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Forecasting Errors in the Absence of a Futures Market: The Seasonal Allocation of Wheat Supplies in India

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Abstract

Agricultural policy in developing countries is strongly shaped by views about speculation in the foodgrain markets. The central issue is whether speculative expectations are rational. Yet, data availability and the absence of futures markets rarely permits a direct examination of this hypothesis. However, the government intervenes in the Indian wheat market in a manner that allows speculative expectations to be inferred from government purchase of grain. The application of standard tests of rational expectations is complicated by measurement errors. Results show systematic biases in forecasting errors of a form that would not be sustainable in the presence of a futures market.

1. Introduction

This paper examines the rationality of price forecasts of speculators in the Indian wheat market. The issue is important as agricultural policy in developing countries is strongly shaped by views about speculation in foodgrain markets.[1] Many countries put in place regulations that severely restrict or even prohibit futures trades and especially so in foodgrains markets. These policies are, however, criticized for ignoring the role of speculation in smoothing supplies, and hence prices, across time. If markets are competitive and speculative expectations rational, then the outcome produced by speculative activity is efficient. Researchers have evaluated the structure of wholesale markets for foodgrains in developing countries according to criteria such as the size and number of traders, barriers to entry, and the extent of spatial arbitrage.[2] There is very little work, on the other hand, examining expectations of speculators, although an answer to this question is necessary in deciding government policy.

Researching this issue is difficult because there is little information about speculative activity in developing-country foodgrain markets. Futures markets, which may provide some data, are either absent or prohibited. It is therefore necessary to find other ways of studying speculative expectations.

Ravallion's (1987) pioneering analysis studied the Bangladesh rice market during the 1974 famine. He used monthly price data together with a number of auxiliary assumptions to develop a testable hypothesis regarding the rationality of price expectations. This method, however, cannot be carried over to the Indian wheat market without substantial revision, as the equations derived by Ravallion are conditional on the assumption that traders carry stocks at all times. As I shall argue later, this is a par-

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ticularly difficult assumption to sustain in the context of wheat markets where the new crop appears only annually.

I devise an alternative method which is based on the fact that government intervention in the wheat market takes place in such a manner that its purchases of wheat reflect storage decisions of producers and traders. Data on wheat procurement by official agencies is available and this information is used here to estimate a model of speculation. The test of rationality is the standard one of checking the correlation of forecast errors with variables in the information set of speculators such as lagged wheat prices. The application of this test, however, is not straightforward because of measurement errors that arise owing to the absence of information on the opportunity cost of funds to speculators.

2. Public Intervention in the Wheat Market

Through purchases and sales, the government is an important player in the wheat market. On the supply side, the government operates a public distribution system (PDS) consisting of a network of retail outlets through which grain is sold at a price typically lower than in the market. The public distribution system is supplied with grain obtained from imports, withdrawal from stocks, and procurement.

On the demand side, the government procures wheat at the *procurement price* announced before the arrival of the annual harvest in April. Since sales to the government are voluntary, effective procurement requires that the procurement price be not less than the market price. Although the government is not committed to buying everything that is offered to it at the procurement price, in practice it has worked that way. As a result, the procurement price is usually not greater than the market price. Thus, it is found that whenever procurement is positive, the procurement price is quite close, if not identical to, the market price (Balakrishnan and Ramaswami, 1995).

The market price, however, does not remain at the level of the procurement price for the whole year. At some point, the costs of storage bid up the market price above the procurement price as the usual seasonal pattern of foodgrain prices asserts itself. The marketing year for wheat extends from April to March and wheat prices are typically at the lowest in the first quarter (April to June) and highest in the last quarter (January to March) of a marketing year. Once the market price rises above the procurement price, farmers stop selling to the government. Consequently, procurement is active in the early months of the marketing year, such as the first quarter, when it is more likely that the procurement price is the price ruling in the market. Indeed, virtually all wheat is procured in the first quarter of a marketing year (Balakrishnan and Ramaswami, 1995).

