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Price dynamics in the Bangladesh rice market: implications for public intervention

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Abstract

In this paper, the price dynamics of a rice market are examined using dynamic programming techniques. The model is parameterised to the case of Bangladesh and thus represents the situation of a very poor country which has characteristically high price elasticity (due to income effects) and high storage and interest costs. The incentives for private sector storage and its impact on price stability are examined. Various options for public intervention in the storage sector are also explored, including price ceiling schemes and subsidisation of storage costs. Results show that interventions that remove private disincentives (such as storage subsidies) are much cheaper than direct intervention by government, but the impact on the probability distribution of prices is quite different. The effect of trade on the probability distribution of prices is also examined.

JEL classification: Q18

Keywords: Commodity price stabilisation; Food policy

1. Introduction

Contemporary studies of commodity price risk have questioned the desirability of public price stabilisation schemes. It has been argued that the existence of markets for reducing price risk, such as storage, credit and futures markets, imply that many of the welfare benefits proposed in earlier studies[1] of price stabilisation were overstated (Turnovsky, 1978; Wright, 1979; Newbery and Stiglitz, 1981; Williams and Wright, 1991). Further, the practical difficulties of operating public storage schemes have been highlighted. Such problems include the tendency to crowd out private storage, the ineffectiveness of public storage in maintaining price targets, and the high fiscal cost of such schemes (e.g. Timmer, 1989, 1996; Williams and Wright, 1991; Gilbert, 1993).

In contrast, governments in Asia continue to view rice price stabilisation as a desirable policy (Islam and Thomas, 1994). A number of theoretical justifications have been proposed as to why these governments pursue market stabilisation, despite the widespread negative criticism of such policies. Many of these relate specifically to the characteristics of developing country economies.

First, most of the academic literature has focused on producer price stabilisation. The focus of rice price stabilisation is strongly motivated by concern for consumer welfare and the effect of high price swings on poor groups of consumers (Gilbert, 1993; Islam and Thomas, 1994). Turnovsky et al. (1980) present a theoretical basis for stabilising staple food prices under conditions where consumers spend a large share of

[1] Reviews of the early literature can be found in Turnovsky, 1978 and Williams and Wright, 1991.

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their budget on it and are risk averse, because of the impact of fluctuating prices on real incomes. Gilbert (1993) argues that these sufficient conditions are likely to prevail in the food markets of developing countries.

Another important characteristic of developing economies is that the markets used for managing price uncertainty that exist in developed countries may be missing or imperfect. For example, efficient inter-temporal arbitrage requires that the private sector have access to adequate credit and storage facilities. Newbery (1989) refers to the possibility of 'market failure' in the provision of storage, suggesting that private storage costs may be significantly higher than the cost of public storage, due to scale economies. Similarly, a high opportunity cost of capital will discourage stockholding behaviour and such conditions are the norm in the rural communities of these countries. Further, unlike their counterparts in developed countries, producers and storage merchants do not have access to futures markets for managing risk in developing countries. In any case, the futures market for rice is thin and unreliable (Herrmann, 1993).

Other authors have focused on the wider economic and political justifications to explain food price stabilisation policies. Timmer (1989, 1996) notes the wider repercussions of fluctuating real incomes brought about by unstable food prices, which include pressure on wage rates, and variable demand for non-food sectors and its impact on production stability and investment. Smith (1997) observes that the legitimacy and survival of governments in these countries has often been associated with its ability to provide food security.

While the political and social justification for public stabilisation schemes may explain the persistence of such policies for staple food crops, another contributing factor may be the general paucity of quantitative studies on the costs and effectiveness staple food stabilisation schemes. An important starting point to addressing this problem is to examine the incentives for private sector storage of staple food crops, and to quantify the effect of public intervention in storage on these incentives. In this paper, a rational-expectations dynamic programming model is used to illustrate the key points, using parameters relevant to the Bangladesh rice market.

The outline of the paper is as follows. First, a basic model of private storage is presented, in which it is assumed that the economy is closed and there is no government intervention in the domestic market.[2] The effect of market conditions on the incentive for private storage, and the volatility of consumption and prices, is quantified. In the subsequent sections, the effect of government storage policies and trade, on the probability distribution of prices are presented, and compared to the associated fiscal costs of such interventions. The paper concludes with a discussion of some of the implications for the food price stabilisation in developing countries.

