of exports/imports under liberalized private trade

Given the random realization of the percentage deviation γ from the trend value of the border price, the realized border price is given by $p^{b} = p^{bo}$ $(1 + \gamma/100)$, where p^{bo} is the trend value for the base year. The discrete probability distribution used to generate these random deviations from trend values is given in Table 2. The import and export trigger prices and are obtained as

$$\hat{p}_i^m = p_i^b(1 + \text{import margins})$$

$$\hat{p}_i^x = p_i^b(1 - \text{export margins}).$$

The import margins in the case of rice and wheat are, respectively, 15.0 and 36.7% of the border price. The export margins for rice and wheat are 5.0 and 9.0%, respectively. The inverse export demand function for the rest of the world is taken as $p^{x} = \alpha_1 + \alpha_2 x$ and the inverse import demand function for India as $p^{m} = \beta_1 + \beta_2\, m$. Trade elasticities used are given in Table 1. The quantities of exports and imports at equilibrium are determined by comparing the market price p with the export and import trigger prices. If $p \leq \hat{p}^m$ then $m = 0$, otherwise $m = (p - \beta_1)/\beta_2$. Similarly, if $p \geq \hat{p}^x$ then $x = 0$, otherwise $x = (p - \alpha_1)/\alpha_2$.

3.6. Determination of variable levies

In the scenarios where variable levies/subsidies are used to keep prices within a price band, the equilibrium levels of these are determined using the following maps.

$$s_i \rightarrow \text{Max}\,\{\text{Min}[(s_i + (p_i - p_i^{\text{high}})), \bar{s}_i], 0\} \qquad (10a)$$

$$t_i \rightarrow \text{Max}\,\{\text{Min}[(t_i + (p_i^{\text{low}} - p_i)), \bar{t}_i], 0\} \qquad (10b)$$

s denotes either import subsidy or export tax, depending on whether $p > \hat{p}^m$ or $p < \hat{p}^x$. t denotes either import tax or export subsidy depending on whether $p > \hat{p}^m$ or $p < \hat{p}^x$. Equilibrium levels of trade levies and prices are determined simultaneously as fixed points of the maps defined in (10) and (8), respectively. $\bar{s}_i$ and $\bar{t}_i$ are chosen suitably high so that the equilibrium levels of s and t are below these levels. The effective trigger prices with levies are defined as follows.

$$\hat{p}^{m'} = \hat{p}^m(1 + (t - s)/100) \qquad (11a)$$

$$\hat{p}^{x'} = \hat{p}^x(1 + (t - s)/100) \qquad (11b)$$

Thus, when equilibrium price, p is not greater than $\hat{p}^{m'}$ and not lower than $\hat{p}^{x'}$ then there is no trade and the levies are set to zero (note that $\hat{p}^x < \hat{p}^m$). If p is greater than $\hat{p}^{m'}$ then the net tax on import of the concerned commodity is given as $t^m = (t-s)/100$ and the tax exclusive import price is given as $p/(1 + t^m)$. Similarly, if p is less than $\hat{p}^{x'}$, then net tax on export of the relevant commodity is given as $t^x = (s-t)/100$ and the tax-exclusive export price is given as $p/(1-t^x)$.

4. Evaluation of different alternatives

4.1. Effects on net social benefit and price stability

In this section we compare the changes in welfare and price variability achieved under different scenarios. The effects of price stabilization using a particular mechanism are obtained by comparing the results under this scenario with those under the reference scenario where there is no government price stabilization program. Under each of the alternatives we have three different price bands as given in Table 1. The three rows under each of the alternative scenarios in Table 3 (indicated as A1, A2, A3; B1, B2, B3 etc.) give results corresponding to the three price bands respectively. In the alternatives with private storage since it is not feasible to implement a price band policy we consider three different levels of subsidy to private storage (50, 100 and 150% subsidy on storage costs incurred) in order to obtain different levels of price stability.