The basic idea of this paper can now be explained. Since grain sales to government take place in the early part of the marketing year, the opportunity cost of sale to the government is the market price of grain at a later point in time. Thus, procurement is determined as a consequence of speculative decisions and reflects the price expectations of wheat speculators. The next section sets out a formal model of the wheat market which allows me to implement this idea in section 4.

3. A Two-Period Model of Private Storage

The model is one of competitive seasonal storage modified to approximate the details of government intervention in the Indian wheat market. A marketing year is assumed to consist of two seasons: a and b. A random harvest H comes in every year in season *a*. These supplies (augmented by grain sales from the public distribution system) are allocated to current consumption, procurement, and storage. The market equilibrium in season *a* is therefore described by

$$D(P_{at}) = H_{at} + X_{at} - S_{at} - PR_{at}, \tag{1}$$

where $D(\cdot)$ is consumption demand, P is market price, X is grain supply from the public distribution storage, S is the carryover to the next period, and PR is procurement. The subscripts on the variables index the season and year.

Note that (1) uses the simplifying assumption that speculators do not carry over grain from season *b* of year $(t-1)$ to season *a* of year *t*. As noted in Balakrishnan and Ramaswami (1995), the wheat price at the beginning of a marketing year was lower than the price at the end of a previous year for virtually all of the 1970s and 1980s. This suggests strongly that the *ex ante* expected profitability of inter-year storage is likely to have been negative as well. Evidence from field studies also supports the supposition that private stocks are liquidated in anticipation of the new crop (Dreze, 1990, p. 50). Lowry et al. (1987) and Pinckney (1989) have also drawn attention to the fact that private inter-year storage is negligible. Nonetheless, in the empirical analysis, the results are checked for their sensitivity to the assumption of zero inter-year storage.

Let PP_t be the procurement price announced in season *a* of year *t*, at which the government offers to buy all grain that is offered to it. Then its relationship to the market price in season *a* is described by the following:

$$P_{at} = \max\{PP_t, \overline{P}_{at}\}, \tag{2}$$

where $\overline{P}_{at} = D^{-1}(H_{at} + X_{at} - S_{at})$ is the equilibrium price in season *a* when $PP_t = 0$. Condition (2) says that: (i) procurement price is not the season *a* market price unless it is greater than $\overline{P}_{at}$; and (ii) the procurement price is the market price whenever it is greater than $\overline{P}_{at}$. Fact (i) follows because sales to government are voluntary, while (ii) reflects that PP_t is also a support price. Note that equation (1) can be rewritten, using the definition of $\overline{P}_{at}$, as $PR_{at} = H_t + X_{at} - S_{at} - D(P_{at}) = D(\overline{P}_{at}) - D(P_{at})$. Hence

$$PR_{at} = 0 \text{ if } P_{at} = \overline{P}_{at}; \text{i.e., when } PP_t \leq \overline{P}_{at} \tag{3}$$

$$PR_{at} > 0 \text{ if } P_{at} = PP_t; \text{i.e., when } PP_t > \overline{P}_{at}. \tag{4}$$

Private traders are risk-neutral and have common expectations. If P^e_{bt} represents the forecast of speculators, their expected profits from the storage of S units of grain is $((P^e_{bt}/(1 + r_t)) - P_{at})S - C(S)$, where r_t is the opportunity cost of funds to speculators, and $C(\cdot)$ is the cost of holding stocks. Stocks are held by traders up to the point when the marginal return from storage is just offset by its marginal cost. Therefore, we have

$$C'(S_{at}) = \beta_t P^e_{bt} - P_{at}, \tag{5}$$

where β_t is the discount factor and is equal to $1/(1 + r_t)$. Since there is no new output in season *b*, the carryover of stock from season *a* to season *b* is always profitable and the optimal amount of such seasonal storage is determined by (5).[3]

Season *b* supplies consist of public distribution grain sales and private carryovers of grain from the previous season. The season *b* equilibrium condition is therefore

$$D(P_{bt}) = X_{bt} + S_{at} - PR_{bt}. \tag{6}$$

Finally, the relationship of season *b* market price to the procurement price is described by a condition analogous to (2):

$$P_{bt} = \max\{PP_t, \overline{P}_{bt}\} \text{ where } \overline{P}_{bt} = D^{-1}(X_{bt} + S_{at})\}. \tag{7}$$

