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# *Foodgrain Stocks, Prices and Speculation*

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## Abstract

Much of recent work has raised the issue that the surge in prices of foodgrains in the last two years cannot be explained satisfactorily in terms of the fundamentals of supply and demand. It has also been suggested that the part that cannot be explained in this way is due largely to speculation. Speculation influences food prices in two distinct ways: one is the huge influx of capital from commodity index funds, hedge funds and pension funds in commodity futures markets or options. Some evidence suggests that expiry prices in commodity futures markets are considerably higher than cash or spot prices, implying that futures markets are not facilitating price discovery. The second form is purchase or hoarding of commodities on the presumption that their prices will continue to rise. The present analysis, based on a rational distributed lag model of global stocks of wheat, maize and rice and their prices over the period 1986-2008, confirms a positive long-run effect of rising prices on stocks. In the case of rice, this effect is considerably stronger. If this finding has any validity, although the need for correcting demand-supply imbalances remains a top priority, careful attention must also be given to limiting speculation. Various suggestions include the imperative of a 'virtual grain reserve' to be established to help calm markets through the futures market. But, above all, there is a strong case for a better functioning trading system-in particular, for trade liberalization in agriculture and to build trust in global food markets and stock management.

**Keywords**: Foodgrain stocks, Price, Speculation, Hoarding

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## Introduction

That global food prices have risen significantly over the past two years, especially since January 2008, may shock only a few, if any. The consumer price index (CPI) measuring inflation for retail foodstuffs in the United States rose 4 percent in 2007, the highest annual increase since 1990. It is, furthermore, expected to rise by 5-6 percent in 2008. These figures, however, pale in comparison with the price increases faced by consumers in the developing world, who more often purchase non-packaged food directly (i.e., corn, not cornflakes) and are thus more exposed to the prices of individual food commodities (Teslik 2008). The prices of rice and wheat, for instance, have more than doubled in twelve months; for someone subsisting mainly on rice and purchasing it directly, this means a food inflation of roughly 100 percent in a single year. Not unexpectedly, therefore, the continuing surge in prices has led to food riots in at least 37 countries (Ivanic and Martin 2008; World Bank 2008; Duflo 2008). There are some alarming predictions of the likely deepening of poverty in the developing world: a recent estimate by World Bank researchers puts it at about 105 million persons (Ivanic and Martin 2008). While not implausible, the methodology used does not allow for a positive supply response of the higher food prices benefiting food producers, including smallholders (Imai, Gaiha and Thapa 2008). Another recent study by the Asian Development Bank (ADB 2008) offers a more nuanced assessment of the impact of soaring food prices in selected Asian countries.

An important finding obtained from simulations for China and Indonesia, for example, is that the negative effects of food price inflation (e.g., higher incidence of poverty and increased income inequality) are dampened by the positive supply response in rural areas. The comparison is interesting as China is a net food exporter while Indonesia is a net food importer. China gains from rising global food prices. Specifically, the largest gains accrue to households dependent on agriculture. Not only does the headcount index of poverty decline but so does the Gini index of income inequality, more than compensating for the unfavourable effects in urban areas. The results, however, differ for Indonesia. Although higher global food prices result in higher consumer prices, exchange rate appreciation and loss of competitiveness of Indonesian exports, and a lowering of real GDP, the food crops subsector expands. Not surprisingly, therefore, the overall headcount of poverty rises albeit slightly.

While there are many detailed analyses of the fundamentals of food supply and demand factors that underlie the continuing surge in food and fuel prices, there is no unanimity on the role of speculation.

Many analysts have drawn attention to the considerable effect of speculative trading practices in influencing rising food prices. The price dynamics is aptly described in a testimony by M.W. Masters, the managing partner of the hedge fund Masters Capital Management, before the US Senate’s Committee on Homeland Security in May, 2008:

> Institutional investors like hedge funds and pension funds started pouring money into commodities futures markets in the early 2000s, pushing up futures contracts and, in turn, spot prices. Spot traders often use futures markets as a benchmark for what prices they are willing pay, so even if futures contracts are inflated by an external factor like a flood of interest from pension funds, this still tends to result in a bump for spot prices. Still, much debate remains about the extent to which speculation in futures markets in fact pushes up food prices (cited in Teslik 2008).

In principle, speculation is purchase (or sale) of something in the hope of gain from price changes over time. In the present context, two forms of speculative behaviour seem pertinent: (i) the purchase or hoarding of commodities on the presumption that their prices will continue to rise; and (ii) purchase of commodity futures or options, essentially bets that prices will either rise or fall- purely as an investment strategy.[1]

An aggressive form of speculative behaviour is to hold large stocks at a time of shortage. It is also sometimes combined with trading strategies that exacerbate shortages. 'cornering the market' – or buying up large enough quantities of a commodity to influence its price – is an extreme case. Smaller markets are more susceptible to such manipulation (IFPRI 2008).

Whether high food prices induce destructive speculation or healthy productive investment in agriculture can only be determined *ex post*. One view is that massive capital inflows have a destructive influence, while according to the diametrically opposite view, high prices make the market more liquid and thus more efficient. Let us consider these issues in detail.

According to Citigroup, an estimate of worldwide investment in commodity futures at the end of March 2008 was US$400 billion, about US$70 billion more than at the beginning of the year, and twice as much as in late 2005. These investments are held by commodity index funds, commodity trading advisers, hedge funds, and exchange-traded funds. Some of these investors aim to construct commodity portfolios to replicate the performance of major commodity price indices such as Standard and Poor's Commodity Index. One important reason is the belief that commodity markets are in the midst of a 'super cycle' that will continue to drive prices higher.[2]

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[1] For a classic, see Newbery and Stiglitz (1981).

