1. Introduction

In consonance with the global trend of redefining the role of the government in developing and transition economies from producer to facilitator, there is today a lively debate in India on government intervention in grain markets, in the form of procurement and distribution of foodgrain. The role of the government in *instituting regulated* wholesale grain markets, with clearly spelled out rules of exchange and a transparent price formation process, is however less well known, compared to its roles of procurer and distributor of grain[1]. The present paper studies such a regulated market for *parmal* paddy in the state of Haryana in North India,[2] with a view to address several objectives.[3]

First, we examine the *process* by which prices are determined in wholesale paddy markets. This has been ignored by most earlier studies of agricultural markets in developing countries, which have focused almost exclusively on market *outcomes*. In North India, grain sales take place through the *open ascending auction*, which is of overarching significance in characterizing the market. We estimate simple game theoretic models of auctions, under non-cooperative and collusive behavior, thereby explicitly modeling price formation. We document a form of collusion between two of the millers who operate in this market; such collusion probably exists in many small wholesale grain markets.[4] Our models enable us to quantify the downward impact of this collusion on market prices.

In addition to instituting regulated markets, the government directly intervenes in two ways: it is committed to providing *a minimum price support* (MSP) to farmers; furthermore, some states impose a levy on processed rice. Millers in Haryana are thus required to sell 75 percent of their output to the government at a pre-announced levy price. The analysis of government behavior as procurer of rice and provider of a price support to paddy farmers is our second objective. We document the 'weak' presence of the government in the paddy market, in which it is unable or unwilling to support its announced support price.

Our final objective is to address questions of government intervention in relation to the market under study. The first set of questions relates to the likely impact (on market prices, collusion and the quantum of government purchases) of a *credible* support price at current levels of intervention. The second set of questions relates to the impact of changing the *level* of government intervention—both the MSP on paddy and the levy on rice—again on market prices, collusion and the quantum of government purchases. Both sets of questions are counterfactuals, relating to unobserved states of the world.

These questions assume importance given the current debate generated by the increased government procurement of grain in the past several years, to the point that stocks exceeded 45 million tons of rice and wheat in 2001, 21 million tons of which was rice. At the same time, disbursement of these grains through the Public Distribution System (PDS), a system of subsidized retail food outlets, has not increased correspondingly; in particular, procurement of rice has exceeded disbursement since the mid 1990's. As the *Economic Survey* tabled in the Indian Parliament in 2001 noted

> "…on the one hand Government is faced with the problem of carrying large surplus stocks, on the other hand, the offtake of foodgrains….under the PDS has been low…on account of the narrowing differential between the PDS and open market prices….In recent years, the annual increases in MSP have been substantial….[and] much above the inflation rate. A serious re-thinking on the rationale of raising the minimum support prices…is called for." [p.94].

The simulation exercises conducted in this paper are motivated by these concerns. In particular, we show that given the structure of intervention, a lowering of the MSP *may not* have the desired effect on acquisition of stocks (although the costs of such acquisition will clearly be lower). This non-standard result is driven by the fact that the government ties the levy price to the minimum support price: the levy price is usually a mark-up over the MSP. A lower MSP would thus imply a lower levy price, which would in turn reduce private millers' profitability, and therefore their willingness to pay for paddy. Furthermore, we demonstrate that the levy percentage is a more powerful tool for aligning procurement with disbursement, one that has the added advantage of lending credibility to support operations.[5]

The literature on the impact of government intervention in grain markets dates back to years following the institution of the agency responsible for setting support and procurement prices, now called the Commission on Agricultural Costs and Prices, in the mid-1960's. A review of this and subsequent literature is beyond the scope of the present study; for reviews and important contributions see Balakrishnan and Ramaswami (2000); Schiff (1993), Krishnaji (1990), Hayami, Subbarao and Otsuka (1982), Raj Krishna and Raychaudhuri(1980), Dantwala (1996; 1967). Suffice it to note that this literature typically does not explicitly model decision making by private players (exceptions include Balakrishnan and Ramawami (2000) and Hayami, Subbarao and Otsuka (1982)). Rarer still are studies analyzing the interface between private players and the government through the market (in our case auction) institution, as we do in this paper. By estimating *structural auction models*, we not only capture the process of price formation in a small market, but are also able to analyze through simulation experiments the impact of government intervention under a variety of scenarios. These models also enable us to capture the link between the levy price and millers' willingness to pay for paddy. The rich insights offered by auction theory have thus far not been applied to the analysis of grain markets in developing countries.

The empirical auctions literature may be divided into two categories: papers that test econometrically the *implications* of auction theory (such as, contrasting the implications of non-cooperative versus collusive bidding behavior), referred to in the literature as testing the reduced form, (e.g., Hendricks and Porter (1988), Nelson (1995), Porter and Zona (1999)) and papers that estimate structural models (e.g., Baldwin, Marshall and Richard (1997), Laffont, Ossard and Vuong (1995), Hong and Shum (2000)). Laffont (1997) and Sareen (forthcoming) are two of several surveys of this literature. Our estimation belongs to the latter category.