Different criteria can be used to compare various options for price stabilization. For instance, the higher the price stability achieved the better an option could be. Or, more generally, one can look at the net effect on social welfare, which is the sum of producer and consumer surplus less government costs and choose the option that yields the maximum social benefit. We use both these criteria. In the case of producers in addition to the changes in mean surplus we consider the risk benefits accruing due to a reduction in the variations in producer surplus. Private storage agents are assumed to break even on an average in the long

Table 3
Welfare implications of different price stabilization options

Alternative	Change in consumer surplus (1)	Change in producer surplus (2)	Government costs (3)	Net social benefit (4)	Change in price variability (5)
Buffer stocks and canalized trade					
A1	−48	283.4	1843.7	−1608.3 (18)	−0.1 (14)
A2	−459.1	909.1	2125.3	−1675.3 (17)	−0.11 (15)
A3	1717.8	−2317.3	2402.1	−3001.6 (20)	−0.144 (8)
Buffer stocks under autarky					
B1	−2523.6	3379.8	846.5	9.7 (6)	−0.049 (11)
B2	−2736.5	3747.8	1132.3	−121.0 (8)	−0.058 (16)
B3	−2801.8	3687.8	756.1	129.9 (5)	−0.044 (12)
Canalized trade					
C1	−48	283.4	1099.2	−863.8 (16)	−0.1 (4)
C2	−459.1	909.1	1177.7	−727.7 (13)	−0.11 (3)
C3	1717.8	−2317.3	2429.8	−3029.3 (19)	0.144 (10)
Buffer stocks under free trade					
D1	−3600.6	5161.6	521.3	1039.7 (3)	−0.034 (7)
D2	−1913.9	3026.7	2985.9	−1873.1 (14)	−0.042 (20)
D3	−3158.5	4605	1587.7	−141.2 (7)	−0.029 (19)
Variable levies under free trade					
E1	−722.9	1089	1066.5	−700.4 (15)	−0.091 (5)
E2	−1057.2	1602.4	1136.9	−591.7 (12)	−0.097 (6)
E3	1933.3	−2591	2494.4	−3152.1 (21)	−0.143 (13)
Subsidy to private storage under free trade					
F1	−2141.8	3499.2	61.4	1296.0 (1)	−0.017 (1)
F2	−2179.9	3484.7	249.3	1055.5 (2)	−0.026 (2)
F3	−2136.3	3281.5	1459.7	−314.5 (10)	−0.037 (18)
Subsidy to private storage under autarky					
G1	5.3	46.8	39.1	13.0 (4)	−0.000 (21)
G2	−208.9	343	151.4	−17.3 (9)	−0.009 (9)
G3	−308	611.4	622.3	−318.9 (11)	−0.026 (17)

Note: Changes are obtained as differences from the reference scenario where there is no policy intervention and no trade. Under each of the alternatives we have three different price bands as given in Table 1. The three rows under each of the alternative scenarios (e.g. A1, A2 and A3) give results corresponding to the three price bands respectively. In the alternatives with private storage since it is not feasible to implement a price band policy we consider three different levels of subsidy to private storage (50, 100 and 150% subsidy on storage costs incurred) in order to obtain different levels of price stability. Producer surplus is the sum of transfer and risk benefits. In Columns (4) and (5) the figures in parentheses give the ranking (in descending order) based on, respectively, the gain in consumer plus producer surplus and the reduction in price variability achieved per unit of government costs. The benefits and costs are in Rs. crores. Price variation is measured as the CV.

run and hence we do not expect any change in their welfare.