[2] Some of the world's richest food companies are making record profits. Monsanto's net income for the three months up to the end of February 2008 more than doubled over the same period in 2007, from US$543 million to US$1.1 billion. Its profits increased from US$1.44 billion to US$2.22 billion. Cargill's net earnings soared by 86 percent from US$553 million to US$1.03 billion over the same three months. Similarly, the Mosaic company, one of the world's largest producers of

Of this investment, 12-30 percent (or US$48-120 billion) is in agricultural futures. Index funds alone account for more than US$47 billion investment in maize, soybeans, wheat, cattle and hogs, up from US$10 billion two years ago. As a result of this massive capital influx, the futures markets have grown enormously. For example, the number of open futures contracts on the Chicago Board of Trade (CBOT) has increased more than threefold for both wheat and corn in the past five years.

Futures markets perform two functions: price discovery and hedging.[3] In general, most futures-market participants have been hedgers or commercial traders who manage risks by buying and selling the underlying commodities. Commodity speculators or 'non-commercial traders', on the other hand, make relatively short-term investments to capture the gains from differences in prices for different delivery months. While traditional or commercial speculators move in and out of the futures markets depending on the fundamentals of demand and supply, index-related investors in commodities seek to balance risks from other sources such as stocks, bonds and real estate. Also, they bet only that prices will rise.

Several commentators argue that large, new, index-driven investments in commodities have driven market prices out of proportion to market fundamentals.[4] This is evident in the failure of futures and cash prices to converge. This implies that futures contracts are no longer an effective hedge against price risks. A related issue is price volatility. In the first few months of 2008, volatility in several futures markets was very high: triple the historical monthly averages for wheat and soyabeans and double for corn (IFPRI 2008).

The combination of a mismatch between futures and cash prices, and high volatility has undermined the role of commodity exchanges as a guide to future price and risk-management or hedging instruments.

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fertilizer, saw its income for the three months ending February 2008 rise more than 12-fold, from US$42.2 million to US$520.8 million, on the back of a shortage of fertilizer (*The Independent*, 4 May 2008).

[3] Although much of trading in futures markets is speculative, for every buyer on a futures market there is an equal and opposite seller (by definition). Thus a bigger open interest has no net effect on prices. Moreover, since futures markets have existed for over a century and have grown steadily since 1990-2008, it is not self-evident that trading on these markets has much to do with the spikes in food prices in the last two years. However, as argued below and demonstrated by our econometric analysis, this is a somewhat simplistic view.

[4] Gilbert (2008) remains sceptical without ruling out this connection for two reasons: (i) Agricultural commodities account for a small proportion of these investments, and (ii) more pertinently, the prices of commodities in which there are either no futures markets (e.g., coal, iron ore, minor metals) or for which futures markets are not important (e.g., steel, rice) have gone up as much as those of traded commodities.

However, many economists and finance specialists remain sceptical of a link between futures-market speculation and rising food prices. Instead, it is argued that futures-market speculation can only be blamed for the increasing food prices if it is accompanied by hoarding (Krugman 2008). Since there is little evidence of hoarding, it is concluded that speculation is not the cause of the surge in food prices. As noted in the IFPRI report (2008), hidden hoarding may still be a significant factor causing commodity prices to rise. This takes the form of households hoarding rice, and importers buying more than they normally do. These small amounts may add up to sizeable quantities.[5]

In addition, in response to spiralling domestic prices, many countries resorted to protective measures without realizing that such measures would force more drastic adjustments and higher prices in global markets. Food exporting countries eliminated export subsidies on foodgrains (China eliminated rebates on value-added taxes foodgrain exports), imposed export taxes (Russia and Kazakhstan raised export taxes on wheat) and quantitative restrictions (Vietnam restricted rice exports), and banned exports (India banned non-Basmati rice and wheat exports, Indonesia banned rice exports). Food importing countries, on the other hand, inflated imports in panic buying in response to tightening supplies: tariff reductions in India (wheat flour), Indonesia (soyabeans and wheat), Thailand (pork), and in EU (grains); and subsidized distribution of food imports (Venezuela). Thus, while global foodgrain supply shrank through export curbs and prices rose faster, food importers escalated demand by bidding aggressively for larger imports to dampen domestic inflation (Trostle 2008).

In the analysis that follows, we have examined the dynamics of global foodgrain stocks and prices over the period. The point of departure of this study is that the graphical or cross-tabulations of foodgrain stocks that many studies have relied upon to support the view that stocks have not grown with higher foodgrain prices lack a robust basis. Instead, what is required is a detailed econometric analysis that allows for lags in stocks adjusting to changes in prices. This analysis is based on global stocks of foodgrains and prices compiled by the United States Department of Agriculture (USDA).

The scheme is as follows. Section 1 gives a brief exposition of the rational distributed lag model estimated with data over the period 1986-2008. The results are discussed in Section 2. Concluding observations are given in the last section from a broad policy perspective.

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[5] Peru's prime minister 'declared war' on food-price speculators in March, 2008. Also, large rice warehouses in New Delhi and Mumbai were raided by the police. In the Philippines, criminal syndicates have been caught reselling large quantities of grains intended for subsidized distribution among the poor (IFPRI 2008).

## 1 Rational distributed lag model (RDL)

The geometric distributed lag model is specified as:[6]

$$y_t = \alpha_0 + \gamma z_t + \rho y_{t-1} + u_t - \rho u_{t-1.....} \quad (1)$$

where $y_t$ denotes stock of, say, wheat in year *t*, $z_t$ denotes price of wheat, and

$\alpha_0$ =(1- $\rho$)$\alpha$. This, however, is a *special* case of the more general RDL model.

$$y_t = \alpha_0 + \gamma_0 z_t + \rho y_{t-1} + \gamma_1 z_{t-1} + v_t ... \quad (2)$$

where $v_t = u_t - \rho u_{t-1}$. By repeated substitution, it can be shown that (1) is equivalent to the infinite distributed lag model (Wooldridge 2006).