The rest of the paper is arranged as follows. Section 2 describes the characteristics of the *parmal* market in Panipat in the state of Haryana, and provides details of the role of the government in paddy and rice procurement. Section 3 sets up the auctions models that we estimate. Sections 4 and 5 contain discussions of the data set and the results of the estimation, respectively. Section 6 addresses, through simulations, the questions of credible support prices and impact of reduction of levy. We conclude and discuss extensions in Section 7.

2. The Institutional Setting: the *Parmal* Market in Panipat

The market—or *mandi* as it is known locally—we focus on is a small (in terms of volume of transactions) regulated market situated in Panipat district, in the state of Haryana. In this market, *parmal* paddy is harvested and marketed primarily in the month of October.

The *parmal* paddy varieties are high-yielding, and have their genetic origins, in part, in the IR-8 varieties that were introduced in India from the Philippines at the start of the green revolution in the mid-1960's. Shorter in length and thicker in width than traditional varieties of paddy, the rice milled from *parmal* is among the cheapest available, and sells at up to one-fifth the price commanded by traditional varieties. Over the 1999 harvest season, *parmal* arrivals in the Panipat market totaled approximately 58,000 quintals.

2.1. The Auction Process

In a regulated market, grain brought by the farmer is displayed in lots in the market yard. The regulated market is overseen by a Market Committee, which appoints an auctioneer who formally conducts the auction. The auctioneer starts the process of auctioning a lot by announcing a starting price which he determines by reaching into the middle of a pile of grain, and inspecting a fistful for quality. Once assessed, it is rare for the lot to be unsold at this price. Because of the heterogeneity in quality of paddy and for other reasons described later in this paper, the starting price was usually *not* the minimum support price. Several players compete for the lot, and each makes independent assessments of quality by similarly examining the grain. Bidding proceeds as the auctioneer then begins to raise the price; as the price rises, bidders indicate that they have dropped out of the race by throwing down the fistful of grain that they drew out to examine. This process continues until all but one bidder have dropped out; this bidder wins the lot at the price last announced.[6] The auctioneer then proceeds to another lot and the process begins again.[7] The auctioneer receives 0.8 percent of the sale value of the lots sold; he thus has an incentive to raise the price as well.

2.2. The Players in the Market

As required by Market Committee regulations, farmers sell their grain through commission agents (who obtain a commission of 2 percent on the sale price). There is a large number of commission agents, each of whom is small in terms of market share.[8] In contrast, the buyers' side of the market is concentrated, with the top three millers in our sample[9] accounting for 40 percent of all purchases (details about the data are provided later in section 4). Among the three, two millers – whom we refer to as Indian Rice Mill and India International Rice, or IRM and IIR, respectively[10] – clearly had an arrangement wherein often one of them would be a big purchaser, and the other would purchase insignificant amounts, on any given day. This pattern is extremely stark on about half the days in the season. Table 1 gives an indication.

Table 1

Market shares of IIR and IRM on selected days

	IIR's share(%)	IRM's share (%)
Oct. 9	0	41
Oct. 14	16	0
Oct. 19	3	44
Oct. 21	1	26
Oct. 26	26	0
Oct. 27	26	2

This is strong and direct evidence of bid rotation amongst these millers. Indeed, one of the two millers told us that they did collude, although he did not specify the form of collusion. Section 5 contains further, statistical evidence of bid rotation in our sample, and its downward impact on prices.

2.3. The Government[11] in Panipat

The minimum support price (MSP) proposed by the Commission on Agricultural Costs and Prices for the kharif (monsoon) season of 1999 was Rs. 495 per quintal for "Grade A" varieties of paddy; the price actually implemented by the central government (which is prone to making concessions to farmers' lobbies) was Rs. 520 per quintal.[12] In principle, the government (through its procuring agencies) is bound to purchase grain at the MSP if the going market price is below it, and if the grain meets prescribed minimum quality norms.[13]

As noted earlier, in addition to support operations, the government also imposes a levy on milled rice. In 1999, millers were required to 'pay' a levy corresponding to three-fourths of milled output, for which they were paid Rs. 913.30 per quintal of rice. This levy price is determined on the basis of the minimum support price, with allowance for processing costs, and a margin of profit for the miller. Two state agencies, HAFED and Haryana Agro, operate in Panipat on alternate days of the week.[14]

The expectation that the government would procure grain at the announced MSP had a salutary impact on prices, with government entry into the market resulting in a one-time jump of Rs.10 per quintal.[15] As it transpired, the government did *not* actively participate in the market: it picked up only 7.1 percent of the lots. Indeed, in our sample, two-thirds of the lots sold at less than the MSP of Rs. 520 per quintal. The ostensible reason for the government agencies not enforcing the MSP was that the lots contained too much moisture and did not meet the prescribed quality norm. We show in Section 6 that this was *not* the entire explanation. The excess stocks with the government, as a result of poor management of flows, meant that it was simply unable to support its own announced support price in this state. The accumulation of stocks in Haryana is more on account of levy rice, rather than paddy bought under support operations. This unsupportability of the support price, and whether the MSP itself was too high in that private millers were generally not willing to pay so much, are questions we investigate through our simulations in Section 6.[16]

