

What Determines the Domestic Prices of Agricultural Commodities in Pakistan?

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1. INTRODUCTION

Rarely a month passes-by in Pakistan without complains on the state of basic commodity markets, be it wheat or sugar, cotton or rice. Prices are too high for the consumers, or too low for the farmers; and often the government is asked to intervene, buying for or selling from stocks, prohibiting export or import, increasing or reducing import duties, introducing/withdrawing export taxes, or taking other measures to protect the consumer or producer. It is as if domestic prices can have a life on their own, with the government asked to guarantee “fair” prices for everybody.

The resulting on-and-off policy intervention by the government is likely to have had a deleterious effect on the development of the domestic and international trade for these commodities. This is because of the uncertainty so generated, with the private traders always facing the risk of a regime change at a time when import or export contracts have already been signed. As a result too, the role of the state-owned Trading Corporation of Pakistan self-perpetuates, even if the government would like to see it minimised, as it is always being asked to intervene because of the private sector’s “failings”.

The purpose of this paper is not to analyse the extent of the under-development of commodity markets in Pakistan, although this would be an interesting topic of its own. Instead, the paper will look at whether the *modus operandi*, including government interventions, on the domestic commodity markets have succeeded in isolating domestic commodity prices from developments in the exchange rate and international prices, in other words, escaping the “law of one price”. Departures from the law of one price have implications not only for the welfare of consumers and producers, and efficiency, but also for inflation forecasting and the macroeconomic adjustment to terms of trade shocks. In particular, they would make it possible for domestic *relative* prices to differ from those dictated, *inter alia*, by the international markets.¹

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¹Implications for welfare and efficiency are probably more clear-cut if the departure from the law of one price is also in the long run. In the short-run, there might be advantages to domestic price stabilisation if external shocks are temporary; although this has also been questioned (see below).

Furthermore, the prices of wheat and other key agricultural commodities are important direct or indirect determinants of the CPI. Since these commodities are close-to-perfect “traded-goods”, monetary policy should be expected mostly to determine their domestic prices through its impact on the exchange rate, taking the developments in international prices as exogenous. If other mechanisms are at work, monetary policy would need to integrate them into any model of inflation forecasting. Section 2 takes a descriptive look at the data. Section 3 proposes a “political economy of domestic prices adjustment” able to explain some of the observed price dynamics. Any domestic or external shock that threatens to make one of the market participants (consumers or producers) worse off brings about attempts to resist the adjustment, with or without the help of government. Section 4 uses a general co-integration approach to test (1) the existence of a long-run relationship between the domestic prices, the exchange rate, the international prices, and, when applicable, the domestic “support” prices; and (2) whether the law of one price applies, at least in a “weak” sense, allowing for a possible constant wedge between domestic and international prices. The associated short-run dynamics, in the form of an error correction mechanism, are also discussed. Section 5 summarises the findings of the paper and draws policy recommendations. The main conclusions are:

- There is only weak evidence of co-integration between domestic price, international price, exchange rate, and domestic support price (when applicable) for key agricultural commodities in Pakistan. Only in the case of wheat is the evidence stronger, but it is mainly on account of the inclusion of the support price variable.
- The elasticity of domestic prices to a change in the exchange rate is close to unity for all commodities. In contrast, the elasticity of domestic prices to a change in international prices is close to unity only for cotton and rice. In the case of wheat and sugar, they are much smaller than unity.
- The hypothesis that the “weak” law of one price applies in the long-run can be rejected in the case of wheat and sugar, but cannot be rejected in the case of cotton and rice.

The above results are broadly consistent with a theory of domestic price determination that emphasises political economy considerations when markets are subject to domestic and external shocks, real or monetary, leading to government interventions. While departures from the law of one price, even in the case of homogenous commodities, have been observed in advanced market economies as well, the *extent* of the departures in the case of wheat and sugar in Pakistan is striking. Thus, there appears to be room for improving the functioning of domestic markets for agricultural products, including through a reduction in government interventions and enforcement of more competitive behaviours, away from the current *modus operandi*. Under the current state of affairs, monetary policy needs to consider more complex price dynamics for the purpose of inflation forecasting. The necessary macroeconomic adjustment (equilibrium real exchange rate) to terms of trade shocks would also be hampered, potentially resulting in greater instability of the trade balance.