$$y_t = \alpha + \gamma_0 z_t + (\rho\gamma_0 + \gamma_1) z_{t-1} + \rho(\rho\gamma_0 + \gamma_1) z_{t-2} + \rho^2 (\rho\gamma_0 + \gamma_1) z_{t-3} + ...... + u_t .. \quad (3)$$

An assumption here is that $|\rho| < 1$. From Equation (3) we can read off the lag distribution. In particular, the impact propensity is $\gamma_0$ while the coefficient on $z_{t-h,}$ where *h* is the number of lags, is $\rho^{h-1}(\rho\gamma_0 + \gamma_1)$ for $h \geq 1$. Thus this model allows the impact propensity to differ in sign from the other lag coefficients, even if $\rho > 0$. However, if $\rho > 0$, the $\delta_h$ or coefficients on lagged values of $z$ will have the same sign as $(\rho\gamma_0 + \gamma_1)$ for all $h \geq 1$. For computing the long-run propensity of *y* with respect to *z*, their values are set at long-run values for all *t,* say, $y^*$ and $z^*$, and then the change in $y^*$ with respect to $z^*$ is obtained.

$$\text{LRP} = (\gamma_0 + \gamma_1)/(1 - \rho). \quad (4)$$

We first estimate Equation (2) using the annual global stock data for wheat, maize, and rice. To make clear the stock adjustment in response to rising prices, we will use the data for 1989-2008, and refer briefly to the results obtained from the shorter but more recent data for 2000-08.[7] As crop price itself is endogenous – specifically, to oil price – we report two cases. In the first case, crop price is used as it is, and in the second case, the price predicted by a vector autoregressive (VAR) model is used. We have also experimented with a logarithmic transformation of the variables in question. Thus for each commodity (viz., wheat, maize and rice) eight cases are obtained:

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[6] This exposition is based largely on Wooldridge (2006).

[7] Stock data are taken from USDA (2008). Crop/commodity price data are based on FAO-STAT.

- Case 1 is based on untransformed variables for the period of 1986-2008;
- Case 2 is the same as Case 1 except that the period is 1989-2008;
- Case 3 is based on logs of variables during 1986-2008; and
- Case 4 is the same as Case 3 except that the period is 1989-2008.
- Cases 5 to Case 8 correspond to Cases 1 to 4, respectively, except that price is replaced by its predicted value in each case.

To make sure that the serial correlation between lagged dependent variable and $v_t$ is taken into account, the standard errors are adjusted appropriately by using generalized least squares (GLS) method. LRP and coefficients for Equation (3) are calculated from the coefficient estimates for Equation (2). Then we also estimate Equation (1) corresponding to the geometric distributed lag model for a comparison with the results for the infinite distributed lag model.

## 2 Results

Tables 1-3 give the results for wheat, maize and rice, respectively. Each table has three panels: the first panel (labelled Case A) shows the results for Equation (2) and the LRP; the second comprises the coefficient estimates for Equation (3), calculated from the results in the first panel (up to the fifth lag); and the third (labelled Case B) shows the results for Equation (1). Appendix 1 contains the VAR price results, estimated using lagged oil price data (up to the fourth lag) for 1985-2008.

Table 1 gives the results for wheat. It is difficult to draw a firm inference, as some of the results change with the specification used. Predicted prices are not significant in Cases 5 to 8. If we consider Case 1, we find that current price of wheat has a negative effect on the stock of wheat, but the long-run effect is likely to be positive, implied by the positive coefficients of lagged price ($t$-1 to $t$-5). The signs of the effects, however, are overturned for the data of the more recent period, 2001-08, in Case 2. That is, price is positive in $t$-1 and negative in $t$-1 to $t$-5. In Cases 3 and 4, however, the signs of the lagged price coefficients change. An initial positive effect in Case 3 is followed by negative lagged price effects while an initial negative effect is followed by positive lagged effects in Case 4. The results for Cases 5 to 8 largely correspond to Cases 1 to 4 in terms of the signs of the coefficient estimates. Significant coefficient estimates of the current price in Cases 1 and 3, however, cease to be significant in Case 5 and Case 7 where predicted prices are used. Lag of wheat stock is positive and significant for Cases 1, 3, 5 and 7 for 1986-2008, but is not significant for the considerably shorter and more recent period (2001-08).

It is more interesting to comment on the long-run propensity (LRP) of $y$, wheat stock with respect to $z$. Although the values differ with the specification, it is noted that these are positive over the period 1986-2008. Of particular importance is the LRP for Cases 1 and 3 (1.994 and 0.417), as these are obtained from significant current and lagged price coefficients. So the extent that these results have validity, a positive long-run relationship between wheat stocks and prices suggests a speculative element. As the results in the third panel without a lagged price variable contain no significant current price effects on wheat stocks, no further comment is necessary.

**Table 1. Rational distributed lag models of wheat stock and price**
**Case A: With lagged price (Equation (2))**

Dependent variable: annual stock of wheat

GMM Estimation

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Price of wheat | -0.273 (2.39)* | 0.322 (0.82) | 0.462 (2.37)* | -0.512 (0.65) | 0.286 (0.89) | 0.029 (0.04) | -0.038 (0.24) | -0.124 (0.50) |
| Stock of wheat(-1) | 0.827 (4.82)** | 0.495 (1.41) | 0.705 (3.57)** | 0.423 (1.02) | 0.943 (4.16)** | -0.01 (0.02) | 0.713 (3.05)** | 0.484 (1.26) |
| Price of wheat (-1) | 0.618 (2.62)** | -0.762 (0.76) | -0.339 (2.51)* | 0.223 (0.56) | 0.473 (1.60) | -2.085 (1.64) | 0.085 (0.62) | -0.001 (0.00) |
| Constant | -13.734 (0.30) | 120.853 (0.96) | 0.919 (0.55) | 4.235 (1.04) | -85.614 (0.96) | 405.215 (1.48) | 1.239 (0.65) | 3.171 (0.94) |
| Observations | 20 | 8 | 20 | 8 | 18 | 6 | 20 | 8 |
| LRP | 1.994 | -0.871 | 0.417 | -0.501 | 13.316 | -2.036 | 0.164 | -0.242 |
| Joint significant tests | | | | | | | | |
| Wald $chi^2(3)$ | 44.83** | 14.95** | 45.03* | 10.93** | 21.57** | 19.25** | 21.48** | 10.51* |
| Prob > $chi^2$ | 0 | 0.0019 | 0.012 | 0 | 0.0001 | 0.0002 | 0.0001 | 0.0147 |