2. The closed-economy private storage model

The model presented in this paper is based upon Williams and Wright's (1991) model of private storage under forward-looking rational expectations. The basic model can be represented by the inter-temporal arbitrage rule, where the amount of storage is adjusted so that the marginal value of current period consumption P_t plus the cost of storage including interest, is equated with the expected value of consumption of that unit of storage in the following period (1), the model is completed by defining market supply as a function of rational producers price expectations and random yield (2), and market price in period t as a function of aggregate consumption in that period (3), which is determined by the market clearing condition (4):

$$P_t + k \geq \frac{E_t\{P_{t+1}\}}{1+r}; \qquad S_t \geq 0 \tag{1}$$

$$h_t = f(P^f_{t-1}(S_t))y_t; \qquad f'(P^r) > 0 \tag{2}$$

$$P_t = g(Q_t); \qquad g'(Q_t) < 0 \tag{3}$$

$$Q_t = h_t + S_t - S_{t+1} \tag{4}$$

where P_t is price in period t, $E_t\{P_{t+1}\}$ represents expectations, in period t, of prices in period $t+1$, S_t quantity carried out of period t and into period $t+1$, k the

[2] While there is increasing attention paid to spatial arbitrage as a price stabilisation tool as developing country governments liberalise their agricultural trade, progress on staple food markets have been slow. Rice in particular, is given 'special commodity' status by many governments. Thus, the analysis of a closed economy is representative of a policy scenario that governments continue to consider, and provides a baseline for comparing the effects of public storage and trade, which are analysed later in the paper.

physical cost of storage, r the interest rate, h_t quantity harvested, $P^f_{t-1}(S_t)$ the producers incentive price[3] and y_t random yield which has a mean $\bar{y}$ and a standard deviation of σ_y, Q_t aggregate consumption.

Since price in any period depends on storage carry-out (4), expectations about prices in a future period will depend on anticipated storage decisions made in that period, which in turn will be affected by anticipated storage decisions in subsequent periods. Thus, the storers' price expectations $E_t\{P_{t+1}\}$ must be estimated using dynamic programming techniques. The approach used in this study is that of polynomial approximation, where the storage rule is written:

$$E_t\{P_{t+1}\} \cong a_0 + a_1 S_{t+1} + a_2 S^2_{t+1} \quad (5)$$

The procedure involves using a discrete representation of yield outcomes, and estimating the expected prices that would be achieved if the approximated storage rule were followed (substituting 5 into 1 and solving for 1–4), for different levels of carry-in storage S_t. A series of realised expected prices and storage carry-in pairs are then used to revise the storage rule, until convergence is reached. In the model presented here, the volume of grain harvested is determined endogenously, as storage affects farmers price expectations, hence planting decisions.[4]

Once the steady state expected price functions have been estimated, a time series of prices can be simulated. Non-negativity conditions on storage mean that price spikes can occur during stock-outs, where the price of current period consumption is much higher than the expected marginal value of future consumption. The storage rule and probability distribution of prices simulated using the rational expectations model provides a result that is consistent with optimising behaviour. It is not optimal to store more than that indicated by the solution to the arbitrage rule, because higher levels of storage imply that the opportunity cost of current consumption is higher than the expected value of future consumption, after storage costs are accounted for.

[3] This is expected marginal revenue, which is different to expected marginal price since yield risk is multiplicative (Williams and Wright, 1991).

[4] For a description of the estimation technique, refer to Williams and Wright, 1991, Chapter 3 Appendix.

2.1. Market conditions in Bangladesh

There are two major harvest periods in Bangladesh corresponding to the wet and the dry seasons. The quantities harvested in each period, and the variability of the harvest, is of similar magnitude. The model represents strategic storage decisions made on a 6 monthly basis, to carry the commodity from one harvest to the next. This strategic storage is made under conditions of uncertainty about the future harvest, as represented by the arbitrage rule in Eq. (1). This storage is not directly comparable with the total quantity of grain stored at harvest, much of which is used to smooth consumption between harvest and non-harvest periods. While in practice, there is no clear distinction between these two types of storage, a policy distinction can be made. In general, government procurement under public food distribution programs has often been justified in terms of smoothing seasonal consumption to prevent price slumps after harvest (Khan and Jamal, 1998). In contrast, the holding of public buffer stocks in excess of planned seasonal consumption is comparable to the type of strategic private storage considered here.