We rank the options using two distinct criteria: reduction in price variability achieved per unit of government costs and gain in producer plus consumer surplus per unit of government costs. Price variability is measured by the coefficient of variation (CV) of prices. A simple average of the coefficients of variation of rice and wheat prices is taken to represent the combined measure of price variability. That is, equal importance is assigned to both the cereals since both of them occupy an equally important place in the domestic consumption and production baskets of cereals. In terms of reduction in price variability achieved per

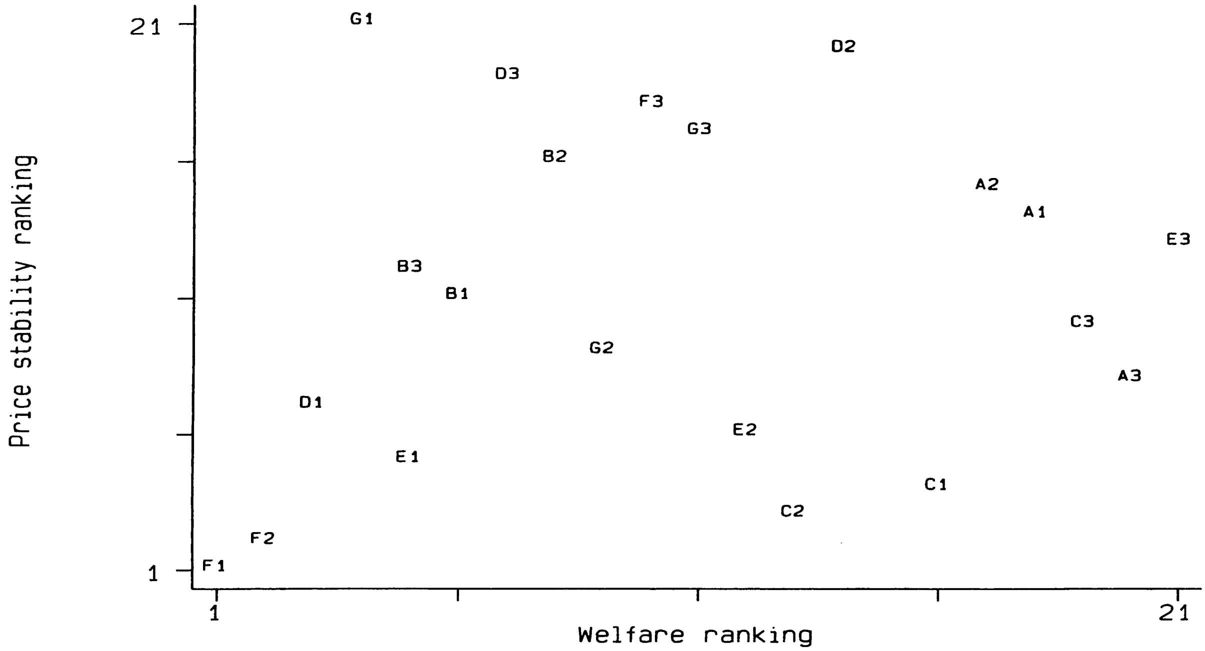

Fig. 1. Range of alternative scenarios.

unit cost, subsidy to private storage under free trade turns out to be the best option. This is mainly due to the fact that administering these subsidies is far less expensive compared to, for example, managing food stocks for the government. In terms of consumer plus producer benefit per unit of government costs also the first two alternatives (F1 and F2 in Table 3) of subsidy to private storage under free trade are the best. However, although price variability is reduced due to higher subsidy, beyond a certain level of subsidy the net social benefit becomes negative.

Fig. 1 places the various alternatives based on the rankings obtained from both the welfare and price stability criteria. The alternatives that appear in the south-west of the graph are attractive from both points of view. The current government policy, a combination of holding domestic buffer stocks and canalized trade ranks very low under both the criteria. Points A1 and A2 appear in the north-east section of the graph. The rankings based on the two criteria are in general very different indicating that greater price stability need not necessarily imply greater welfare.

In the case of price band policies the effect on net social benefit depends on the width of the price band used or the extent of price stability achieved. Attempts to achieve very high price stability through a choice of narrow price bands can lead to negative net social benefits. As the width of the price band is reduced private storage agents are squeezed out of the market leading to an increased storage burden for the government. Thus stabilizing prices beyond a certain level appears to be not very cost-effective. Similar observations are made in Islam and Thomas (1996) after analyzing the effectiveness of price stabilization policies in five Asian countries. They note that if the gap between the ceiling and floor price is small it can increase public costs substantially and suggest that this gap should be large enough to encourage private stocks.