| | **Coef. estimates for Equation (3) based on the estimates of Equation (2) above** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Effect of price: at *t* on stock at *t* | -0.273 | 0.322 | 0.462 | -0.512 | 0.286 | 0.029 | -0.038 | -0.124 |
| at *t*-1 on stock at *t* | 0.392 | -0.603 | -0.013 | 0.006 | 0.743 | -2.085 | 0.058 | -0.061 |
| at *t*-2 on stock at *t* | 0.324 | -0.298 | -0.009 | 0.003 | 0.700 | 0.021 | 0.041 | -0.030 |
| at *t*-3 on stock at *t* | 0.268 | -0.148 | -0.007 | 0.001 | 0.660 | 0.000 | 0.029 | -0.014 |
| at *t*-4 on stock at *t* | 0.222 | -0.073 | -0.005 | 0.000 | 0.623 | 0.000 | 0.021 | -0.007 |
| at *t*-5 on stock at *t* | 0.183 | -0.036 | -0.003 | 0.000 | 0.587 | 0.000 | 0.015 | -0.003 |

Note: Absolute value of z-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

**Case B: Without lagged price (Equation (1))**

Dependent variable: annual stock of wheat

GMM Estimation

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Price of wheat | -0.056<br>(0.59) | 0.03<br>(0.31) | -0.161<br>(1.22) | -0.016<br>(0.10) | 0.182<br>(0.54) | 0.434<br>(0.57) | -0.01<br>(0.06) | -0.125<br>(0.59) |
| Stock of wheat(-1) | 0.607<br>(2.97) ** | 0.695<br>(2.96) ** | 0.464<br>(2.01) * | 0.61<br>(1.97) * | 0.724<br>(3.12) ** | 0.702<br>(3.04) ** | 0.672<br>(2.83) ** | 0.485<br>(1.59) |
| Constant | 72.999<br>(1.66) | 32.995<br>(0.66) | 3.52<br>(2.06) | 1.989<br>(0.87) | 23.315<br>(0.32) | -16.505<br>(0.15) | 1.721<br>(0.93) | 3.166<br>(1.29) |
| Observations | 20 | 8 | 20 | 8 | 18 | 6 | 20 | 8 |
| Joint significant tests | | | | | | | | |
| Wald $chi^2(2)$ | 18.62** | 14.51** | 19.59** | 11.18** | 12.08** | 9.3** | 17.98** | 10.5** |
| Prob > $chi^2$ | 0.0001 | 0.0007 | 0.0001 | 0.0037 | 0.0024 | 0.0096 | 0.0001 | 0.0053 |

Note: Absolute value of z-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

Table 2 shows the results for maize. Although a robust inference is ruled out, comments are given on a subset of the results. In Case 1 for 1986-2008, the coefficient on the price of maize is negative and significant at the 10 percent level, while that on the lagged price is positive and significant at the 5 percent level. Thus the initial negative price effect at *t* is followed by positive effects in *t*-1 to *t*-5. However, the current and lagged prices are not significant in Case 2. In Cases 3 and 4, where prices are in logs, the current price has a positive effect, while the lagged price has a negative effect. In Case 5 for 1986-2008 with predicted prices, the current price has a positive but non-significant coefficient, while the lagged price has a positive and significant coefficient at the 1 percent level. In Case 6, however, both current and lagged prices have positive and significant effects at the 1 percent level, while lagged stock has a positive and significant effect at the 1 percent level. However, we are wary of drawing any inference in view of the few degrees of freedom.

The second panel shows that in Cases 3 and 5 the current and lagged price effects are positive for *t* to *t*-5. For the former, the LRP is 0.831 and for the latter it is considerably higher (9.748). The plausibility of the higher LRP is not self-evident as the predicted prices may not track actual prices as closely as they should.

The last panel in Table 2 shows the results without lagged price. As the current price variable does not have a significant effect on maize stocks in any of the eight cases, no further comment is necessary.

**Table 2. Rational distributed lag model of maize stock and prices**
**Case A: With lagged price (Equation (2))**

Dependent variable: annual stock of maize

GMM Estimation

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Price of maize | -0.288 | -0.171 | 0.564 | 0.139 | 0.124 | 0.454 | -0.211 | -0.172 |
| | (1.77) | (0.80) | (2.49)* | (0.34) | (0.69) | (3.08)** | (1.15) | (0.87) |
| Stock of maize(-1) | 0.752 | 0.327 | 0.722 | 0.263 | 0.897 | 0.842 | 0.721 | 0.194 |
| | (4.94)** | (1.81) | (4.27)** | (1.20) | (9.69)** | (6.91)** | (3.95)** | (0.86) |
| Price of maize (-1) | 0.579 | 0.184 | -0.333 | -0.214 | 0.88 | 1.256 | 0.234 | -0.125 |
| | (2.54)* | (0.43) | (1.75) | (0.86) | (4.30)** | (4.70)** | (1.06) | (0.38) |
| Constant | -0.062 | 80.948 | 0.265 | 3.9 | -107.395 | -182.506 | 1.268 | 5.304 |
| | (0.00) | (1.90) | (0.21) | (2.12) | (3.88) | (3.50) | (0.73) | (2.56) |
| Observations | 20 | 8 | 20 | 8 | 18 | 6 | 20 | 8 |
| LRP | 1.173 | 0.019 | 0.831 | -0.102 | 9.748 | 10.823 | 0.082 | -0.368 |
| Joint significant tests | | | | | | | | |
| Wald $chi^2(3)$ | 51.43** | 8.08* | 46.33** | 6.3 | 120.7** | 48.12** | 24.65** | 6.59 |
| Prob > $chi^2$ | 0 | 0.0444 | 0 | 0.0981 | 0 | 0 | 0 | 0.086 |