2. A DESCRIPTIVE LOOK AT THE DATA

In this section, we look at charts depicting times series of domestic prices (in PRs) and international “parity” prices (i.e international prices in US\$ converted in PRs at the market exchange) for wheat, cotton, sugar, and rice (Charts 1a, 1b, 1.c, 1.d). Time series depicting domestic prices expressed in US\$ at the market exchange rate, and international prices in US\$ also guide the interpretation (Charts 2a, 2b, 2c, 2d). International prices for wheat are taken to be US Gulf Ports; for cotton, Liverpool; for sugar, Caribbean (New York); and for IRI rice, Thailand.² In the case of wheat, for which there exists a long time series of domestic support prices, the charts also plot these prices, expressed in PRs and US\$, respectively.³

For wheat and cotton, the domestic and international “parity” prices appear close to each other, if we look at average levels; for sugar, the domestic prices have been systematically higher than their international parity prices based on Caribbean (New York) prices; and for rice, the domestic prices have been systematically lower than their international parity prices based on the Thailand prices. For sugar, the (positive) discrepancy would be explained by the systematic protection offered to local sugar producers; for IRI rice, the (negative) discrepancy appears to reflect quality differences, as well as a relatively weak market infrastructure.

The time series display some interesting properties. First, while, in general, domestic and international parity prices appear to move together, domestic prices tend to be more stable, whether we look at prices in PRs or US\$. This is especially the case for wheat, apparently reflecting the effectiveness of domestic support prices. One exception are domestic cotton prices, which, if at all, appear more volatile than their international parity prices (Table 1).

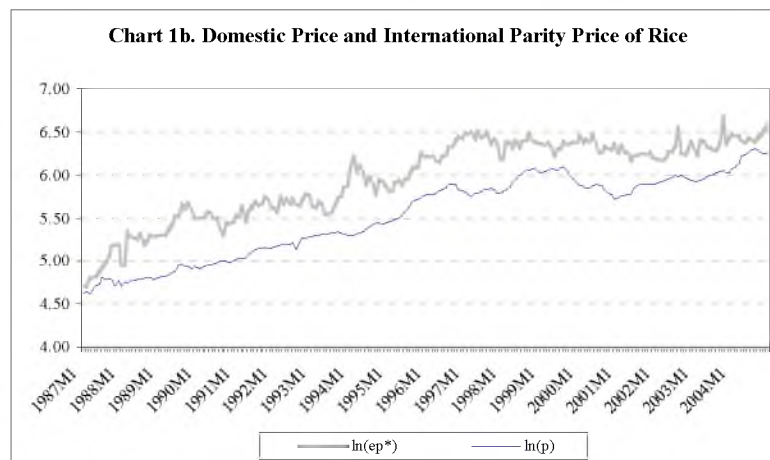
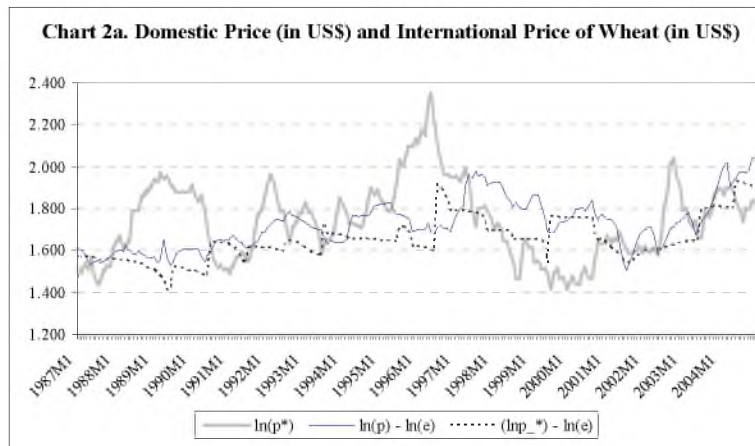
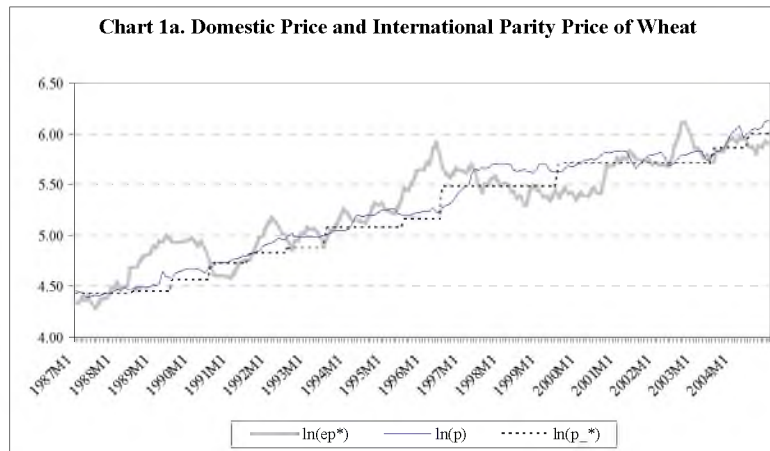
Table 1
*Variance Comparisons*¹