The market price in season b is the greater of the procurement price and $\overline{P}_{bt}$, which is the price that equates supply and demand in the absence of procurement. Just as (3) and (4) follow from (1) and (2), (6) and (7) imply

$$PR_{bt} = 0 \text{ if } P_{bt} = \overline{P}_{bt}; \text{i.e., when } PP_t \leq \overline{P}_{bt} \tag{8}$$

$$PR_{bt} > 0 \text{ if } P_{bt} = PP_t; \text{i.e., when } PP_t > \overline{P}_{bt}. \tag{9}$$

Equilibrium in the wheat market is characterized by conditions (1), (2), (5), (6), and (7). Public intervention is indicated by the levels of three variables PP_t, X_{at}, and X_{bt}, all of which are regarded as exogenous to the model. The assumption is for expositional convenience as a weaker condition will suffice for the empirical test to be valid. The weaker assumption and its empirical basis are discussed later.

4. Data and Empirical Model

The dataset consists of time-series observations from marketing year 1971/72 to 1991/92. The data were obtained from various issues of the following Government of India publications: Bulletin of Food Statistics (Ministry of Agriculture), Economic Survey (Ministry of Finance), and the Statistical Panorama (Food Corporation of India, 1990).

As noted earlier, the wheat marketing year in India runs from April to March. In the empirical implementation, it is assumed that season a consists of the months April, May, and June. This division of the marketing year is consistent with the two features that characterize season a in the theoretical model. First, the new harvest arrives in season a. Second, the market price in season a is equal to the procurement price whenever procurement is positive. Note that this is also true of shorter periods ending before June. However, the first quarter of the marketing year from April to June is typically the longest period for which the procurement price is the market price.

During the period of this study the government purchased wheat in all years and virtually all of these purchases occurred in the first quarter; i.e., in season a of the model. These facts together with (4) and (9) imply the equalities $P_{at} = PP_t$ and $P_{bt} = \overline{P}_{bt}$. The model in equations (1), (2), (5), (6), and (7) therefore, reduces to the following three equations:

Optimal stocks:

$$C'(S_{at}) = \beta_t P_{bt}^e - PP_t \tag{10}$$

Market equilibrium in season a:

$$D(PP_t) = H_t + X_{at} - S_{at} - PR_{at} \tag{11}$$

Market equilibrium in season b:

$$P_{bt} = D^{-1}(X_{bt} + S_{at}). \tag{12}$$

5. Test of Rational Expectations

Let $W_t = \beta_t P_{bt} - PP_t$ denote the discounted price spread. Then a linear estimable version of (10) is

$$S_{at} = a_0 + a_1 W_t^e, \tag{13}$$

where W_t^e is the speculators' forecast of the discounted price spread. If ε_1 is the error in forecasting the discounted seasonal price spread (i.e., $\varepsilon_{1t} = W_t - W_t^e$), (13) could also be written as

$$S_{at} = a_0 + a_1 W_t - a_1 \varepsilon_{1t}. \tag{14}$$

As is well known, speculators are said to forecast rationally if their forecasting errors are uncorrelated with all variables in their information set. Let I_t be the information set of speculators in season a, and let Z_t be a vector of variables that belong to I_t. Then rational expectations requires $E(\varepsilon_{1t}|Z_t) = 0$. A standard way of testing this restriction is to regress S_{at} on W_t and Z_t and to check for the significance of Z_t variables (Baillie, 1989). Expectations are not rational if any of the Z_t variables turn out to be significant.

The above test could be implemented if time-series data on S_{at} and W_t were available. In neither case, however, do ideal measures exist. While both these variables can be measured with error, the usual test of the orthogonality restrictions of rational expectations might not be generally valid in these circumstances. To clarify the specific assumptions under which the rational-expectations test can still be implemented, I turn to a discussion of the measurement errors in the two variables.