**Coef. estimates for Equation (3) based on the estimates of Equation (2) above**

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Effect of price: | | | | | | | | |
| at *t* on stock at *t* | -0.288 | -0.171 | 0.564 | 0.139 | 0.124 | 0.454 | -0.211 | -0.172 |
| at *t*-1 on stock at *t* | 0.362 | 0.128 | 0.074 | -0.177 | 0.991 | 1.638 | 0.082 | -0.158 |
| at *t*-2 on stock at *t* | 0.273 | 0.042 | 0.054 | -0.047 | 0.889 | 1.379 | 0.059 | -0.031 |
| at *t*-3 on stock at *t* | 0.205 | 0.014 | 0.039 | -0.012 | 0.798 | 1.161 | 0.043 | -0.006 |
| at *t*-4 on stock at *t* | 0.154 | 0.004 | 0.028 | -0.003 | 0.715 | 0.978 | 0.031 | -0.001 |
| at *t*-5 on stock at *t* | 0.116 | 0.001 | 0.020 | -0.001 | 0.642 | 0.823 | 0.022 | 0.000 |

Note: Absolute value of z-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

**Case B: Without lagged price (Equation (1))**

Dependent variable: annual stock of maize
GMM Estimation

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Price of maize | -0.035 (0.25) | -0.085 (1.08) | -0.045 (0.28) | -0.139 (1.25) | 0.448 (1.80) | 0.292 (0.93) | -0.19 (1.05) | -0.206 (1.42) |
| Stock of maize(-1) | 0.726 (3.73)** | 0.302 (1.74) | 0.71 (3.36)** | 0.241 (1.14) | 0.837 (5.26)** | 0.461 (2.35)* | 0.628 (3.22)** | 0.237 (1.19) |
| Constant | 42.309 (1.04) | 94.621 (3.21) | 1.643 (1.02) | 4.31 (3.09) | -30.783 (0.75) | 30.174 (0.59) | 2.753 (1.77) | 4.654 (3.17) |
| Observations | 20 | 8 | 20 | 8 | 18 | 6 | 20 | 8 |
| Joint significant tests | | | | | | | | |
| Wald $chi^2(2)$ | 20** | 7.67* | 18.09** | 6.08* | 28.57** | 5.5 | 17.43** | 7.1* |
| Prob > $chi^2$ | 0 | 0.0216 | 0.0001 | 0.0479 | 0 | 0.0638 | 0.0002 | 0.0287 |

Note: Absolute value of z-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

The results for rice in Table 3 are different from those for wheat or maize. In most cases, the effects of price on stock are positive and persistent. The results in the middle panel show that the effects of lagged and current prices (*t* to *t*-5) are positive in most cases except Case 2 in which a small negative effect is observed at *t*, followed by persistently positive effects in *t*-1 to *t*-5. The first panel indicates that lagged rice stock has a positive and highly significant effect (at the 1 percent level) for all cases. In Case 1 with actual prices for 1986-2008, we find a positive but non-significant effect of current price and a positive and significant effect of the lagged price on rice stock. The results for Case 2 are similar except that the current price effect is negative but non-significant. In Cases 3, 4, 5, 6, and 7, the coefficient estimate of current price is positive and significant in explaining the rice stock, lagged stock is highly significant and lagged price is not significant. In Case 8, neither current nor lagged price is significant. LRP is positive in most cases, but negative in Case 6 and 7. Of particular significance is the fact that in Cases 1, 3 and 5, the LRPs are substantial (8.5, 14.15, 13.1, respectively). These estimates imply a strong positive effect of prices on rice stocks.

We find positive and significant coefficient estimates for current price in explaining rice stock in Cases 3, 4, 5, 6, 7, and 8. In Cases 1 and 2, however, these coefficients are weakly significant (i.e., at the 15 percent level). So, as noted in other studies (Sekhar 2003), stock of rice responds more sensitively to its price changes than does wheat or maize stock. As in other commodities, lagged stock has a positive and significant effect on current stock.[8]

**Table 3. Rational distributed lag model of rice stock and price**
**Case A: With lagged price (Equation (2))**

Dependent variable: annual stock of rice
GMM Estimation

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Price of rice | 0.023 | -0.078 | 0.343 | 0.509 | 0.357 | 0.856 | 0.305 | 0.087 |
| | (0.38) | (0.82) | (3.90)** | (2.87)** | (3.85)** | (2.49)* | (3.12)** | (0.19) |
| Stock of rice (-1) | 0.966 | 0.822 | 0.974 | 0.88 | 0.965 | 1.175 | 1.044 | 0.899 |
| | (11.52)** | (8.98)** | (14.05)** | (8.13)** | (10.54)** | (6.59)** | (12.98)** | (3.29)** |
| Price of rice (-1) | 0.266 | 0.376 | 0.025 | -0.122 | 0.101 | -0.078 | 0.105 | 0.252 |
| | (3.56)** | (2.43)* | (0.31) | (0.80) | (1.18) | (0.36) | (1.22) | (0.77) |
| Constant | -37.369 | -25.047 | -1.694 | -1.358 | -59.514 | -118.013 | -2.238 | -1.235 |
| | (2.56)* | (1.44) | (3.37)** | (1.50) | (3.71)** | (3.34)** | (3.62)** | (0.60) |
| Observations | 20 | 8 | 20 | 8 | 18 | 6 | 20 | 8 |
| LRP | 8.500 | 1.674 | 14.154 | 3.225 | 13.086 | -4.446 | -9.318 | 3.356 |
| Joint significant test | | | | | | | | |
| Wald $chi^2(3)$ | 180.68** | 112.86** | 298.59** | 129.43** | 155.17** | 452.27** | 201.16** | 106.93** |
| Prob > $chi^2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Coef. estimates for Equation (3) based on the estimates of Equation (2) above**