The assumptions concerning production and consumption are shown in Table 1. There are two market characteristics that are of particular importance in this analysis. First, interest rates paid by rural traders are very high. In a survey of rural traders in Bangladesh, Chowdhury (1992) found that average interest rates paid by traders were around 20% although sometimes as high as 30–40%, compared to an official bank rate of around 10%. The physical cost of storage is also relatively high. Rice is stored in bags under owned or rented shelters, and while these costs are low, there is a high risk of loss due to insect damage or spoilage (Chowdhury, 1992). When measured against the market price for rice, the annual physical cost of storage is around 6% of the value of rice, this is much higher than the cost of storing wheat in a developed country, which is around 2% of the value of production (Brennan, 1994). One motivation for government intervention might be that the private sector lacks sufficient incentive to store, because of high storage and interest costs. The analysis of private storage decisions under a range of assumptions about these incentives is therefore relevant.

A second factor that characterises the rice market in Bangladesh is the relatively elastic market demand

Table 1
Private sector storage

Parameter assumptions used in model				
Storage cost per season[a]	27.6	Taka per 100 kg		
Interest rate per season	10	%		
Demand elasticity[b]	−0.5			
Supply elasticity[c]	0.4			
Mean price	970	Taka per 100 kg		
Mean consumption per year	8300	Thousand tonnes		
Mean yield per season	0.6	Tonnes per ha		
Yield variability (C.V.)	7	%		
Private sector storage in absence of government intervention				
Sensitivity to cost of storage	Base case	Case 2	Case 3	Case 4
Annual interest (%)	20	10	10	30
Storage cost (take per 100 kg)	27.6	27.6	13.8	27.6
Average storage (thousand tonnes)	57	141	181	27
% periods with storage	25.4	46.3	52.6	14.0
Price variability (C.V.)	12.9	11.4	10.7	13.9
Sensitivity to demand elasticity	Base case	Case 5	Case 6	
Demand elasticity	−0.5	−0.3	−0.7	
Average storage (thousand tonnes)	57	162	21	
% periods with storage	25.4	49.4	12.5	
Price variability with storage (C.V.)	12.9	19.1	9.6	
Price variability without storage (C.V.)	20.9	35.7	14.8	

[a] One season is 6 months.
[b] Constant elasticity demand curves are used, and the position of the curves is calibrated according to historical data on mean consumption and prices.
[c] A linear supply curve was used.

curve. The measured aggregate demand elasticity for rice in Bangladesh is around −0.5 (e.g. Goletti, 1993b; Ahmed and Shams, 1994) compared to, for example, the demand elasticity in Japan which is reported to be −0.05 (Agcaoili and Rosegrant, 1994). The relatively high elasticity is influenced by strong income effects and is more pronounced in the poorer groups of the population. For example, Goletti (1993a) estimated the price elasticity of the lowest income quartile to be −0.89, and for the highest income quartile demand elasticity was −0.3.

2.2. The incentive for private sector storage

Using the parameter assumptions outlined in Table 1, the rational expectations storage rule was estimated. The price distribution simulated from 10,000 periods using the estimated storage rule, farmers price expectations and a random yield sequence, is shown in Fig. 1. Also shown is the price distribution that would have been observed if all production had to be consumed in the period in which it was produced. Storage reduces the coefficient of variation of prices from 20.9 to 12.9%. It is less effective in reducing the probability of high prices than low prices

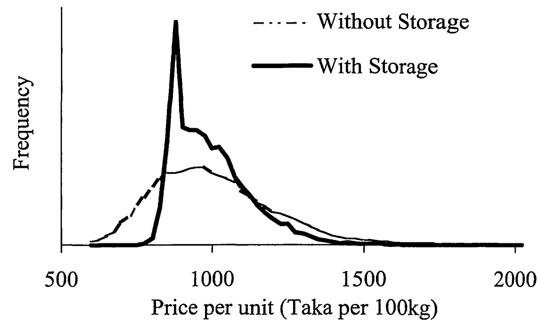

Fig. 1. Impact of private storage on market stability.

resulting in the skewed price distribution, characteristic of commodity prices (Deaton and Laroque, 1992).