3. The Models

To analyse these and related questions, we formulate simple models of open, ascending auctions. Although many lots of *parmal* are auctioned each day, they are extremely heterogeneous in quality. On any given day, we rarely observe several lots of identical quality being sold. Therefore we may use the theory of auctions of a *single* object as a framework for analysis.[17]

Suppose a single lot is to be auctioned, and there are p potential buyers for this good. We employ the "independent private values" (IPV) assumption: i.e., (a) the *valuation* v_i (or *willingness to pay* for the lot) of bidder i, is privately known to the bidder; (b) the bidders' valuations $v_1,\ldots,v_p$ are drawn independently from some underlying distribution or distributions that are common knowledge. We assume that all the valuations are drawn from the same distribution F.

Besides the simplicity that the IPV assumption lends to the ensuing analysis, its other virtue is its reasonableness in our context. The valuation of a bidder depends upon the difference between the price he receives for selling rice and the cost of processing paddy[18]. 75% of the rice is sold to the government at a levy price that is known at the time of paddy purchase; the rest of the rice is sold on the open market all over the country. Open market (retail and wholesale) prices of rice vary substantially across the country and by grade[19]. The processing cost of paddy, however, is mill-specific (as evidenced by the wide variation in the *conversion factor*[20]) and privately known, and lends support to an IPV, rather than a common-values, specification.

It is well known that for ascending auctions in the IPV setting (see for example Klemperer (1999)), in Bayesian equilibrium a player's bid (or price at which he quits the auction) equals his valuation. The winning bid or sale price is therefore equal to the second highest valuation out of $(v_1,..., v_p)$. If we assume that the bidders' strategies in our data set are not dynamic but lot-specific as in the above description, it then follows that the winning prices are realizations of the second (i.e., second-highest) order statistic. Since we observe, for any given lot, the *starting price s* (the first price announced by the auctioneer), and the number of bidders *n* that are subsequently involved in the bidding, this number *n* corresponds to those bidders whose valuations are greater than *s*. We therefore compute the distribution of the second order statistic by assuming that a random sample of size *n* is drawn from the underlying distribution *F* of valuations, where *F* is *truncated* at *s*. The distribution $F_2(v\,|\,s,n)$ of the second order statistic of this random sample is given by

$$F_2(v \mid s, n) = (n\,[1 - F(v)]\,[F(v) - F(s)]^{n-1} + [F(v) - F(s)]^{n})\,(1 - F(s))^{-n} \qquad (1)$$

The corresponding density $f_2(v\,|\,s,n)$ is given by

$$f_2(v\,|\,s,n) = n\,(n-1)\,[1-F(v)]\,f(v)[F(v)-F(s)]^{n-2}[1-F(s)]^{-n} \qquad (2)$$

To complete the setup, we must consider two additional factors: the behavior of the government as a bidder, and the role of bid rotation between IRM and IIR. Whenever the government bids, it is committed to bid exactly the MSP (which is Rs.520 in our data set). Thus when a lot sells for less than the MSP, the government is clearly not a bidder. When a lot sells for a price greater than the MSP, the government may be a bidder, but the second highest valuation (which equals the win price) exceeds the MSP. For the subset of the data in which the win price is less than or greater than the MSP, therefore, this win price can be taken to be a realization of the second order statistic whose density is given by Eq. (2) (so *n* can be seen to represent the number of *private* bidders whose valuations exceed the starting price *s*). On the other hand, if a lot sells to the government at the MSP, it must be that the (*n* – 1) other bidders at the auction have valuations that are less than the MSP. Thus the winprice of 520 is a realization of the *first* (highest) order statistic, whose distribution and corresponding density are respectively

$$F_1(520 \mid s, n-1) = [F(v) - F(s)]^{n-1}[1 - F(s)]^{-(n-1)} \quad (3)\text{, and}$$

$$f_1(520 \mid s, n-1) = (n-1)[F(v) - F(s)]^{n-2} f(v)[1 - F(s)]^{-(n-1)} \quad (4)$$

Our sample is thus partitioned into two: those lots which sold at Rs. 520 and those that did not. We use Eq.(2) for lots which sell at prices other than the MSP, and Eq.(4) for those which sell to the government at the MSP, for our likelihood specification. For empirical implementation, we make the oft-used assumption that *F* is lognormal. For a given lot i, its mean equals $z_i\beta$, where β is a vector of parameters and z_i is a vector of lot-specific distribution shifters. β and σ^2 (the variance of *F*) are estimated by the method of maximum likelihood.