Measurement Errors in Discounted Price Spreads

Although price data are available, there is no information on discount rates of speculators. As a matter of official policy, bank finance for stockholding is subject to severe restrictions which suggests that bank advances are not the predominant form of finance (Tyagi, 1990, pp. 194–5). In addition, there is no information, in time-series form, on interest rates in informal financial markets. These two facts mean that the true discount rate facing speculators is unobservable to the econometrician.

Let $\hat{\beta}_t$ be a proxy for β_t, and let $W_t^m = \hat{\beta}_t P_{bt} - PP_t$ be the measured price spread. Equation (14) can be written in terms of the measured variable as

$$S_{at} = a_0 + a_1 W_t^m - a_1 (W_t - W_t^e) - a_1 (W_t^m - W_t) \tag{15}$$

or

$$S_{at} = a_0 + a_1 W_t^m - a_1 \varepsilon_{1t} - a_1 \varepsilon_{2t}, \tag{16}$$

where ε_{1t} is, as before, $W_t - W_t^e = \beta_t(P_{bt} - P_{bt}^e)$, and $\varepsilon_{2t} = W_t^m - W_t = P_{bt}(\hat{\beta}_t - \beta_t)$.

Compared with (14), (16) is in terms of a measured price spread but at the cost of an additional error term, namely ε_{2t}, which is the measurement error in β. The question is whether the standard rational-expectations tests could still be performed with respect to (16). Clearly if the measurement error in the discount rate is correlated with any of the information-set variables (Z_t), then finding significance of those variables in a regression of S_{at} on W_t^m and Z_t would not necessarily mean rejection of the hypothesis of rational expectations.[4]

Motivated by adaptive expectations schemes which imply correlation of forecast errors with past prices, this paper considers the lagged wheat price spread (W_{t-1}^m) as an information-set variable. The proposed model of forecast errors is

$$\varepsilon_{1t} = \gamma W_{t-1}^m + \eta_t. \tag{17}$$

In the light of equation (16), the question is whether W_{t-1}^m might be correlated with measurement error in the discount rate. To answer this question, suppose r_t is the true opportunity cost of funds to speculators, while $\hat{r}_t$ is a proxy that is used in place of r_t. Approximating the function $1/(1 + x)$ by $(1 - x)$, and choosing $\hat{r}_t$ to be zero for every t, the error in the discount rate due to the use of this proxy rate becomes $-\varepsilon_{2t} = P_{bt}(\hat{\beta} - \beta) = -P_{bt}(r_t - \hat{r}_t) = -P_{bt}r_t$. Then it is clear that ε_{2t} would be correlated with W_{t-1}^m if it matters in the determination of the interest rate r_t.

How could the lagged wheat price spread matter for the supply or demand for credit? Taking the demand side first, the demand for credit from speculators, and hence the interest rate, varies directly with their expectations. This suggests that the interest rate may be positively correlated with the lagged price spread if expectations are nonrational and backward-looking. In this case, the significance of the lagged seasonal spread correctly reflects nonrational expectations. On the supply side, although bank credit to traders is restricted, the terms of such credit are often revised by the central bank (Reserve Bank of India) to influence the cost of stockholding. Thus, for example, if the Reserve Bank of India fears commodity price inflation on the basis of past experience, it may choose to increase the interest rate on credit against stocks to increase the costs of stockholding. By causing bank interest rates to increase, lagged price spreads therefore enter the storage function with a negative sign even when speculator's expectations are rational. The importance of this argument is not easy to assess, *a priori*. While commodity traders use bank finance only to a limited extent, their opportunity cost of funds may yet vary with bank interest rates.

Measurement Errors in Private Storage

From (11), grain in storage with private agents at the end of season *a* is given by

$$S_{at} = H_t + X_{at} - PR_{at} - D(P_{at}). \tag{18}$$

The problem here is the absence of full information on season *a* wheat consumption. Consumption from PDS grain purchases is captured through the X_{at} term. Similarly, consumption by producers can be accounted for by replacing the output series (H_t) by a market-arrival series (MA_t). Then we have

$$S_{at} = MA_t + X_{at} - PR_{at} - D_n(P_{at}), \tag{19}$$

where D_n is the component of wheat consumption which does not include on-farm consumption and public distribution system sales. There is no information available on D_n. Therefore, S_{at} can at best be proxied by the variable Y_{at} defined as