Interest rates are and important factor affecting the cost of storage in a developing country because private traders can rarely get access to credit through formal channels. The effect of interest rates on the incentive to store is shown in Table 1. If traders were able to get credit at formal rates (10% per annum), strategic storage would occur in 46% of periods. However, since most traders rely on informal credit sector and pay double this rate, storage only occurs in 25% of periods. The mean level of storage is nearly three times as high at formal interest rates, and the coefficient of variation of prices is lower by 1.5% points. The impact of a relatively high interest rate (30% per annum) is a reduced incentive to store and more variable prices. The effect of both lower physical storage and interest rates on the incentive to store is also shown in Table 1. If the costs of storage were 50% lower than the base case, the increased incentive to store would reduce the coefficient of variation of prices by 2.2% points.

The effect of demand elasticity on the incentive to store is also illustrated. A more inelastic demand creates a greater incentive to store, because prices are lower in periods of oversupply and higher in periods of shortage. Increased storage under inelastic demand leads to higher consumption stability. Conversely, a more elastic demand lowers the incentive to store and means that the variability of consumption is relatively high.

It can be noted that the interest rates and demand elasticities relevant to Bangladesh are considerably different from the assumptions used in Williams and Wright's (1991) analysis. While they conducted extensive sensitivity analysis, they did not cover the combination of high interest rates and high demand elasticity shown in Table 1. In their analysis (Williams and Wright, 1991, Chapter 4), the typical commodity market had interest rates of 5% and demand elasticity of −0.2, and storage was predicted to occur in 80% of periods. When they examined the scenario of demand elasticity at −0.5, other costs were more conducive to storage, so the predicted pattern of storage was that it occurred in 57% of years. The combination of parameters relevant to the Bangladesh storage market highlights the low incentive for private sector storage in such markets.

3. Government intervention in storage

3.1. Price ceiling—buffer stock policy

Gilbert (1993) argues that concern over the impacts of high prices on consumers is a key motivation for public stabilisation schemes in developing countries. A price ceiling policy could be pursued by public sales from a buffer stock during periods of low market availability. However, the success of such a scheme would be affected by the quantity available for public sale during periods of short supply. There is a trade off between the cost of holding public stocks and the reliability of the price ceiling, which is quantified here.

The presence of government intervention in the market will affect price expectations. In the model presented here it is assumed that the government holds a fixed quantity of 'emergency' stocks and releases them onto the market whenever it is necessary to keep prices from rising above the ceiling. It is further assumed that they replenish these stocks as soon as possible in subsequent period(s) subject to the constraint that their buying activity does not raise prices above the ceiling. In the private sector, price expectations will be affected by the public intervention policy (buffer stock size and price ceiling) as well as the current level of government stocks. For example, the rational producer response is to increase plantings when government stocks are not full, because of anticipated public buying activity associated with stock replenishment. The inter-temporal arbitrage and producer planning rules for the model are:

$$P_t(h_t + S_t - S_{t+1} + G_t) + k \geq \frac{E_t\{P_{t+1}(S_{t+1}, B_{t+1})\}}{1+r}; \qquad S_t \geq 0 \tag{6}$$

$$h_t = f(P^f_{t-1}(S_t, B_t))y_t \tag{7}$$

$$P_t[h_t + S_t - S_{t+1} + G_t] \geq P^c; \qquad 0 \leq G_t \leq B^{\max} \tag{8}$$

$$P_t[h_t + S_t - S_{t+1} + G_t] \leq P^c; \quad B_t - B^{\max} \leq G_t \leq 0 \tag{9}$$

where B_t is government stocks carried out of period t, $B^{\max}$ the targeted buffer stock size, and G_t government sales (negative if purchases), $B_t - G_t = B_{t+1}$.

Table 2
Price variability and private sector storage under government stockholding

Buffer stock thousand tonnes	Average government stocks thousand tonnes	Average private stocks thousand tonnes	Price variability	
			C.V.	Price ($P > P^c$)
Price ceiling 1050 ($P > P^c$ in free market = 0.25)				
250	191	30	11.4	0.173
500	396	21	10	0.105
1000	839	18	8.6	0.035
Price ceiling 1120 ($P > P^c$ in free market = 0.16)				
250	219	43	11.6	0.084
500	450	37	10.8	0.044
1000	933	35	10.1	0.01

Eqs. (6) and (7) represent private storage and farmer behaviour, and are identical to Eqs. (1) and (2), except that price expectations now depend upon both private and government stocks. Eqs. (8) and (9) respectively define government selling and buying activity. These equations can be used to develop a stochastic dynamic programming solution to the storage rule. For each buffer stock policy or price ceiling level, a new private storage rule must be estimated, as the extent of government stockholding affects the probability of high prices, hence returns to storage.