Bid rotation between IRM and IIR in our data set results in only one of these two players being present on some days; on days when both are present, they often end up picking up quite asymmetric shares of the market. We make the reasonable assumption that on both types of days, non-cooperative play would imply that on most of the lots sold, we would observe one additional bidder, as *both* these players would then participate in the bidding at each lot (unlike the observed rotation of bidding that they employ). To choose between the hypotheses of bid rotation and non-cooperative behavior, we use the likelihood specification described above for the bid-rotation scenario. For the likelihood specification in the non-cooperative scenario, we add one to the number of bidders observed at each lot.

It is natural to ask why bid rotation does not involve all bidders, or at least a larger coalition of bidders; in this paper however, we model directly the *observed* bid rotation between IIR and IRM. We do not attempt to explain how they benefit from bid rotation. Clearly, the rotation lowers their winprices -- if it does not at the same time disturb their market shares too much, relative to non-cooperative behavior, they benefit. Obtaining this benefit may entail enforcing bid rotation via the threat of punishment (e.g., by reverting to non-cooperative behavior) if one of the players fails to rotate the bidding.[21] The pattern that is observed could also be justified by tacit coordination between large players who buy in, and coordinate their bidding across, several *mandis*.[22] Interviews with owners of IIR and IRM reveal that they operate in several *mandis*, making it likely that they do indeed coordinate bid-rotation across *mandi*s as well.

4. The Data

Parmal paddy arrives at the Panipat market primarily in the month of October. We conducted our own primary survey in October 1999, and supplemented this database with information from market committee records[23], and personal interviews. We tracked a random sample of *parmal* auctions on six days in October (totaling 305 auctions), with a team of two investigators; one noted the starting price, winning price, number of bidders and the name of the winner of each lot, while the other noted down particulars of quality.

Prior interviews with market committee and Food Corporation of India (the procurement arm of the central government) officials, buyers and agricultural scientists indicated that the following quality characteristics influence paddy prices: moisture content, uniformity in grain size, the presence of chaff, grain lustre, the presence of green and immature grain (indicative of a premature harvest), the percentage of broken grains, and a category of 'other' variables (such as fungal disease, pest infestation etc.). Through pre-testing, we determined a consistent pattern of evaluating some of these on a scale of 1 to 3 (worst to best quality), and some others on a scale of 1 to 2 ('poor' and 'good').[24] These constitute the major variables in z in Section 5.1 below.

5. Collusion and Price Formation in Panipat

5.1 Testing for the Presence of Bid-Rotation:

To test whether *parmal* paddy sales are, in fact, characterized by a collusive arrangement, we estimate the following two models:

Under non-cooperative behaviour, the winprice of lot *i*, $x_i \sim f_2(.|s,n)$ as defined in Eq.(2) above, whenever the winning price different from the MSP; and $x_i \sim f_1(520|s,n-1)$ as defined in Eq.(4) above whenever the government purchases the grain.

If there were bid rotation, then we would expect $x_i \sim f_2(.|s,n-1)$ whenever the winning price different from the MSP, and $x_i \sim f_1(520|s,n-2)$ whenever the government purchased the grain. As is common in the literature, we assume that $f(.)$ is lognormal with mean $z_i\beta$ and variance σ^2.

z_i is a lot-specific vector of distribution shifters, including:

Seven quality variables:

- Moisture content of the lot
- Uniformity of grain
- Presence of chaff
- Presence of brokens
- Grain lustre
- Presence of green and immature grain
- Other factors (such as disease)

Previous day's arrivals

Dummy variables for three of the four weeks in our sample

Maximum likelihood estimates of β, under both non-cooperative and collusive behaviour are set out in Table 2.

Table 2

Maximum Likelihood Estimation of Non-cooperative and Collusive Models

	Non cooperative Model		**Collusive Model**	
	Parameter estimate	**Standard Error**	**Parameter estimate**	**Standard error**
Moisture content	0.018	0.008	0.019	0.008
Uniformity of grain	0.014	0.009	0.014	0.009
Presence of chaff	-0.021	0.009	-0.017	0.009
Presence of brokens	0.001	0.011	0.001	0.011
Lusture of grain	0.019	0.011	0.019	0.010
Green & Immature grain	-0.003	0.014	-0.002	0.013
Other	0.002	0.010	Neg	Neg
Previous day's arrivals	-0.00004	0.00001	-0.00004	0.00001
Week 2 dummy	-0.016	0.013	-0.017	0.013
Week 3 dummy	-0.138	0.029	-0.127	0.028
Week 4 dummy	-0.088	0.044	-0.110	0.044
Constant	6.193	0.046	6.203	0.046
Residual sum of squares	4.89		2.84	

In both models, apart from moisture, most of the other quality variables have high standard errors, indicating that it is in fact moisture that is the most important determinant of *parmal* price. In the non-cooperative model, we observe one perverse sign associated with the presence of chaff in the grain. However, as expected, the quantum of arrivals on the previous day also significantly influences valuations, and two of the three weekly dummies are also significant.