$$Y_{at} \equiv S_{at} + D_n(P_{at}) = MA_t + X_{at} - PR_{at}. \tag{20}$$

Y_{at} clearly overestimates S_{at}. However, from the point of view of testing the orthogonality restrictions imposed by rational expectations, the error should not be of consequence as consumption demand does not depend on expected price change, nor is there any compelling reason to suggest that it depends on either the lagged wheat price spread or the lagged rate of inflation. In addition, the bias, if any, due to these errors can be addressed by including, in the regression, variables that determine D_n.

A second source of error in the storage series comes from the assumption that no stocks are carried into season *a* from season *b* of the previous year. Although no direct information exists on the volume of such stocks, it was argued earlier that such stocks are likely to be negligible in view of the fact that the inter-year price spread has always been negative. Some stocks may, however, be carried for convenience-yield considerations. This error leads the computed series to be an underestimate of the true series. Following Working (1949), it is known that the lower is the return from storage (i.e., the expected fall in price from season *b* of year $t-1$ to season *a* of year *t*) the lower will be the stocks held for convenience yield. An observed correlation between the storage series and W^m_{t-1} might then be an artifact of a strong correlation between W^m_{t-1} and the inter-year price spread. This possibility can, however, be ruled out as W^m_{t-1} and the inter-year price spread are virtually uncorrelated (–0.07).

6. Results

Substituting (17), the model of forecast errors, into (16) we have

$$S_{at} = \delta_0 + \delta_1 W_t^m + \delta_3 W_{t-1}^m + \upsilon_t, \tag{21}$$

where υ is a random disturbance and is the sum of forecast errors and measurement errors in the discount rate and storage series. Since $\delta_3 = -a_1\gamma$, the proposed model of forecasting errors is validated if δ_3 is significantly different from zero. Since the forecast error is correlated with W_t^m, instrument-variable methods are used to obtain consistent estimates.[5] 2SLS estimates are reported in column (1) of Table 1. As the form of measurement error in the discount rate suggests heteroskedasticity, estimators more efficient than the 2SLS estimator are considered. Within the class of instrument-variable estimators, the efficient estimator is the 2S2SLS estimator (Cumby et al., 1983) which uses 2SLS residuals to form an initial variance–covariance matrix. The 2S2SLS estimator is also the generalized method of moments estimator for this case. As the 2SLS residuals were found to be free of autocorrelation, the 2S2SLS estimates, reported in column (2) of Table 1, are computed on the assumption of zero autocorrelation.[6]

The coefficient on the lagged wheat price spread is positive and significant. In the previous section, I considered an argument as to why measurement errors in the discount rate might lead the lagged price spread to be significant even when expectations are rational. However, that argument also predicts a negative sign for the coefficient of the lagged seasonal price spread, which is contradicted by the positive sign of the estimated coefficient. The significance of the lagged wheat price spread is, therefore, strongly suggestive of nonrationality in speculative forecasts in the wheat market. The

Table 1. Regression of Storage on Price Spread and Information-Set Variables

Explanatory variables	*Coefficients (1)*	*Coefficients (2)*	*Coefficients (3)*
Constant	3.37	3.30	3.25
	(11.69)	(15.39)	(14.03)
Current wheat price spread	0.021	0.022	0.025
	(2.12)	(4.37)	(4.63)
Lagged wheat price spread	0.075	0.075	0.071
	(6.44)	(10.49)	(7.50)
Rice price relative to wheat price	—	—	0.009
			(0.75)
Standard error of equation	0.73	1.27	1.29
Wald statistic	934	2,532	1,964
SH statistic	1.25	1.34	1.30
Mean of dependent variable	5.07	5.07	5.07
Estimation method	IV/2SLS	2S2SLS/GMM	2S2SLS/GMM