The welfare implications for consumers and producers are different. In general, when the width of the price band is broad consumers lose and producers gain from price stabilization. This is mainly due to the fact that the government is required to defend the floor price more often than the ceiling price. Thus, while producers benefit more often from price support, consumers are deprived of the benefits from lower prices. However, when the government can reduce price variability considerably by strictly defending a narrow price band as in cases A3, C3 and E3, we find that benefits to consumers are positive since the mean prices are lower in this case (see Table 3). This decrease in mean prices is due to increase in supply resulting from imports. Producers, however, lose due to lower mean prices. Thus when narrow price bands can be strictly defended we obtain results similar to the case of complete price stabilization, which involves stabilization at the mean of prices that would prevail in an unstabilized market (see Bigman, 1980a). But in the buffer stock scenarios even if the width of the price band is reduced there is the possibility that government is unable to defend the ceiling price due to storage constraints.

4.2. *Trade-off between price stability and government costs*

In general, the price stabilization options considered in this study lead to varying levels of price stability and government costs. The same price band used under a different scenario yields a different level of price stability and implies a different level of costs to the government. Thus in the previous section comparisons across scenarios were made in terms of price stability achieved per unit of government costs. However, such comparisons cannot reveal if one option is superior to another irrespective of the level of price stability achieved under each case. Although we expect greater price stability to be associated with higher costs, the trade-off between price variability and stabilization costs is different for each of the alternatives considered (Fig. 2). One alternative can be said to dominate another only if its trade-off curve lies completely below that of the other. That is, any given level of price stability can be achieved at a lower cost using the dominant option. We find that under a situation of autarky, the option of holding public buffer stocks is dominated by the options of canalized trade and subsidy to private storage (see graph (a) in Fig. 2). One of the reasons for this result is that the costs of administering canalized trade and subsidy to private storage are far lower than those of maintaining buffer stocks. It is also the case that under canalized trade the government can successfully defend floor and ceiling prices at all times as compared to buffer stocks where most often capacity constraints prevent the government from defending the price band. In other words, even by incurring the same cost as in the former case, the level of price stability achieved in the latter case may be lower. In the case of subsidy to private storage, cost-effectiveness is limited to a small range beyond which the trade-off curve becomes flat. A flat curve implies that the marginal cost of reducing price variability is very high. Thus, among the three alternatives under autarky canalized trade appears to be the preferred mechanism.

In addition to ranking alternative options our simulation results can answer certain specific questions. For example, if for political or strategic reasons the government is required to hold buffer stocks, would liberalization of external trade increase its costs of price stabilization? We find that the costs of buffer stocks are higher under free trade. This is mainly due to the significantly higher average public wheat stocks in this case (Table 4). With liberalized external trade, mean rice price increases and government rice stocks decrease on an average as there is lesser need for price support. However, price of wheat declines and government stocks of wheat rise. The net effect is an increase in public storage costs. The curves depicting the trade-off between price variability and public costs of buffer stocks have different slopes in the free trade and autarky scenarios (graph (b) in Fig. 2). The trade-off curve in the free trade case is flatter indicating that buffer stocks are quite ineffective in stabilizing prices in this case. Under liberalized trade the possibility of private imports during bad crop years appears to frustrate the government's efforts to stabilize prices. Due to the possibility of imports, stock depletion is less frequent as compared to the case of autarky and the government is forced to hold more stocks. This happens in the case of wheat. Thus government costs are higher. The failure to achieve adequate reduction in price variability is due to the following reason. Due to higher stocks in the case of free trade storage constraints are binding more often and the government fails to defend the floor price more frequently.