To compare the two models, we compute the residual sum of squares, which is much smaller in the collusive than in the non-cooperative model.[25] Thus, the bid-rotation scheme outlined in section 3 above would appear to characterize purchasing behavior in the *parmal* market in Panipat.

5.2. The Impact of Collusion on Market Prices

The obvious way to assess the extent to which bid-rotation depresses market prices is to examine the impact of an additional bidder on the winning price. Table 3 reports the results of such a simulation exercise. In determining $z\beta$ for the simulation, the quality of lots is taken to be slightly better than average for six of the indicators; but with ideal moisture content. Also, $z\beta$ is evaluated setting the dummies for weeks 2 and 4 equal to zero. The variables z are evaluated at the parameter (β) vector corresponding to the collusive model. Given that the government did not, in effect, support the MSP, the simulation does not include the government as a bidder. The number of potential bidders varies from four to ten, which we believe adequately captures the range of potential bidders in the market on any given day (this is approximately the range in the total number of winners per day). Clearly, the impact of the observed bid rotation lessens as the total number of bidders increases. With only four potential bidders, the average win price is Rs. 7 per quintal less (approximately one-and-half percent less) than if there are five bidders. When the total number of bidders is as large as 9, the impact of an additional bidder on the winning price is much smaller, at Rs. 2.

Table 3

Predicted winning price for average quality lots with low moisture in the absence of the government (1000 simulations each)

Number of bidders	Simulated Winning Price	Number of bidders	Simulated Winning Price
4	484	8	501
5	492	9	505
6	496	10	507
7	498		

6. The Impact of Government Intervention.

6.1. Would a credible government presence mitigate the effects of bid rotation?

Simulation experiments along the lines outlined above, except with the inclusion of a government bidder with a valuation of Rs. 520, suggest that there would have been no adverse effect of bid rotation on market prices. Since most of the winprices in the absence of government were below the MSP, a credible support price would result in their getting picked up at 520. Thus the prevailing average price would have been approximately Rs. 520. The addition of a bidder adds no more than 20 paise to the winning price. This is illustrated in Table 4 below.

Table 4

Predicted winning price for average quality lots with low moisture with credible government presence (1000 simulations each)

Number of bidders	Simulated Winning Price	Number of bidders	Simulated Winning Price
4	520.30	8	520.80
5	520.50	9	521.50
6	520.70	10	521.70
7	520.80		

6.2. What would be the Implications for Stock Accumulation of a Credible MSP?

As noted earlier, one explanation offered for the government playing a minimal role in this market was that the quality of lots available in the market did not meet government stipulated standards. Of these, the most critical, both in terms of ease of storage, and processing is moisture content. It is true that the quality of lots bought by the government tended to be superior to that bought by other players, as indicated below:

Table 5

Percentage of lots with the best quality bought by the government and others

	Government	Other buyers
Moisture	48	40
Uniformity	57	47
Chaff	17	20
Brokens	70	47
Lustre	82	60
Green and Immature grain	17	17
Other factors	39	37

However, this is not the entire explanation. Many of the lots that came to the market early in the season did, indeed, have high moisture content. It was not uncommon for a sale price to be agreed upon on the condition that the grain would be dried before being bagged and sent to the purchaser. The problem of high moisture eased considerably over time—but the government did not respond correspondingly. Thus the average quality of lots that sold at between Rs. 500 and 520 per quintal in our sample *was no different* from those that sold at the MSP of Rs. 520.

Farmers were of course aware of the level of the MSP and irritated at what they considered as being given short shrift. Around mid-season, this simmering discontent was transmuted into a ‘march’ into the mandi led by a local politician from the opposition who had lost the election. After a great to-do, and badgering of the market officials and the government agencies, the politician and his group trouped out the way they had come. Although the spectacle value of this visit was substantial (especially for us) the impact on prices or government purchase decisions was non-existent.

In order to assess what government procurement would have been if it had supported its MSP, we simulate the percentage of lots that would sell for less than Rs. 520, given that the lots meet the government’s quality standards (particularly of low moisture). This underlies our formulation of $z\beta$ noted above. In particular, we draw a random sample of size n (where n ranges from 4 to 10) from a log normal distribution with mean $z\beta$ and variance ^{2}. If the second-highest of these draws is greater than Rs. 520, then the buyer is a private miller. If on the other hand, the highest draw is less than Rs. 520, then the lot is bought by the government. We repeat this exercise 1000 times for each n, and compute the percentage share of the government. The results of this simulation exercise, set out in Table 6, suggest that the government should have procured between 45 and 75 percent of the better quality grain.

Table 6

Percentage of lots with ideal moisture and average quality that the government would have bought (for which the maximum of *n* draws from *F* was below Rs. 520)

Number of bidders	Simulated Percentage of Lots bought by The government	Number of bidders	Simulated Percentage of Lots bought by The government
4	76	8	55
5	70	9	51
6	61	10	45
7	60		

Approximately 40 percent of our sample had ideal moisture content; thus, with an MSP of Rs. 520 per quintal, the government should have procured between 18 and 30 percent of the Panipat *parmal* market. Instead, it's actual share was seven percent. The net impact on government accumulation of stocks would have been less, however, owing to less grain going to private millers, resulting in lower procurement of levy rice.