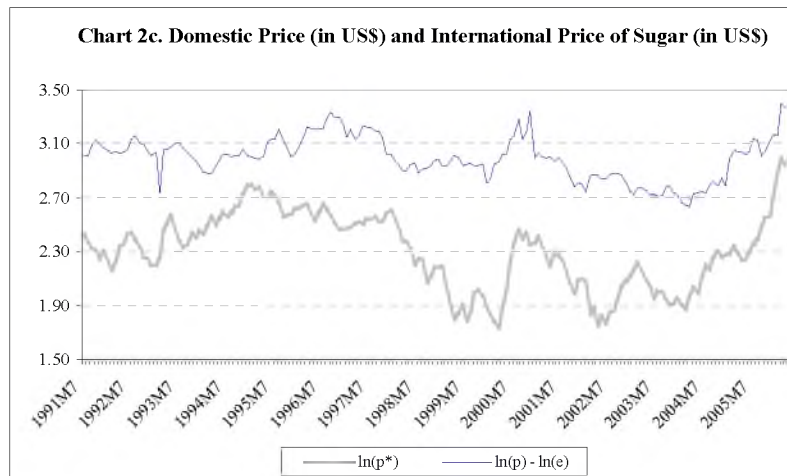
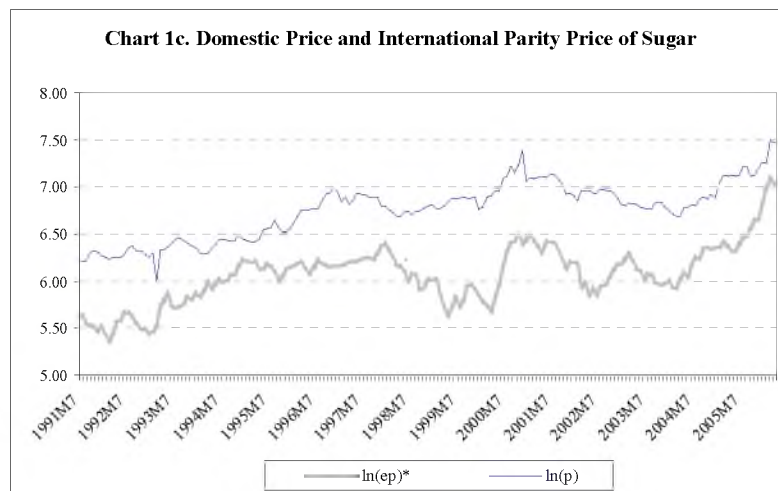
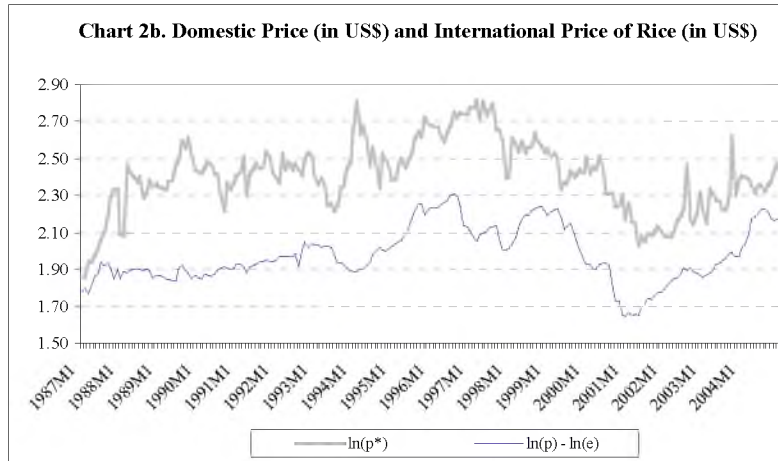
Commodity	$\ln(p^*)$	$\ln(p) - \ln(e)$
Wheat	0.034	0.014
Rice	0.037	0.023
Sugar	0.080	0.025
Cotton	0.050	0.072