Dependent variable is private storage. Instruments are the first differences of wheat output, first differences of rice output, lagged rate of inflation, twice- and thrice-lagged price spreads of wheat. Figures in parantheses denote *t*-values. Wald is the chi-squared statistic for the test that all the coefficients in the model are zero. It is distributed asymptotically with three degrees of freedom in columns (1) and (2) and with four degrees of freedom in column (3). SH is the Sargan–Hansen test statistic, for four valid overidentifying restrictions, which is distributed asymptotically chi-squared with four degrees of freedom.

results imply that, in years following large seasonal spreads, speculative forecasts are excessively optimistic, leading to "overhoarding." Conversely, in the few years that seasonal spreads were negative, speculative expectations were biased downwards and private stocks smaller than optimal in the succeeding year. In terms of magnitude and significance, the effect of the recent past is much stronger than forward-looking behavior. Not only is the coefficient on W^m_{t-1} more than three times the coefficient on W^m_t, the 95% confidence intervals do not overlap. The smallest value of the coefficient of W_{t-1} in this band is 0.06, while the highest value of the coefficient of W_t in its interval is only 0.032.

One concern about the results reported in column (2) might be its sensitivity to measurement errors in the storage series. Column (3) checks the robustness of results to measurement errors in private storage arising from lack of information about nonfarm and private sales of wheat in season a. Using (20), (21) can be written as

$$Y_{at} = \delta_0 + \delta_1 W^m_t + \delta_3 W^m_{t-1} + D_n(P_{at}) + \upsilon_t. \tag{22}$$

The benchmark regression in column (2) was computed by merging $D_n(P_{at})$ with the error term. An alternative procedure would be to augment the regressors in the benchmark regression by variables that determine $D_n(P_{at})$ such as season a rice and wheat prices. Even in first differences, the rice and wheat prices are highly collinear and, in a preliminary regression, have approximately equal and opposite effects on Y_{at}. Accordingly, the demand variable that is included in column (3) is the time series of the absolute difference between rice and wheat prices (in first differences). As can be seen, the results closely resemble the estimates in column (2).

A limitation of the instrument-variable estimation procedure as applied to (21) is that its consistency cannot be established if expectations are rational and if all information, at $(t-1)$, about W_t is contained in W^m_{t-1}. In this case, the data-generating process of W_t is $W_t = \lambda W^m_{t-1} + e_t$. Under these conditions, $E(Z_t W^m_t) = \lambda E(Z_t W^m_{t-1})$ for any valid instrument Z_t. To see this, note that, since $W^m_t = \lambda W^m_{t-1} + e_t + \varepsilon_{2t}$, $E(Z_t W^m_t) = \lambda E(Z_t W^m_{t-1}) + E(Z_t(e_t + \varepsilon_{2t}))$. But ε_{2t} is a component of the error term v_t (in (19)) and so is e_t as it is the forecast error (i.e., ε_{1t}) when expectations are rational. Since Z_t is a valid instrument, $E(Z_t(e_t + \varepsilon_{2t})) = 0$ and the result follows. Thus, if X denotes the matrix of observations on the right-hand-side variables in (21), and if Z is a matrix of observations on the instrument variables, then $Z'X/T$ converges in probability to a singular matrix. As a result, equation (21) when estimated by instrument variables is not identified.

The premise that, at time $t-1$, all information about W_t is contained in W^m_{t-1} can, however, be tested directly since it is equivalent to the hypothesis $\Phi = 0$ in the model $W^m_t = W^m_{t-1}\lambda + U_t\Phi + \eta_t$, where U_t is a subset of variables that belong to the information set of speculators in season a. This can be rewritten as $\Delta W^m_t = -(1-\lambda)W^m_{t-1} + U_t\Phi + \eta_t$. In a regression of this kind, where U_t included twice- and thrice-lagged price spread and the first differences of wheat and rice output, the null hypothesis of $\Phi = 0$ was rejected, which therefore validates the instrument variables estimation of (21). Owing to lack of space, the detailed results are not presented here.