Two price ceilings were investigated, representing prices 0.5 and 1 S.D. above mean prices (1050 and 1120 taka per 100 kg respectively). Three buffer stock sizes were examined. Average levels of government and private stocks (carryout) are shown in Table 2. Government stockholding results in lower private sector storage, because of the reduced profits in periods of low production, brought about by the price ceiling. Because there are some periods where government selling activity depletes public stocks, the average level of government stocks is less than the targeted buffer stock size. With lower government stock policy, the frequent occurrence of government stock-outs means that the price ceiling scheme is not very effective. For example, in the case of the lower price ceiling ($P^c = 1050$) which is exceed 25% of the time in a free market, price will be exceeded 17% of the time with a 0.25 million tonne buffer stock, while with a 1 million tonne buffer stock it is only exceeded 3.5% of the time. Clearly, governments placing a high value on maintaining a specified price ceiling would be inclined to hold larger stocks.

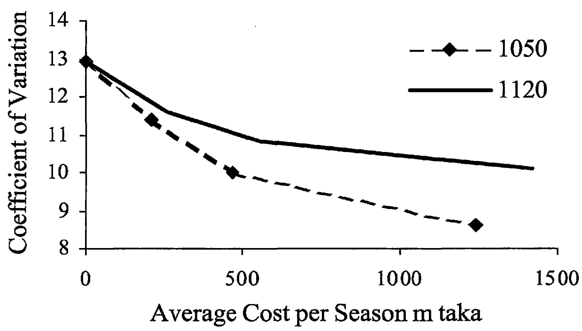

Fig. 2. Cost of reducing price variability under price ceiling policy, for two price ceilings (1050 and 1120 taka per 100 g).

Comparing between different price ceiling policies, several points can be made. For any given buffer stock size, a higher price ceiling will be less prone to failure. However, government participation in the market is less frequent, and the overall variability of prices, as measured by the coefficient of variation in prices, is higher. The fiscal costs[5] of the two price ceilings, for different stock holding policies, are compared in Fig. 2 against the coefficient of variation of prices for each policy. The cost of achieving a given coefficient of variation of prices is less for the lower price ceiling. The alternative measure of success, the reliability of the scheme in meeting its price ceiling, is

[5] In this section, costs are measured in terms of market (private sector) rates of interest and storage costs. In a later section, where the possibility of distortions to private sector incentives are explored, it is assumed that the cost of public stockholding is 50% lower than the private sector.

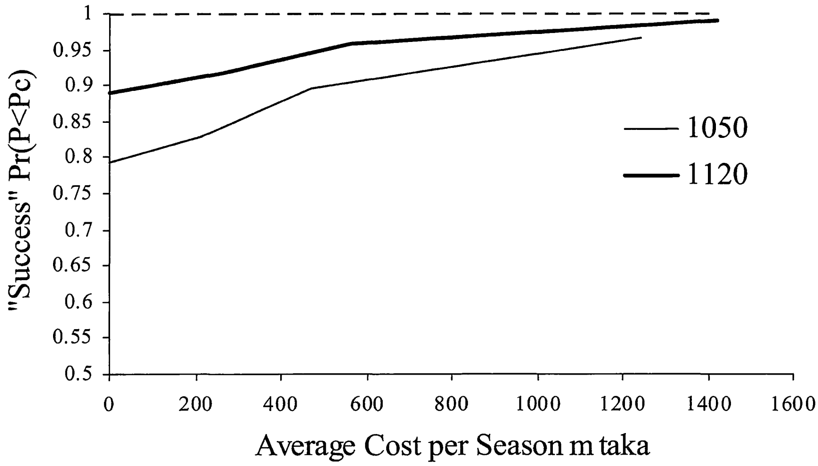

Fig. 3. The cost of achieving the price ceiling, for two different price ceilings (1050 and 1120 taka per 100 g).

compared against the cost of public stockholding in Fig. 3. It becomes increasingly costly to guarantee a price ceiling as the probability of success approaches 1. This is because large stocks have to be held to protect against extreme events such as a sequence of poor seasons.