6.3. Would a Lower MSP be More Realistic?

The wide discrepancy between realized market prices (of Rs. 498) and the MSP may be taken as an indication that the MSP was "too high" as is implicit in the *Economic Survey* cited above. Would a lower MSP—such as that recommended by the CACP (of Rs. 495 per quintal)—be more 'reasonable' in the sense that its purchase commitments would have been far lower, thereby enabling it to maintain a credible presence in the market? We simulate this outcome by considering as before a set of *n* draws from a log normal distribution. The mean of this distribution is however, lower because the lower MSP also translates into a lower levy price. We then follow the same procedure as above, except that a Rs. 495 rather than Rs. 520 cut-off is used for government intervention. These simulation experiments suggest that the impact on government purchases is not significant.

As Table 7 indicates, with an MSP of Rs. 495, the government agencies would have to procure between 41 and 70 percent of this quality of grain, depending on the number of bidders. Given the distribution of quality, this would have translated into between 16 and 28 percent of the market; figures which are not very different from the Rs. 520 scenario.

Table 7

Percentage of lots with ideal moisture and average quality that the government would have bought (for which the maximum of *n* draws from *F* was below Rs. 495)

Number of bidders	Percentage of lots bought by the government	Number of bidders	Percentage of lots bought by the government
4	70	8	52
5	66	9	47
6	59	10	41
7	57		

This apparently unexpected result has a fairly simple explanation. A lowering of the MSP also has the effect of lowering the levy price, and hence the mean of the distribution from which millers draw their valuations. This effect is particularly strong, given that the levy percentage on milled rice is as high as 75 percent. Given unchanged open market prices—a reasonable assumption given that world prices of rice were higher than Indian prices that year, and that some exports of *parmal* rice did take place in 1999—a Rs. 25 decrease in the MSP translates into a corresponding Rs. 21.56 decrease in the mean of *F*.[26] Therefore with lower valuations on the part of private millers, the market share of the private millers is correspondingly less.

6.4. What would be the Impact of a Decrease in the Government Levy Percentage?

Since the relationship between changes in the MSP and the change in the mean of the valuations is determined in large measure by the levy percentage, it is useful to consider the impact of reducing the levy percentage by, say, 25 percent, while maintaining the MSP at Rs. 520. We consider two polar scenarios as far as the impact on the open market price is concerned: (a) that the impact of the reduction in levy will not be felt on open market prices. This may be justified on several grounds: for instance, prices in several markets some distance from Panipat did exceed Rs. 1000 by margins that were probably more than sufficient to cover transportation costs. Also, prices of similar grades of rice were higher in the international market, so that the option of exports could have been exercised. Further, if the reduction in levy is passed on as a lower allocation to the public distribution system, some consumers would have to 'switchover' to the open market thus exerting upward pressure on prices. In this case, a reduction in the levy percentage would imply that millers are able to sell a higher (non-levy) percentage of their output at a higher price than was previously the case. In fact, *the mean valuation would increase by approximately Rs. 14.*[27]

(b) that the resulting increase in supply available on the open market would reduce open market prices. A recent CGE simulation exercise which assumes no grain exports (Storm, 1992) suggests that a 20 percent decline in procurement would result in a 6 percent decrease in the open market price (if there were no corresponding decrease in the amount distributed through the fair price shops). We consider here a decrease in open market price to the level of the levy price.[28] In this case, even though a lower proportion of output is being sold to the government at the levy price, the remaining output is being sold on the open market at a lower price than what prevailed before. Thus, *the mean of the valuations would decrease by approximately Rs. 14.50*.[29]

The implications for government under the two scenarios are set out in Table 8

Table 8

Percentage of lots with average quality and ideal moisture content that the government would buy in case the levy percentage was reduced from 75 to 50% (while maintaining an MSP of Rs. 520) and as a result (a) there were no change in open market price ; and (b) the open market price were to decline to the levy price.

No change in open market price		Open market price declines to levy price	
Number of bidders	% lots	Number of bidders	% lots
4	50	4	89
5	43	5	88
6	34	6	84
7	26	7	82
8	23	8	80
9	19	9	77
10	16	10	76

Not surprisingly, the implications for government intervention are dramatically different depending on whether the miller's gross margin per quintal of paddy increases as in case (a) or decreases, as in case (b). It is instructive to compare these simulation results with those outlined in Table 6, where the government implemented an MSP of Rs. 520 with a levy of 75 percent. In case (a) where open market prices were unaffected, government would need to intervene only in 16 to 50 percent of the lots offered for sale. Overall, the government would procure much less with a lower levy percentage than with attempting to support an MSP of Rs. 520 per quintal—*both* because of the lower levy percentage, *and* the lesser need to intervene to support the price of Rs. 520. The key to 'killing two birds with one stone' is that decreasing the levy also increases millers' valuations for paddy, as they get to sell more on the more lucrative open market.