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Effect of price: | | | | | | | | |
| at *t* on stock at *t* | 0.023 | -0.078 | 0.343 | 0.509 | 0.357 | 0.856 | 0.305 | 0.087 |
| at *t*-1 on stock at *t* | 0.288 | 0.312 | 0.359 | 0.326 | 0.446 | 0.928 | 0.423 | 0.330 |
| at *t*-2 on stock at *t* | 0.278 | 0.256 | 0.350 | 0.287 | 0.430 | 1.090 | 0.442 | 0.297 |
| at *t*-3 on stock at *t* | 0.269 | 0.211 | 0.341 | 0.252 | 0.415 | 1.281 | 0.462 | 0.267 |
| at *t*-4 on stock at *t* | 0.260 | 0.173 | 0.332 | 0.222 | 0.400 | 1.505 | 0.482 | 0.240 |
| at *t*-5 on stock at *t* | 0.251 | 0.142 | 0.323 | 0.195 | 0.386 | 1.769 | 0.503 | 0.216 |

Note: Absolute value of z-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

[8] For a graphical illustration of the price and stock relationships, see Appendix 2. The graph for wheat does not reflect a positive relationship while those for maize and rice do. However, we are inclined to go more by the econometric evidence-especially long rum propensities of stocks to prices.

**Case B: Without lagged price (Equation (1))**

Dependent variable: annual stock of rice

GMM Estimation

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|---|---|---|---|---|---|---|---|---|
| Whether in log? | No | No | Yes | Yes | No | No | Yes | Yes |
| Price predicted by oil prices? | No | No | No | No | Yes | Yes | Yes | Yes |
| Period | 1986-2008 | 2001-08 | 1986-2008 | 2001-08 | 1986-2006 | 2001-06 | 1986-2008 | 2001-08 |
| | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) | Coef. (Z-stat) |
| Price of rice | 0.108 (1.63) | 0.106 (1.43) | 0.208 (2.47)* | 0.2 (1.47) | 0.421 (5.26)** | 0.737 (6.69)** | 0.383 (5.04)** | 0.435 (3.24)** |
| Stock of rice(-1) | 0.969 (8.13)** | 0.795 (6.33)** | 1.024 (9.84)** | 0.894 (5.33)** | 1.01 (11.54)** | 1.116 (15.34)** | 1.079 (14.10)** | 1.082 (7.64)** |
| Constant | -13.114 (0.66) | -2.566 (0.12) | -1.151 (1.49) | -0.558 (0.42) | -59.914 (3.52)** | -107.191 (5.56)** | -2.27 (3.65)** | -2.549 (2.05)* |
| Observations | 20 | 8 | 20 | 8 | 18 | 6 | 20 | 8 |
| Joint significant tests | | | | | | | | |
| Wald $chi^2(2)$ | 71.16 | 54.92 | 102.14 | 47.02 | 136.75 | 417.79 | 200.34 | 97.47 |
| Prob > $chi^2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Note: Absolute value of z-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

## 3 Conclusion

Much of the recent work has raised the issue that the surge in the prices of foodgrains in the last two years cannot be explained satisfactorily in terms of the fundamentals of supply and demand. It has also been suggested that the part not explained in this way is due largely to speculation. Speculation influences food prices in two distinct ways: one is the huge influx of capital from commodity index funds, hedge funds and pension funds in commodity futures markets or options. A suggestive piece of evidence is that expiry prices in commodity futures markets are considerably higher than cash or spot prices, implying that futures markets are not facilitating price discovery.[9] The second is purchase or hoarding of commodities on the presumption that their prices will continue to rise. A presumption here is that if commodity prices are expected to rise, market supplies may contract and hoarding of commodities will increase. As global stocks have depleted in recent years, and prices continue to rise, it is asserted that there is little or negligible speculation. There are some difficulties in drawing this conclusion. First, there are hidden stocks; and second, there has been massive panic buying of foodgrains and

[9] As Gilbert (2008) argues, the 'weight of money' matters in the short-term when markets are tight and so relatively small transactions can have a disproportionate impact. But equally important is the implication that in such an event the fundamentals of demand and supply may take longer to reassert their role.

restrictions on food exports which may not show up in global stocks. Also, the relationship is likely to be more robust if stocks are viewed as responding to futures markets prices. In the absence of easy access to futures markets prices, we have experimented with a rational distributed lag model in which changes in global stocks of wheat, maize and rice are linked to current and lagged prices and stocks. The analysis is based on data over 1986-2008, supplemented by results from a considerably shorter but more recent sample over 2000-08. As the latter are unlikely to be robust, we use them with considerable caution.

Although the results vary a great deal with the specification used, what is important to note is that there are many cases in which both current and lagged prices have significant effects on the current stocks of these commodities. Specifically, contrary to assertions made, the long-run propensity to hold stocks (or the long-run effect of commodity prices) is positive. In the case of rice, the propensities are substantially larger. This corroborates that speculative hoarding has contributed to exacerbating the shortages in the global food market and thus reignited inflation.

If this view is corroborated, while correcting the demand-supply imbalances will remain a top priority, careful attention must also be given to limiting speculation. Various suggestions (Duflo 2008; von Braun and Torero 2008) include:

- Implementing technical reforms, especially those related to commodity delivery, in order to tighten links with cash prices;

- More comprehensive and detailed reporting of transactions, to better understand speculative activities;

- Imposing limits on the size of speculative positions, especially for index fund investors;

- Revising margin requirements (requiring investors to provide larger 'down payments' on futures contracts); and

- A 'virtual grain reserve' to be established to help calm markets through the futures market.[10] And, above all, there is a strong case for a better functioning trading system, in particular for trade liberalization in agriculture and to build trust in global food markets and stock management.