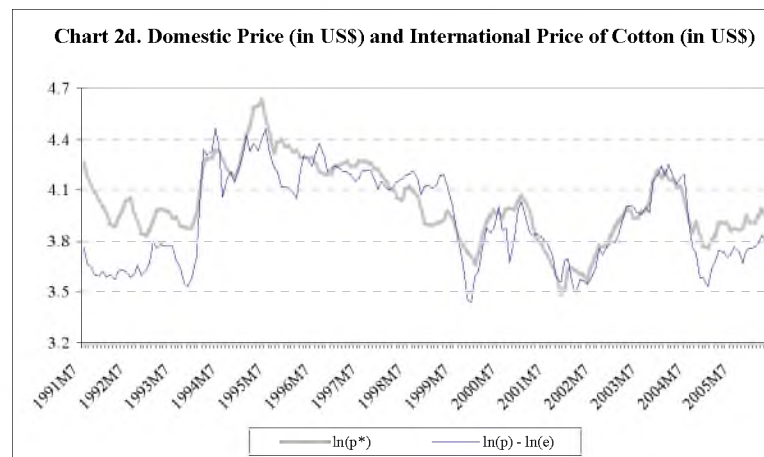
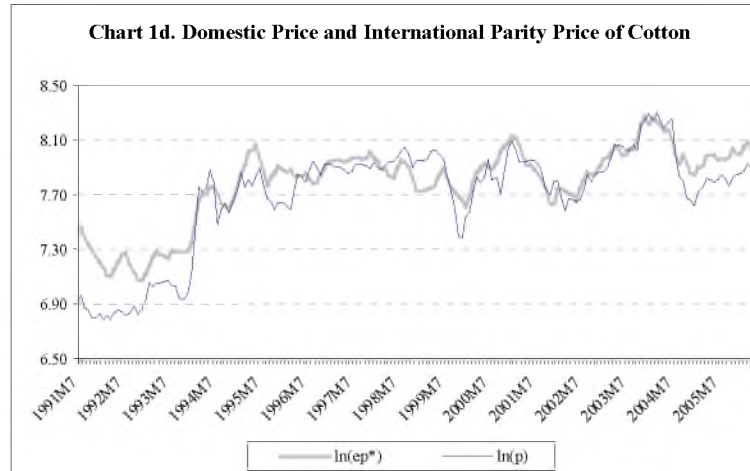
¹Sample Variance.

²International Financial Statistics (IFS), IMF.

³The Ministry of Agriculture also publishes a list of support/ intervention prices for rice and cotton (seed). In contrast to the case of wheat support price, they operate mainly as indicative prices, with very limited government intervention taking place at those prices. An initial effort to integrate them in the empirical analysis suggested their irrelevance. Therefore, we have excluded them from the analysis reported in this paper.







Second, there is evidence of fairly long periods of time during which domestic prices have tended to be systematically higher or lower than their international parity prices (in the case of sugar and rice, this statement must be understood as the *wedge* between the two prices being systematically higher or lower than on average). This is particularly striking for wheat during 1989-90, 1996-97, and 2003 (domestic prices lower), as well as 1998-2000 and 2005-06 (domestic prices higher). Typically, when international prices for wheat (in US\$) have surged, domestic prices have not followed up, and the same has been true when international prices have dipped, suggesting, in the first instance, that measures were taken to protect the domestic consumers, and in the second instance, the domestic producers, including through the support price mechanism.

Cotton prices since 2004 offer a striking contrast, with domestic prices in 2004 falling more than their international parity prices, and remaining below. The reason appears to be the bumper crop of 2004-05, which was allowed to strongly impact on domestic prices, thereby providing especially cheap inputs to the textile sector, with cotton exports only partially picking up the excess supply. A similar situation appears to have prevailed in 1999.

Since the second half of 2005, measures have been taken to prevent the surge in international prices for sugar to all time highs to lead to a similar increase in domestic prices, including the removal of pre-existing protective duties and taxes, and a ban on exports. As a result, the positive wedge between domestic and international prices has virtually disappeared. This is in sharp contrast with the 1998–2000 period during which a sharp decline in international prices was accompanied by only a marginal decline in the domestic prices, resulting in a widening of the wedge between the two prices.