Another question that can be answered is: Is canalized trade a better way of stabilizing prices as compared to the use of variable levies (tax/subsidy) on private external trade? There is not much difference in the outcomes of the two scenarios, except that the magnitude of external trade is larger in the latter (Table 5). The curves depicting the trade-off between

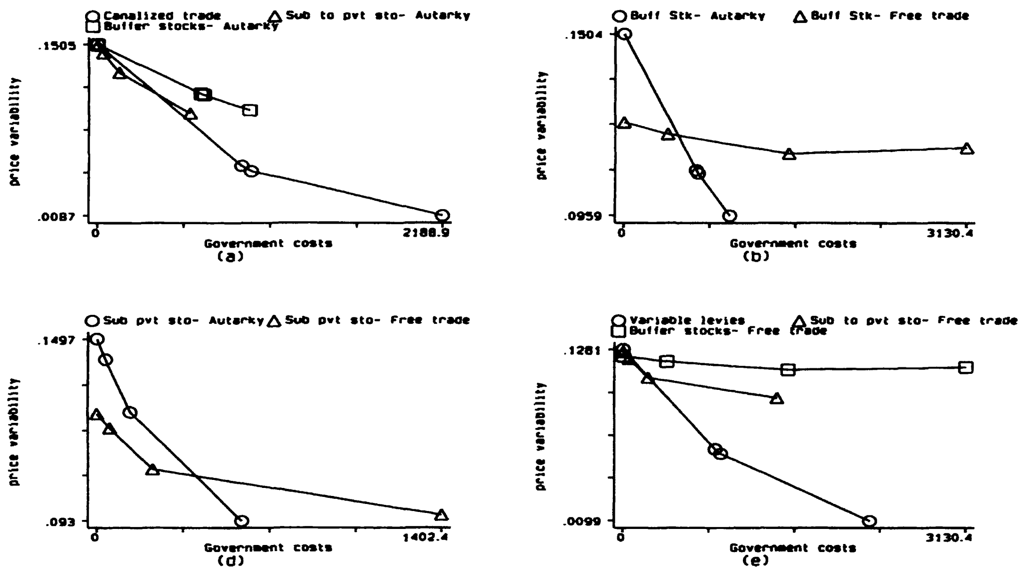

Fig. 2. Trade-off beween price variability and stabilization costs.

Table 4
Implications of buffer stocks under free trade and autarky

		Autarky	Free trade
Market price (rupees/quintal)	Rice	937.43 (0.1130)	957.21 (0.1391)
	Wheat	525.63 (0.1131)	505.84 (0.1132)
Domestic consumption (million tonnes)	Rice	66.80 (0.0536)	65.84 (0.0698)
	Wheat	51.50 (0.0647)	53.11 (0.0557)
Production (million tonnes)	Rice	68.25 (0.0896)	69.48 (0.0870)
	Wheat	51.85 (0.0784)	51.67 (0.0792)
Government stocks (million tonnes)	Rice	4.63	2.37
	Wheat	0.98	11.72
Private stocks (million tonnes)	Rice	0.00	0.36
	Wheat	0.00	0.00
Producer surplus (rupees crores)		221,799.10	222,790.10
Consumer surplus (rupees crores)		83,219.88	82,778.82
Price stabilization costs (rupees crores)		693.99	1573.78
PDS costs (rupees crores)		7436.92	7392.20
Total government costs (rupees crores)		8130.92	8966.00

Note: The above figures are average values of simulated outcomes for 1000 periods, where the price bands used for rice and wheat are, respectively (871, 889) and (465, 475). Figures in parentheses are coefficients of variation.