In the second scenario (with a lowering of open market prices), the government would have to procure a much greater share of the lots meeting the quality norms than was the case with simply supporting an MSP of Rs. 520 with a levy of 75 percent. However, it is important to note that the increase in *paddy* procurement implied by the lower levy is more than offset by the decreased acquisition of levy *rice*, especially in smaller markets such as Panipat, where the number of bidders are typically few. For instance, with five bidders, the government would with a 50 percent levy have to procure 88% (Table 8) instead of 70% (Table 6) with a 75 percent levy of the paddy; a difference of 18 percent which is less than the decrease in levy of 25 percent. When the fact that not all the grain coming into the market is of acceptable quality is factored in, these differences would be much greater.

7. Conclusions

This paper sets out a methodology hitherto unused in studying grain markets in developing countries. Explicit modeling of the auction process aids in understanding better the behavior both of private agents and their interaction with the government. Moreover, working with *structural* auction models helps in addressing questions relating to alternative government policies, as they may be used to simulate alternative states of the world.

The Panipat market, perhaps like many other small wholesale grain markets in India, is characterized by collusive behavior. The downward impact of collusion on market prices is limited to less than two percent of average market price; in itself a testimony to the effectiveness of regulated markets. In fact, a question that we haven’t addressed, but one worthy of exploration, is the role of the auctioneer in ensuring this outcome through judicious choice of starting prices.

We demonstrate that the reason that the average market price was lower than the MSP had less to do with the poor quality of grain, and much more to do with the unwillingness of the government to support its announced MSP. Had the government been a credible presence in the market, it would have procured at least one-fifth of the arrivals, assuming that a conservative 40% of the grain was of acceptable quality.

Assuming that this unwillingness of the government stems from excess stock accumulation, we experiment with alternative MSP and levy policies. We find that changing the MSP alone will not solve the problem of excess accumulation, as long as there is a one-to-one relationship between the MSP and the levy price. This is not to argue against the reduction of the MSP, only to highlight its ineffectiveness in managing stocks. However, a supportable MSP is not inconsistent with effective management of flows, provided levy percentages are decreased. Moreover, if open market prices do not decrease appreciably, this route leads to a win-win situation: millers earn higher gross margins and farmers sell at higher wholesale paddy prices.

Appendix A

The distribution F_2 of second order statistic (the second-highest) of n draws from a cumulative distribution function F and a corresponding probability density function f is given by (see, for example, David (1981), p.8):

$$F_2(v \mid n) = n[1 - F(v][F(v)]^{n-1} + [F(v)]^n$$

When truncated on the left at s, the expression becomes equation (1) on p. 8.

The likelihood function under collusive behaviour and log-normality is given by:

$$\prod_{i \in A} n(n-1)[1-\Phi(y)]\phi(y)[\Phi(y)-\Phi(s)]^{n-2}[1-\Phi(s)]^{-n} \prod_{i \in B}(n-1)[\Phi(y)-\Phi(s)]^{n-2}\phi(y)[1-\Phi(s)]^{-(n-1)}$$

where ϕ and Φ refer to the pdf and cdf, respectively, of the standard normal variate; *y = [ln(v)-z]/ ;* set A refers to the lots that sold at prices other than Rs. 520; and set B to those that sold at Rs. 520. We drop the subscript i on y, n and s for notational convenience.

The likelihood function under non-cooperative behaviour is obtained by replacing n with $n+1$ in the expression above.

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[1] Regulated markets, set up under the Market Regulation Act, are run by market regulatory committees. The functions of a market committee include: maintaining the physical infrastructure of the market place; supervise weighment; settle disputes; appoint auctioneers; provide transparency to the price formation process; maintain market records (on arrivals and auction prices), and to ensure that no unauthorized costs are passed on to the farmer.

[2] 'Paddy' refers to the harvested grain whereas 'rice' refers to the milled grain. See Section 2 for a description of *parmal* paddy.

[3] This paper is part of a larger study on price formation, foodgrain marketing and the role of the state in Northern India.

[4] See, for example, Palaskas and Harriss-White (1997) for evidence of collusion in markets in West Bengal.

[5] This paper focuses exclusively on the interactions between private players and the government at the wholesale market. We do not consider behavior at the retail level--including the Public Distribution System.

[6] There is a caveat to this: the farmer has the right to opt out of the transaction if the final price is not satisfactory for any reason (although such incidents are rare). In principle, therefore, the auctioneer's starting price is not the same as the farmer's reservation price. The auctions proceed too quickly for the auctioneer to take time to determine the farmer's reservation price at each lot.

[7] Most lots are approximately equal in size (weight), and it is rare for multiple lots to be sold in any auction.

[8] There were 49 such commission agents in Panipat. Each handled approximately the same quantity of *parmal* sales.