In conclusion, the benefits of emergency relief would be reinforced by the insurance against a collapse of food entitlements.

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[10] As Duflo notes (2008), maintaining large stockpiles of grains by the government buying when prices are low and selling when the prices are high has not worked well in India.

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## Appendix 1: Results of VAR model for prices of foodgrain

### Table A-1. VAR model for wheat price

| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| p_wheat_w | 21 | 9.000 | 14.5643 | 0.6663 | 41.9263 | 0 |
| oil | 21 | 9.000 | 8.89645 | 0.4648 | 18.2406 | 0.0195 |

| | | | |
|---|---|---|---|
| p_wheat_w | | | |
| p_wheat_w | | | |
| | L1 | 0.842 | (4.58)** |
| | L2 | -0.746 | (-3.11)** |
| | L3 | 0.373 | (1.51) |
| | L4 | -0.402 | (-2.16)* |
| oil_r | | | |
| | L1 | -0.381 | (-0.97) |
| | L2 | -0.164 | (-0.35) |
| | L3 | -0.732 | (-1.59) |
| | L4 | 0.758 | (2.18)* |
| _cons | | 128.052 | (4.47)** |
| oil_r | | | |
| p_wheat_w | | | |
| | L1 | 0.101 | (0.90) |
| | L2 | -0.192 | (-1.31) |
| | L3 | 0.103 | (0.68) |
| | L4 | -0.071 | (-0.62) |
| oil_r | | | |
| | L1 | 0.730 | (3.03)** |
| | L2 | -0.151 | (-0.53) |
| | L3 | -0.014 | (-0.05) |
| | L4 | 0.027 | (0.13) |
| _cons | | 19.519 | (1.11) |

**Table A-2. VAR model for log of wheat price**

| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| logp_wheat_w | 24 | 9 | 0.18227 | 0.7484 | 71.3744 | 0 |
| logoil_r | 24 | 9 | 0.28663 | 0.6926 | 54.0768 | 0 |

| | | |
|---|---|---|
| logp_wheat_w | | |
| logp_wheat_w | | |
| L1 | 1.521 | (5.94)** |
| L2 | -0.985 | (-2.48)* |
| L3 | 0.440 | (1.06) |
| L4 | -0.040 | (-0.13) |
| logoil_r | | |
| L1 | 0.118 | (0.84) |
| L2 | 0.091 | (0.51) |
| L3 | -0.059 | (-0.33) |
| L4 | -0.027 | (-0.20) |
| _cons | -0.089 | (-0.06) |
| logoil_r | | |
| logp_wheat_w | | |
| L1 | 0.800 | (1.99)* |
| L2 | -0.834 | (-1.33) |
| L3 | 0.380 | (0.58) |
| L4 | -0.013 | (-0.03) |
| logoil_r | | |
| L1 | 0.868 | (3.93)** |
| L2 | -0.169 | (-0.60) |
| L3 | 0.211 | (0.75) |
| L4 | -0.137 | (-0.66) |
| _cons | -0.813 | (-0.37) |

**Table A-3 VAR model for maize price**

| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| p_maize_w | 21 | 9 | 16.0775 | 0.6141 | 33.4211 | 0.0001 |
| oil_r | 21 | 9 | 8.51025 | 0.5103 | 21.883 | 0.0051 |

| | | | |
|---|---|---|---|
| p_maize_w | | | |
| p_maize_w | | | |
| | L1 | 0.545 | (2.73)** |
| | L2 | -0.110 | (-0.47) |
| | L3 | -0.198 | (-0.90) |
| | L4 | -0.212 | (-1.15) |
| oil_r | | | |
| | L1 | -0.786 | (-1.67) |
| | L2 | -0.822 | (-1.52) |
| | L3 | 0.263 | (0.51) |
| | L4 | 0.266 | (0.66) |
| _cons | | 145.172 | (4.32)** |
| oil_r | | | |
| p_maize_w | | | |
| | L1 | 0.076 | (0.72) |
| | L2 | -0.126 | (-1.02) |
| | L3 | -0.095 | (-0.81) |
| | L4 | 0.080 | (0.82) |
| oil_r | | | |
| | L1 | 0.695 | (2.78)** |
| | L2 | 0.014 | (0.05) |
| | L3 | 0.087 | (0.32) |
| | L4 | -0.163 | (-0.77) |
| _cons | | 19.083 | (1.07) |

## Table A-4. VAR model for log of maize price

| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| logp_maize_w | 24 | 9 | 0.1639 | 0.6817 | 51.4002 | 0 |
| logoil_r | 24 | 9 | 0.26866 | 0.7299 | 64.8724 | 0 |

| | | |
|---|---|---|
| logp_maize_w | | |
| logp_maize_w | | |
| L1 | 1.202 | (5.68)** |
| L2 | -0.766 | (-2.62)** |
| L3 | 0.083 | (0.28) |
| L4 | 0.166 | (0.73) |
| logoil_r | | |
| L1 | 0.129 | (1.02) |
| L2 | -0.048 | (-0.29) |
| L3 | 0.205 | (1.28) |
| L4 | -0.219 | (-1.90) |
| _cons | 1.295 | (0.95) |
| logoil_r | | |
| logp_maize_w | | |
| L1 | 0.647 | (1.87) |
| vL2 | -0.752 | (-1.57) |
| L3 | -0.204 | (-0.42) |
| L4 | 0.458 | (1.22) |
| logoil_r | | |
| L1 | 0.883 | (4.27)** |
| L2 | -0.064 | (-0.24) |
| L3 | 0.313 | (1.20) |
| L4 | -0.306 | (-1.62) |
| _cons | -0.092 | (-0.04) |