3. THEORETICAL CONSIDERATIONS

This section provides a simple theoretical framework to analyse the empirical observations. If domestic prices fail to reflect international prices at prevailing exchange rates for long periods of time, what is inhibiting the international price arbitrage for those key agricultural commodities?

There are obvious reasons why the law of one price may not fully apply, such as quality differences, imperfect market development, systematic protection from imports or discouragement of exports, transportation bottlenecks and thus costs, or simply statistical problems with the price series used. Many of these factors appear to have been fairly constant in the period studied, though the possibility of structural and systematic policy shifts, and thus the so-called Lucas' critique, must be recognised. Here, we will focus on factors more directly related to the short-run functioning of markets, in particular possible interferences (by government or others) in the competitive market mechanisms on behalf of one or other participant when those markets are subject to domestic and external shocks. The analysis will, in particular, highlight the political economy considerations underpinning these interventions.

It is convenient to think of the following demand and supply functions for commodity i :

$$d_i = a_i (M/p_i)^{c_i} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \quad (1)$$

where:

- d_i = demand for commodity i
- a_i, c_i = fixed parameters
- M = money stock
- p_i = domestic price of commodity i

$$s_i = k_i (w/p_i)^{b_i} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \quad (2)$$

where:

- s_i = supply of commodity i
- k_i, b_i = fixed parameters
- w = domestic money wage

Furthermore, we will make the simplifying assumption that the domestic money wage is constant in foreign currency (US\$) terms,⁴ i.e.:

$$w = e \underline{w}^* \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \quad (3)$$

⁴This is to abstract from peripheral issues.

where:

\underline{w}^* = fixed US\$ wage

e = exchange rate (PRs per US\$)

Fig. 3a.

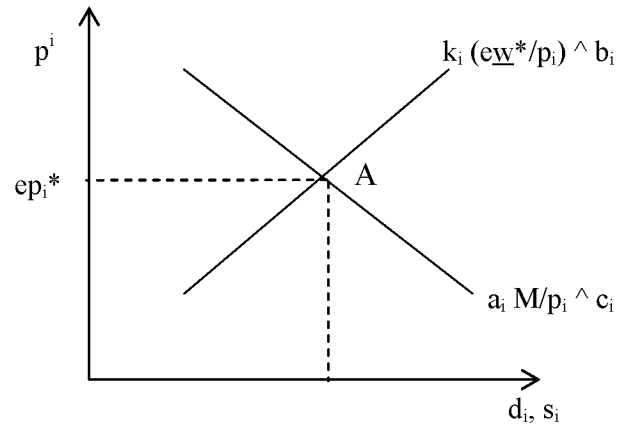


Fig. 3b.

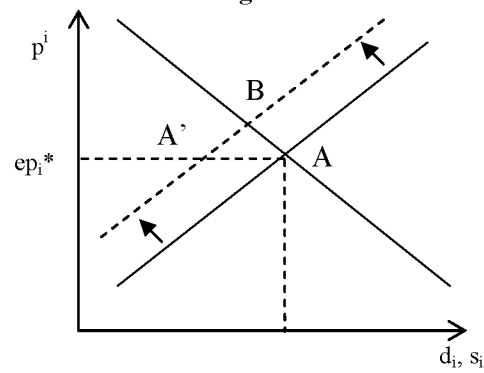


Fig. 3c.

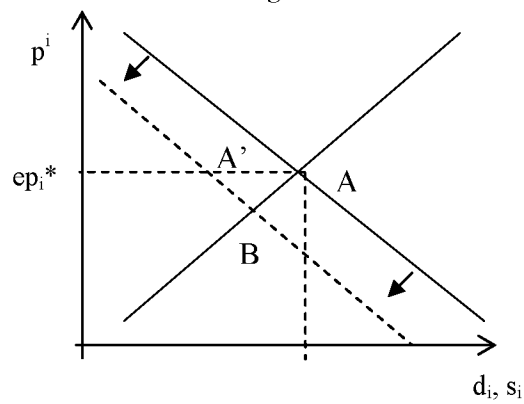


Fig. 3d.