[9] There were 25 distinct purchasers of *parmal* paddy apart from two government agencies. The market was dominated by seven buyers, nearly all of whom were local millers. These seven accounted for over 75 percent of the lots sold in our sample. The smaller purchasers typically participated only in some of the auctions, the modal number of actual bidders in any auction was three. The sample records seven days of auctions (totaling 320 lots). In all, auction of *parmal* paddy occurred on 38 days between October 1 and November 11, 1999.

[10] The names of all private players have been changed in order to protect their identities.

[11] For the purposes of this paper, no distinction between Central and State Government operations is made.

[12] In its report, the Commission did leave open the possibility that the central government announce a higher price than that recommended, but suggested that any increase be limited to Rs. 25, and that it only be applicable to those states which charged farmers at least 50p per kw/hr. for electricity.

[13] The critical determinant of quality for *parmal* paddy is moisture content.

[14] These two state agencies are required to purchase grain for the state-owned mills, or to enforce the MSP. In effect however, the massive excess stocks with the government meant that only support operations were relevant.

[15] The government agents appeared at the market a week into the season. As a result, as the following regression indicates, there was a one-time jump of Rs. 10 per quintal in the average daily prices of *parmal* paddy. In addition, prices trended upward mildly, to the extent of Rs. 1 per day throughout the marketing period:

$$\underset{\text{(t-ratio)}}{\text{Average daily price}} = 471.97 + \underset{(7.23)}{1.08\ \text{trend}} + \underset{(2.06)}{10.23\ \text{Government}}$$

where Government is a dummy variable with a value of 1 for days after 7th October 1999; and the trend variable ranges from 1 to 38 (the total number of marketing days is 38).

[16] There are, of course, issues relating to the political economy of grain markets. For instance, while the MSP is apparently unsupportable in Haryana, it is supported in Punjab. The available literature (for example, Sukhatme and Abler) tends to treat both states on equal footing. The evidence in this paper suggests that this may be inappropriate; however this is beyond the scope of this paper.

[17] Recent work on sequential, *multi-unit* auctions (Donald, Paarsch and Robert (1997)) assumes homogeneity of objects. The principal difference vis-à-vis single-object auctions is that players' bids may not be equal to their valuations; multiple perfect-Bayesian equilibria exist, and empirical implementation must exclude all but one of them. There is little by way of theoretical and empirical work in this dynamic setting for heterogeneous objects; this is an area of future research.

[18] Most of the bidders in our market are millers, and resale of unprocessed grain is seldom considered; such resale, if significant, could add a common-value component to the valuation.

[19] To the extent that the markets a miller sells to are privately known, this is an IPV component.

[20] The conversion factor (the ratio of rice output from 1 kg of paddy) for *parmal* varies from 50 to 70 percent, depending on the vintage of the various processing units of the mill, quality of the paddy, and whether the final output is parboiled rice, or raw rice.

[21] See Skrzypacz and Hopenhayn (1999) for a theoretical discussion of this and other collusive schemes.

[22] See Sareen (2001) for a discussion of tacit coordination at timber auctions in Ontario.

[23] A market committee official records the following details of each sale: the name of the farmer and of the commission agent representing him, the winning bid (in Rs./quintal), the name of the winner, and the approximate quantity of the lot. Thus information on the quantum of daily arrivals can also be obtained by aggregation. The records do not distinguish between varieties, and do not record any explicit 'quality variables' or the auctioneer's starting price. We can cull variety specific information from these records by noting the different harvesting and marketing periods, and distinct price bands of each variety. We determine price bands for *parmal* from our sample data and the trend in prices over the season. Thus we construct our 'population', which has over 3000 transactions of *parmal* in Panipat.

[24] The pairwise correlations of the quality variables in our sample turned out to be low. Note also that ideal moisture content is not too high nor too low; both extremes affect milling ratios, the latter because it tends to make the grain brittle.

[25] Note that a direct comparison of log likelihood values is not possible as the likelihood function for the collusive model will always be higher than for the non-cooperative one, given $z\beta$.

[26] The gross return on a quintal of paddy earned by millers given a levy 75%, a levy price of Rs. 913.30, an open market price of Rs. 1000 per quintal, and a paddy-milled rice conversion factor is simply 0.67*[(0.75)(913.30 + (0.25)(1000)]. The decline in levy price given a Rs. 25 decline in the MSP is (25)(1.5)(1.15) where 1.5 is the inverse of paddy-rice milling conversion factor, and 1.15 represents market fees and other taxes. The gross return on a quintal of paddy and therefore the mean of the valuations would decline by (0.75)*(1.15)*25. We abstract from possible scale effects in processing, in all our simulations.

[27] This is the difference between 0.67[(0.75)(913.30) + (0.25)(1000)] and 0.67[(0.50)(913.30) + (0.5)(1000)].

[28] An open market price below the levy price is clearly perverse, even though this has occurred in the past. The government could then purchase on the open market at lower cost; moreover, an issue price above the levy price would also imply zero offtake from the public distribution system.

[29] This is the difference between 0.67[(0.75)(913.30) + (0.25)(1000)] and 0.67*913.30.