**Table A-5. VAR model for rice price**

| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| p_rice_w | 21 | 9 | 18.921 | 0.6902 | 46.7772 | 0 |
| oil_r | 21 | 9 | 7.52558 | 0.6171 | 33.839 | 0 |

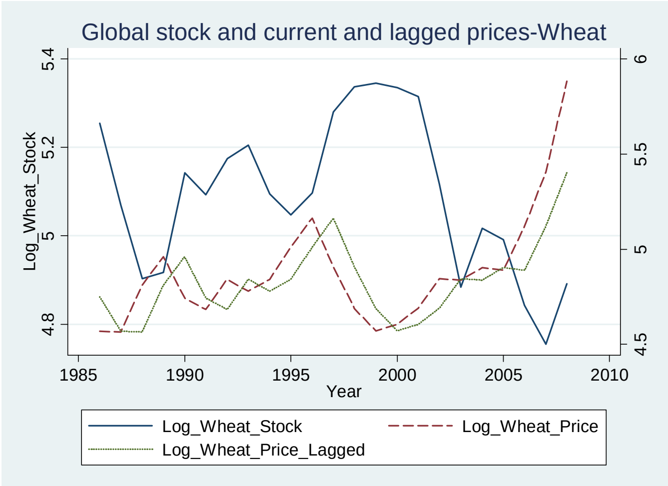
| | | | |
|---|---|---|---|
| p_rice_w | | | |
| p_rice_w | | | |
| | L1 | 0.655 | (3.32)** |
| | L2 | 0.207 | (0.83) |
| | L3 | -0.149 | (-0.64) |
| | L4 | -0.292 | (-1.94) |
| oil_r | | | |
| | L1 | -0.442 | (-0.86) |
| | L2 | 0.057 | (0.09) |
| | L3 | -0.311 | (-0.52) |
| | L4 | 0.616 | (1.41) |
| _cons | | 79.289 | (3.09)** |
| oil_r | | | |
| p_rice_w | | | |
| | L1 | 0.065 | (0.83) |
| | L2 | -0.024 | (-0.25) |
| | L3 | -0.225 | (-2.42)* |
| | L4 | 0.060 | (1.00) |
| oil_r | | | |
| | L1 | 0.662 | (3.25)** |
| | L2 | -0.052 | (-0.21) |
| | L3 | -0.087 | (-0.36) |
| | L4 | -0.036 | (-0.21) |
| _cons | | 32.226 | (3.16) |

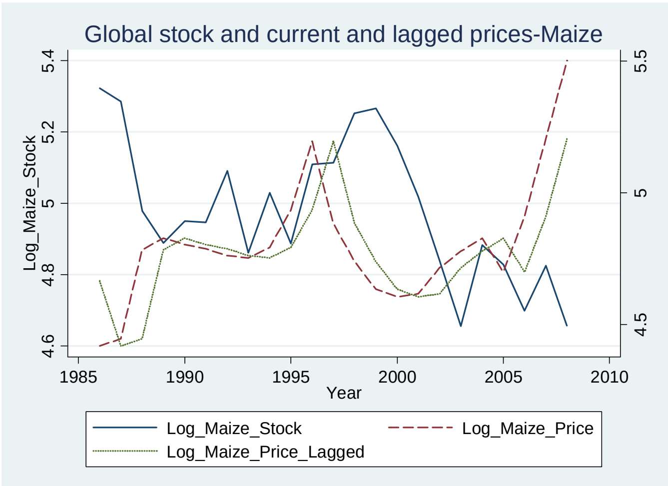
## Table A-6. VAR model for log of rice price

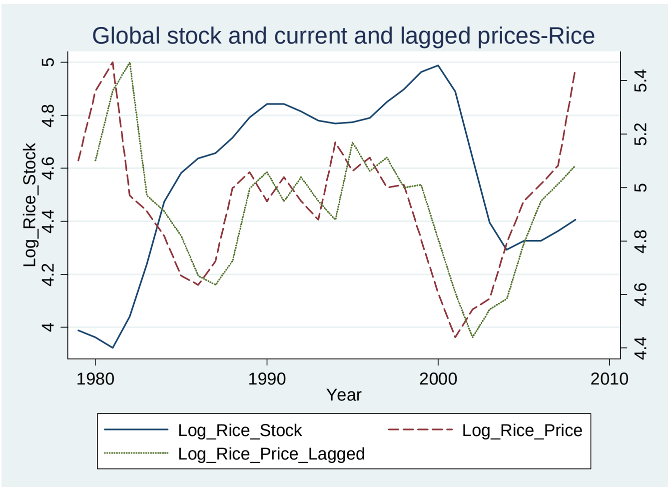
| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| logp_rice_w | 24 | 9 | 0.15185 | 0.726 | 63.6034 | 0 |
| logoil_r | 24 | 9 | 0.27446 | 0.7182 | 61.1581 | 0 |

| | | |
|---|---|---|
| logp_rice_w | | |
| logp_rice_w | | |
| L1 | 0.785 | (3.47)** |
| L2 | 0.118 | (0.39) |
| L3 | -0.026 | (-0.10) |
| L4 | -0.393 | (-2.06)* |
| logoil_r | | |
| L1 | -0.066 | (-0.53) |
| L2 | 0.115 | (0.75) |
| L3 | 0.050 | (0.34) |
| L4 | 0.036 | (0.35) |
| _cons | 2.076 | (2.21)* |
| logoil_r | | |
| logp_rice_w | | |
| L1 | 0.332 | (0.81) |
| L2 | -0.018 | (-0.03) |
| L3 | -0.543 | (-1.09) |
| L4 | -0.119 | (-0.35) |
| logoil_r | | |
| L1 | 0.838 | (3.77)** |
| L2 | -0.108 | (-0.39) |
| L3 | 0.244 | (0.90) |
| L4 | -0.199 | (-1.07) |
| _cons | 2.497 | (1.47) |

**Appendix 2.**
**Trends in global stock and current and lagged prices of foodgrain**



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