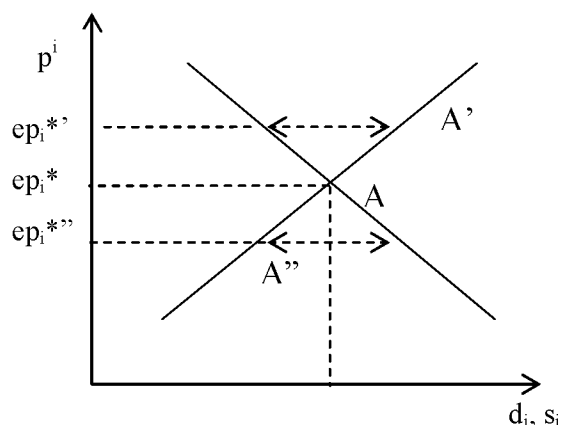


Fig. 3e.

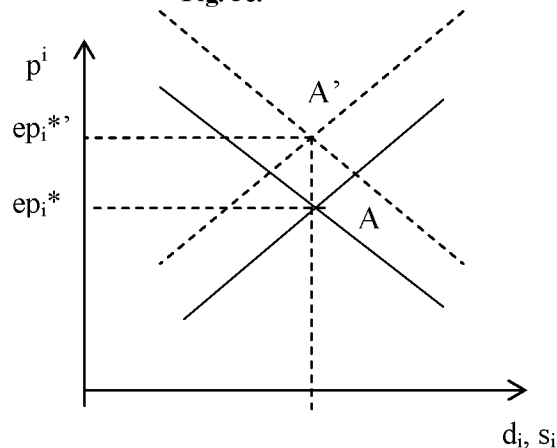


Figure 3a illustrates a market equilibrium for which it happens that $p_i = e p_i^*$, where p_i^* is the international (US\$) price for commodity i , i.e. the law of one price applies, and furthermore, autarky prevails at this equilibrium (neither export nor import). Equilibrium point A is a useful benchmark.

Four types of shocks are considered. In each experiment, we limit the discussion to the cases where the direction of shocks point to at least one of the market participants (i.e. the demand/ consumer or supply/ producer side) being made worse off by not resisting the market mechanism/ trade. This can perhaps be viewed as a sufficient condition for any real pressure to resist the market mechanisms to materialise. With this qualification, the following shocks are highlighted.

- (1) **Negative Domestic Supply Shock**, in the form of downward shift in the supply parameter k_i , for example the impact of poor rains (Figure 3b). If the law of one price continues to prevail, the market equilibrium moves from A to A' , with the country *importing* AA' . Clearly, the domestic producer would prefer to move from A to B rather than to A' , i.e. the no-trade option. Preempting imports would allow

the producer to limit its losses from the adverse supply shock. If he is successful, the law of one price will generally cease to apply.⁵ Any domestic support price at the initial equilibrium price would then become ineffective.

- (2) **Negative Domestic Demand (Non-monetary) Shocks**, for example impact of adverse shift in preferences or perceived lower permanent income (Figure 3c). The market equilibrium moves from A to A', with the country *exporting* AA'. In this case, it is the consumer who would prefer to see the market equilibrium moving from A to B rather than A to A'. Any domestic support price at the initial equilibrium price would become effective in support of an export scenario.
- (3) **Shocks to International Commodity Prices**. Everything else the same, including the exchange rate, an increase (decrease) in international commodity prices, if passed-through onto domestic prices, would decrease (increase) domestic demand and encourage (discourage) domestic supply and exports (imports). In the event of an increase in international prices, domestic prices could remain unchanged if the government introduces an export ban or export tax to protect the consumer. Any domestic support price at the initial equilibrium price would become ineffective unless accompanied by an export ban. In the event of a decrease in international prices, domestic prices could remain constant if imports are discouraged by a ban on imports or the imposition of import duties to protect the producers. Any domestic support price at the initial equilibrium price would become effective if accompanied by an import ban. In either case, interference would preempt domestic prices to be consistent with the law of one price (Figure 3d).

We complete this theoretical discussion by considering one type of shock for which there does not appear to be any incentive for neither the producer nor the consumer to block the market mechanism, the case of a purely monetary/ exchange rate shock.

- (4) **Monetary/Exchange Rate Shocks to Demand and Supply**, for example an increase in the money stock leading to a proportional depreciation of the exchange rate (Figure 3e). There appears to be no obvious reason preventing the equilibrium to move from A to A', with the depreciation of the exchange rate being fully passed through onto the domestic price, and the law of one price continuing to prevail. Any domestic support price at the initial equilibrium price would have to increase proportionally not to become ineffective.