3.2. Public subsidisation of private sector storage

The impact of private sector storage costs on the incentive for private storage was quantified in Table 1, where the existing market costs were compared with storage and interest costs that were 50% lower. The case for public intervention may be justified on the grounds that there are distorted incentives in the private sector, due to poorly developed infrastructure. Provision of better infrastructure/institutions in the private sector, or direct subsidies on storage or interest rates, could improve incentives for private sector storage. In Table 3, the average and maximum fiscal cost of subsidising private storage is compared with the cost of public stockholding. These results were calculated on the assumption that the cost of public storage was 50% lower than private sector storage for the buffer stock case, and that equivalent subsidies (50% of physical storage and interest costs) were offered to the private sector in the subsidy case. Thus, the resource costs of storage are the same in each scenario, and the difference in outcome is due to differences in storage strategies used by the public scheme and those adopted by the private sector.

A subsidisation policy that left the private sector responsible for storage would be a cheaper means of reducing the coefficient of variation of rice prices. For example, under the storage subsidy examine here, the coefficient of price variation is 10.8%, which is the same as the fifth price ceiling policy (1120 taka price ceiling and 0.5 million tonne stock). The average fiscal cost per season is 107 million taka for the storage subsidy, compared to 280 taka for the buffer stock scheme. The higher cost of the government storage scheme reflects the high cost of withholding stocks. While the government buffer stock scheme generates a net surplus by selling rice at high prices (at the ceiling) and replenishing stocks at lower prices in subsequent periods, it is not enough to compensate for the high physical and interest costs of the large stockpile. Another implication of the public storage scheme is the variability in the fiscal cost of the scheme. The average results shown here mask the large fiscal outlay that must be made when stocks are being replenished. In the 10,000 period simulation here, the maximum seasonal cost of operating the buffer stock scheme (which occurred when replenishing the buffer at relatively high prices) was 6940 million taka. In contrast, the maximum seasonal cost of the private storage scheme was 640 million. Clearly, subsidisation of private storage would provide a more robust scheme that could avoid the problems of fiscal fail-

Table 3
Costs of government intervention: comparison of storage subsidy with buffer stock

Impact on prices			Fiscal costs per season million taka	
	Probability that price is exceeded	C.V.	Average cost	Maximum cost
Subsidy on private sector storage and interest costs				
Probability that price > 1050	0.208	10.8	107	910
Probability that price > 1120	0.109			
Price ceiling 1050 (0.5 S.D. above mean)				
Buffer stock 250,000 tonnes	0.173	11.4	90	2783
Buffer stock 500,000 tonnes	0.105	10	220	5506
Buffer stock 1,000,000 tonnes	0.035	8.6	710	11040
Price ceiling 1120 (1 S.D. above mean)				
Buffer stock 250,000 tonnes	0.084	11.6	120	3470
Buffer stock 500,000 tonnes	0.044	10.8	280	6940
Buffer stock 1,000,000 tonnes	0.01	10.1	830	13690
Likelihood of sequence of high prices				
Price	No intervention	Subsidised	Small stock[a]	Large stock
Probability that price is greater than *P* once				
1120	0.16	0.109	0.096	0.022
1050	0.25	0.208	0.173	0.035
Probability that price is greater than *P* 2 years in succession				
1120	0.034	0.022	0.006	0.002
1050	0.1	0.079	0.021	0.011
Probability that price is greater than *P* 3 years in succession				
1120	0.01	0.007	0	0
1050	0.04	0.031	0	0

Free market prices: coefficient of variation 12.9.
[a] Small stock scenario is buffer stock 250,000 tonnes and a price ceiling of 1050. Large stock scenario is buffer stock 1,000,000 tonnes and a price ceiling of 1050.

ure that are so commonly observed in public storage schemes.

The impact on the probability distribution of prices differs between the buffer stock schemes and the alternative of subsidising the private sector. This is illustrated in Fig. 4. If the motivation for intervention is to reduce the probability of very high prices in order to protect poor urban consumers, then price ceiling schemes have a greater impact than subsidising private sector participation in the market. The impact on prices can also be examined in terms of the probability of a sequence of bad (high price) outcomes. These results are shown at the bottom of Table 3. The public storage schemes, which result in larger overall storage being held, have a greater likelihood of avoiding a sequence of high price outcomes.