Table 5
Comparison of outcomes under canalized trade and variable levies

		Canalized trade	Variable levies under free trade
Market price (rupees/quintal)	Rice	883.31 (0.0095)	881.57 (0.0095)
	Wheat	473.05 (0.0084)	469.87 (0.0106)
Import price (rupees/quintal)	Rice	1223.78	1343.04
	Wheat	620.76	620.98
Export price (rupees/quintal)	Rice	998.11	982.21
	Wheat	413.12	413.09
Import tax	Rice	0.00	−0.09
	Wheat	0.00	−0.14
Export tax	Rice	0.00	−0.04
	Wheat	0.00	−0.02
Domestic consumption (million tonnes)	Rice	68.30 (0.0046)	68.33 (0.0042)
	Wheat	54.47 (0.0049)	54.67 (0.0054)
Production (million tonnes)	Rice	67.47 (0.0892)	67.37 (0.0894)
	Wheat	51.14 (0.0795)	51.04 (0.0796)
Imports (million tonnes)	Rice	2.61	3.16
	Wheat	3.86	4.26
Exports (million tonnes)	Rice	1.78	1.85
	Wheat	0.46	0.63
Producer surplus (rupees crores)		215,481.90	215,175.10
Consumer surplus (rupees crores)		86,832.95	86,996.81
Price stabilization costs (rupees crores)		2500.37	2565.11
PDS costs (rupees crores)		6403.89	6356.58
Total government costs (rupees crores)		8904.26	8921.70

Note: The above figures are average values of simulated outcomes for 1000 periods, where the price bands used for rice and wheat are respectively (871, 889) and (465, 475). Figures in parentheses are coefficients of variation. Private stocks are zero in both cases and hence not reported. The differences in trade outcomes arise because canalized trade takes place only when prices tend to go out of band, whereas free trade can take place even otherwise.

price variability and government costs are quite close for both the scenarios. Thus, canalized trade and variable levies on private external trade appear to lead to very similar economic consequences. The decision then to use either of them should depend on other considerations such as administrative ease.

Is it cost-effective to subsidize private storage under free trade as compared to the case of autarky? Once again, the trade-off curve under free trade is flatter. This implies that the cost-effectiveness of reducing price variability through a subsidy to private storage is lower under free trade, a result similar to that observed in the case of buffer stocks. The possibility of spatial arbitrage due to external trade encourages private agents to store more and hence increases government's subsidy costs. Since domestic price variability does not decrease much in this case, it is possible that higher private storage produces stabilization benefits for the rest of the world.

Among the various options considered under free trade we find variable levies to be the most preferred (see graph (e) in Fig. 2). Bigman (1980b) also finds that variable levies are an efficient way of achieving any desired degree of price stability compared to policies such as the price support program. However, he also expresses concern regarding the possibility of a destabilizing effect on prices in the rest of the world.

5. Summary of findings

This study examines alternative price stabilization mechanisms for the two important cereals in India, rice and wheat, and obtains their welfare implications. Particular attention is given to alternatives that do not require physical storage of grain by the government. Comparison between these alternative mechanisms is made using price stability and welfare criteria. The following are some of the broad results obtained.

The ranking of different alternatives varies with the criterion used. The ranking also depends on the level at which prices are stabilized. For example, for a particular level of price variability we find that subsidizing private storage is the best option in terms of reducing price variability per unit cost. But, it is not cost-effective in achieving reduction in price variability beyond a certain level. The effects on net social benefit also depend on the extent of price stability achieved. In general, we note that too much price stability increases government costs substantially leading to negative net social benefits. The implications for consumers and producers are different in different cases.

In order to make a comparison between alternatives irrespective of the level of price stability achieved we make use of curves depicting trade-off between price variability and government costs for each of the alternative price stabilization schemes. This leads to the following conclusions. Stabilization of prices through public buffer stocks is the least preferred option. The options of canalized trade and variable levies appear better compared to buffer stocks. The former two options lead to similar welfare outcomes and a choice between them can be made based on administrative considerations.

Subsidy to private storage is more effective in stabilizing prices under autarky as compared to the case of free trade. Similarly, buffer stocks appear to be ineffective in stabilizing prices under free trade as compared to the case of autarky. However, implementation of variable levies turns out to be an attractive mechanism for stabilizing prices under liberalized trade and is comparable to the outcomes achieved under canalized trade.

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