Thus, the analysis also suggests that some types of shocks are more likely to induce intervention in the competitive market mechanism than others. In particular, "real" shocks in the domestic supply and demand, and in international prices appear more likely to induce such intervention, and thus failure of the law of one price, than purely "monetary/ exchange rate" shocks.

⁵In the case of a positive supply shock, the surplus could simply be exported, leaving the consumer unaffected and the producer better off. However, as observed, with the bumper cotton crop of 2004-05, the consumer (the textile sector) was apparently allowed to benefit from domestic prices lower than international prices.

The intuitive analysis presented above suggests that, in practice, *actual* domestic prices could turn out to be some weighted average of the *no-trade equilibrium* domestic prices, obtained from $d_i = s_i$, and of the *international parity* prices. Assuming that the weights are λ and $(1-\lambda)$, respectively, we derive:⁶

$$\ln p_i = \lambda [(\ln a_i - \ln k_i - b_i \ln \underline{w}^*) / (c_i - b_i)] + \lambda [(-b_i \ln e + c_i \ln M) / (c_i - b_i)] + (1-\lambda) \ln e + (1-\lambda) \ln p_i^* \quad \dots \quad \dots \quad \dots \quad \dots \quad (4)$$

Assuming that M/e is always constant, and without loss of generality that it is equal to 1, expression (4) reduces to:

$$\ln p_i = \lambda [(\ln a_i - \ln k_i - b_i \ln \underline{w}^*) / (c_i - b_i)] + \ln e + (1-\lambda) \ln p_i^* \quad \dots \quad \dots \quad (5)$$

Note that the coefficient for $\ln e$ is unity.⁷

An interesting question is whether it is reasonable to assume that the contemporaneous international price alone enters the domestic price equation in the linear fashion assumed, irrespective of its *absolute* level. The Charts 1 and 2, for wheat in particular, clearly suggest that this is not the case; temporary spikes or collapses in international prices are less passed-through. Some notion of “normal” international prices seems to play a role in the determination of domestic prices.

In the case of wheat, the domestic support price (expressed in US\$)⁸ appears to be a reasonable proxy for that “normal” price. Because in Pakistan procurement at the support price covers only a fraction of market transactions, domestic *market* prices can of course differ from the support price. To reflect the above considerations, we expand Equation (5) into Equation (6) as follows:

$$\ln p_i = a_0 + \ln e + (1-\lambda) (1-\zeta) \ln p_i^* + (1-\lambda) \zeta \ln \underline{p}_i^* \quad \dots \quad \dots \quad \dots \quad (6)$$

where \underline{p}_i^* is the support price (expressed in US\$) and $0 = \zeta = 1$.

It is worth illustrating one theoretical prediction from Equation (6): assume that between two time periods, both the international price (in US\$) and the support price, usually set in domestic currency terms, are fixed, but that there is a monetary shock leading to a proportional exchange rate depreciation. Equation (6) suggests that the impact on the domestic price for wheat will be $\Delta \ln e - (1-\lambda) \zeta \Delta \ln e$,⁹ which could be small if the wheat market is open to international trade (i.e. $(1-\lambda)$ is close to unity) and there is a strong support price policy set in domestic currency terms (i.e. ζ is close to unity). Under such circumstances, a monetary/ exchange rate shock, everything else remaining the same, might have little pass-through on the domestic price.

Generally, one could expect the support price to influence differently the domestic market prices when the support price is *effective*, i.e. when it is higher than the international price, than when it is *ineffective*. And conversely for the influence

⁶When there is a systematic wedge between domestic and international parity prices, the weighted average is between the no-trade equilibrium price and $\ln \theta + \ln p^*$, where the constant θ is the wedge.

⁷Ardeni (1989) does not allow for differentiated impact of the exchange rate and international price.

⁸Expressing the domestic support price in US\$ is consistent with the theoretical reasoning of the previous Section.

⁹Recall that with a fixed support price in domestic currency terms, a depreciation of the exchange rate will reduce the support price in foreign currency terms proportionally.

of the international price. Thus, one might have to allow for two different “regimes” in the relationship, although the experience has been that official procurement still goes on at the support price when it is below the international price, simply because of the reliability of the official procurement system, especially for small farmers. In addition, the domestic support price tends to serve as a benchmark for the private procurement as well.