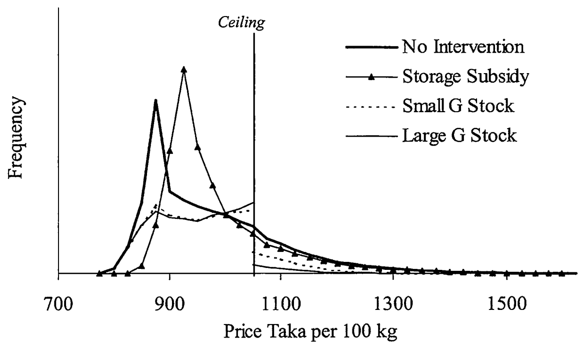

Fig. 4. Price probability distributions for different public storage policies.

3.3. Alternative subsidisation strategies

Gardner and Lopez (1996) suggest that subsidies on private sector storage should be focused on physical storage costs rather than interest costs, using an empirical example from the US soybean market. In the empirical example considered in this paper, the difference in costs between interest rate subsidies and physical storage cost subsidies is small. For example, compared to a complete subsidy on physical costs of storage, an interest rate subsidy of 14% would achieve the same level of price variability. The costs of subsidising the physical cost of storage is lower, but the difference is only 2% of average scheme costs.

4. Open economy

In the preceding analysis, the economy was assumed to be closed to trade. However, many developing countries are becoming increasingly liberal in their trade policies, and this has implications for price stability. While a full treatment of trade policies is beyond the scope of this paper,[6] it is useful to compare the impact of an open border policy on rice price stability, with the stability provided by closed-border public storage policies. These factors can be represented by a simple extension of the closed economy model that approximates trading opportunities. This was done by including a serially correlated world rice price, and a non-zero price elasticity with respect to Bangladesh trade. The state variables in this model were domestic storage and current world rice price:

$$P_t(h_t + S_{t-1} - S_t + I_t) + k \geq \frac{E_t(P_{t+1}[S_{t+1}, P_t^w])}{1+r} \quad (10)$$

$$h_t = f(P_{t-1}^f(S_t, P_t^w))y_t \quad (11)$$

$$|P_t[h_t + S_{t-1} + S_t + I_t] - P_t^w[I_t]| \leq T \quad (12)$$

$$P_t^w = \phi P_{t-1}^w + cI_t + \varepsilon \quad (13)$$

where P_t^w is current world price, ϕ the serial correlation of world price, I_t net imports, ε a disturbance term for world prices, c the impact of Bangladesh imports on world rice prices ($c > 0$) and T the cost of trade.

The error term on world price equation was chosen to give a coefficient of variation of world prices of 14%, based on border prices in Bangladesh in the 1980s and 1990s. Other assumptions were a serial correlation coefficient of 0.83 (Deaton and Laroque, 1992), a mean trade level of 0 for Bangladesh and 15 million tonnes for the rest of the world; trade costs of 100 taka per 100 kg; and no government intervention in domestic storage. Parameters on the trade equation were chosen to represent a world price elasticity, with respect to net imports to Bangladesh, of 0.1. This assumed low elasticity reflects the thin world rice market and has been used in other studies (Siamwalla and Haykin, 1983; Sarris and Freebairn, 1984).

The solution of the model is based on estimating the steady state rule for farmers and storers' price expectations. A joint probability distribution representing world price and local yield disturbances was used to calculate expected price outcomes, for pairs of values for carry-in storage and world prices and solving for temporal and spatial arbitrage conditions (Eqs (10)–(13)). After the steady state storage rule was found, a price series was simulated. The simulated probability distribution of prices is shown in Fig. 5 along with the closed economy price distribution. The shape

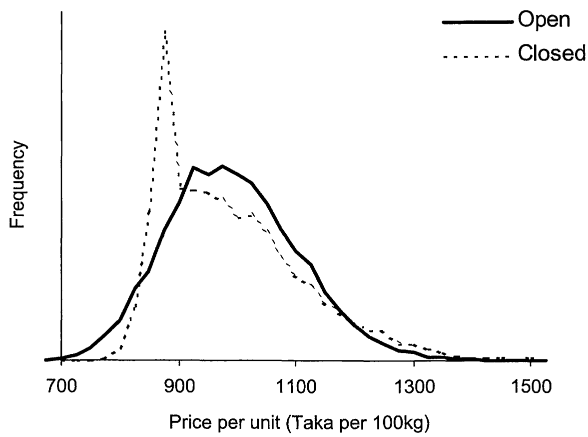

Fig. 5. Price variability in open economy compared to closed economy.