Finally, if public intervention is endogenous, does it affect the identification of the model of forecasting errors as in (17)? First, note that since forecasts are formed in season a when PP_t and X_{at} are already known, the issue of endogeneity relates only to X_{bt}. Second, a referee has pointed out that if the X_{bt} were endogenous—and in particular if past prices (W^m_{t-1}) were the sole indicator on the future ability of the government to intervene in the market—then the results in Table 1 might not constitute a test of rational expectations. However, from the earlier discussion, it is clear that endogeneity would cloud the test of rational expectations only if it meant that all information about W_t is contained in W^m_{t-1}. This, as we have seen, is not supported by the data. Furthermore, the data do not support any relationship between X_{bt} and W^m_{t-1} either. The correlation (square) between X_{bt} and W^m_{t-1} is 0.018. The relationship was also examined in a multiple regression where the other variables were lagged X_{bt} and procurement. Variation in W^m_{t-1} is unimportant in explaining variation in X_{bt}.

7. Concluding Remarks

In developing countries, information about speculation in foodgrain markets is scarce, although food policies are often shaped by views about its determinants and its effects. This paper makes use of the manner of government intervention in India to estimate the amount of wheat stocks in private hands at the same point in time every year. With such a private storage series, it is possible to estimate a model of speculative activity which throws light on the relative importance of its determinants. Since intervention in the form of government procurement takes place in many developing countries, the methods proposed here may find application elsewhere.

In India, the government disallows futures markets in foodgrains. Where futures markets exist, the futures price conveys information to market participants about sources of uncertainty (such as supplies from diverse sources). In their absence, as in India, the seasonal allocation of grain supplies is determined entirely in the spot market without the benefit of market institutions that aggregate and disseminate information about future events. How has this worked? This paper finds strong evidence that speculators in the Indian wheat market made systematic mistakes in forecasting future prices. The bias in their forecasts varies directly with past price spreads. Relative to the rational-expectations equilibrium benchmark, the seasonal allocation of wheat supplies has been inefficient. Thus, for instance, in years following large seasonal price rises, traders store too much wheat compared with the rational-expectations equilibrium.

What are the implications of this finding for food policy? If expectations formation is regarded as exogenous, a case could be made for government controls on speculation as well as countervailing measures such as sales of grain from public stocks. If, on the other hand, it is recognized that expectations formation is not exogenous but dependent on market institutions as well as on individual incentives for the collection and processing of information, then a different conclusion emerges. The pattern of forecasting errors suggests that the seasonal allocation of wheat supplies would have been different in the presence of a futures market.

The storage of wheat in India is a largely seasonal activity. Within the crop marketing year, no new supplies can be expected. The principal sources of uncertainty for an individual trader are then shocks to demand and the storage plans of other traders.[7] If demand changes predictably from year to year, as seems likely, the problem becomes one of forecasting the storage plans of others. The backward-looking expectations of the type witnessed in the Indian wheat market suggests a lack of coordination of storage plans among traders. Such expectations, where an individual trader naively chooses to remain uninformed about the storage plans of other traders, cannot be sustained in the presence of a futures market.[8] For instance, if past experience leads traders to expect a large seasonal price rise, the resulting supply of wheat at a future date would depress the futures price, invalidating the initial expectation. The legislated absence of futures markets in the Indian context removes an important mechanism for coordinating storage decision of market participants and might have therefore made it more difficult to forecast future prices. Note that in this instance, what is required is not even a fully fledged futures market. Futures contracts limited to intra-year delivery would suffice.

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Notes

1. For a sample of these views, see Ravallion (1987, ch. 1).
2. Lele (1971) and Subbarao (1978) are two landmark studies of foodgrains markets in India.
3. The proviso is that public sales in season *b* are not so great as to eliminate all private trade.
4. By postulating constant time-independent discount rates, Ravallion (1987) assumes away the possibility of measurement error in the discount rate being correlated with the chosen variables in the information set.
5. In addition, there is a simultaneous equation bias as well. Current price spreads will be smaller, the larger is the seasonal carryover.
6. The statistic (distributed with two degrees of freedom) from a Lagrange multiplier test of serial correlation up to the second order was 0.20.
7. Sales from the public distribution system have to be forecasted as well. Crop-year aggregates of such sales have, however, been extremely stable and should have been easy to predict.
8. If demand is predictable, one can construct models in which the futures price perfectly reveals aggregate storage (Grossman and Stiglitz, 1976).