[6] Development of a dynamic model to represent both storage and trade in the world rice market would require state variables for private and government storage in each country. It would require that the government intervention policies in each country could be described by stable decision rules (such as Eqs. (8) and (9)). It would be impractical to solve a dynamic programming model with such a large number of state variables.

Table 4
Storage and trade

	Economy with no storage or trade	With private storage	
		Closed economy	Open economy
Average private storage (thousand tonnes)	0	56.8	15.8
Periods with storage (%)	0	25.4	12.2
Price variability (C.V.)	20.9	12.9	11.30

of the distribution is less skewed for the trade scenario, because trade is not subject to non-negativity constraints.

Results are also summarised in Table 4. The introduction of trade reduces the incentive to store. This is because the occurrence of low prices that occur during bumper crops is reduced (in other words, export competes with storage), and because occurrence of high prices when crops are poor is also reduced (so are returns from storage). However, because production in the rest of the world is not perfectly correlated with Bangladeshi production, world prices can be lower and higher than in Bangladesh at any point in time, and the effect of trade is to stretch the probability distribution of prices, compared to a closed economy, as seen in Fig. 5. When measured in terms of coefficient of variation, the level achieved is 11.4%, which is similar to the coefficient of variation achieved under the low volume buffer stock scheme (cases L1 and H1). In the case of the open economy, this is achieved with a zero fiscal cost, compared to an average cost of 90 (case L1) or 120 (case L1) million taka per season (Table 3) and a maximum seasonal cost of 2783 (case L1) or 3470 (case H1) million taka for the price ceiling/buffer stock policy.

5. Discussion and policy implications

The importance of private storage in stabilising commodity markets, and the crowding out effects of government stockholding, have been well illustrated by Williams and Wright (1991) and others (e.g. Turnovsky, 1978; Newbery and Stiglitz, 1981). However, these studies have tended to examine parameters relevant to the developed world. In the analysis presented in this paper, it is shown that the incentive for private sector storage in food markets in Bangladesh is very weak, because of the combination of high storage costs and relatively elastic demand.

The relevant question is whether or not there is any deviation between social values and the observed low incentives for private sector storage, in which case there might be reason to justify public intervention in the storage market. For example, the argument that private traders have poor access to credit, or face diseconomies of scale in storage could be applied. Another justification might be based on welfare grounds—simply that the relatively high price elasticity is a reflection of high budget shares for food (i.e. poverty). Some governments may be disinclined to rely on spatial arbitrage for food supplies because it implies reduced autonomy—in the event of trade wars or sanctions. At the international level, there is a general concern about food security in the even of extremely poor world harvests and agencies such as the United Nations Food and Agricultural Organisation concern themselves with monitoring stock behaviour.

The analysis conducted in this paper assist in highlighting the relative costs of government intervention in commodity storage. Unlike the price band and floor price schemes that were the subject of Williams and Wrights' (1991) analysis, this study examined a question that is of concern to developing country governments—"What size should the public food security stock be?" The analysis highlighted the relative costs and effectiveness of different size stocks, and compared results to an alternative scheme, of providing private traders' better access to credit.

The simulations make it possible to illustrate the effect of public policies on the extreme tails of the probability distributions. If a high priority is placed on preventing the extreme price peaks that are the characteristic of storable commodity markets, then public buffer stock schemes are a more effective policy than subsidising private storage. The cost curves derived here may be useful in educating policy makers about the nature of the trade off between the size of stock (and fiscal cost of the scheme) and the likelihood of not being able to keep prices below a ceiling target.

However, analysis of buffer stock policies aimed at improving food security should not be considered in isolation from other welfare policies aimed at protecting the poor from hikes in staple food prices. Targeted food rationing schemes have been proposed by numerous authors as an alternative to food price stabilisation (e.g. Newbery, 1989; Gilbert, 1993). Islam and Thomas (1994) highlight the administrative problems encountered in the operation of such schemes, because of difficulty in defining target groups and problems of leakage. However, it can be noted that a market consequence of a targeted food rationing scheme based on the purchase and distribution of rice to poorer sectors of the population would be a more inelastic market demand curve, which would in turn increase the incentive for private storage.

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