We did in fact perform for wheat the econometric analysis described below under various regime specifications using dummy variables and data partitioning. Results were statistically poor, and generally not supportive of the view that the support price variable loses its significance when it is not effective, as defined above (in fact sometimes the opposite was suggested!). This might be because, even when the support price is not effective, the domestic price movements might still be more closely correlated with the support price movements than the international price movements.¹⁰ It is also worth noting that the support price was effective, as defined above, for only 75 out of 214 observations. Accordingly, these regime specifications are not further discussed below.

4. ECONOMETRIC ANALYSIS

The domestic price equation of expression (6) above has the following immediate empirical counterpart (omitting from now on the subscript i , and for the moment the time subscript t as well):

$$\ln p = a_0 + a_1 \ln e + a_2 \ln p^* + a_3 \ln \underline{p}^* + \mathbf{v} \quad \dots \quad \dots \quad \dots \quad (7)$$

where the domestic supply and demand shocks can be viewed as incorporated within the random variable \mathbf{v} .¹¹ If the law of one price strictly applies, in addition to the theoretical prior $a_1 = 1$ we also have $a_0 = 0$; $a_2 = 1$; and $a_3 = 0$.¹² In what follows, we will mostly be interested in whether the “relative” law of one price applies, i.e. we allow for the constant a_0 to be different from zero.

Since we will use long monthly times series data and we suspect non-stationarities, co-integration techniques to estimate Equation (7) is the right approach.

The first step is to analyse the statistical properties of each data time series y_t . The generalised model accommodating higher-order autoregressive process for the error term is:

$$y_t = \mu + \beta_t + \gamma y_{t-1} + \sum_{j=1}^p \gamma_j \Delta y_{t-j} + \varepsilon_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (8)$$

¹⁰The simple correlations between the domestic price and support price (in US\$ terms) is 0.7 and 0.6 using the partitioned data set for which the support price is effective, and not effective, respectively. Both are significantly higher than the correlations between the domestic price and international price under the same data partitioning.

¹¹The paper by Khan and Schimmelpfennig (2006) provides support for a link between the domestic support price for wheat (in PRs) and domestic inflation, albeit only in the short-run. Here, the analysis allows for a distinction between adjustment in domestic support price (in PRs) which reflects *adjustment* to inflation (via the exchange rate), and that which reflects *independent shock* from the domestic support price (in US\$).

¹²If $\ln \underline{p}^*$ is independent of $\ln p^*$, $a_3 = 0$ is clearly the correct statistical interpretation of the law of one price. If $\ln \underline{p}^*$ were not independent of $\ln p^*$, in the extreme case for instance if $\ln \underline{p}^*$ directly follows $\ln p^*$, $a_2 + a_3 = 1$ might, trivially, be a proper interpretation of the law of one price.

The augmented Dickey-Fuller test for the existence of a unit root has the null hypothesis $\gamma = 1$; the lag length is up to the last lag for which the estimated coefficient is statistically significant according to the t-statistic.

The null hypothesis of a unit root *cannot* be rejected for all (log of) domestic prices time series. Furthermore, the statistically significant estimated lag coefficients indicate that (log of) domestic prices for wheat, cotton, rice, and sugar are all I(1) time series, i.e. integrated of order one. The same is true for the (log of) exchange rate (PRs per US\$) time series, as well as for the (log of) support price (in US\$) time series. On the other hand, the null hypothesis of a unit root *can* be rejected for all (log of) international prices (in US\$) time series, which appear to be I(0), i.e. stationary, though not at the 1 percent level. Sugar also appears to be an exception, and integrated of order 1, I(1) (Table 2). Since the stationarity test for the international prices (in US\$) is weak on the level of prices, but improves significantly when taking the first difference, we can reasonably *assume* in what follows that all series are integrated of the same order 1, and thus proceed with co-integration. In any case, even if we did not assume integration of the same order 1, we can still proceed with the Johansen (1988) co-integration approach because it appears to require only that the time series be *at most* I(1); alternatively, we can re-arrange Equation (8) to read it as involving only time series which are I(1).¹³

First we can relate our finding of weak stationary properties of international prices for agricultural commodities with the literature on the persistence of shocks affecting these prices. If agricultural commodity price series have (or are close to have) a unit root, then shocks would have *permanent* (long lasting) effects.

The knife-edge nature of unit root tests, such as the ADF test, has been criticised by Cashin, Liang, and McDermott (2000), who use the median-unbiased estimator technique proposed by Andrews (1993) to obtain an exact point and interval estimate of the autoregressive parameter in the commodity price data, and to derive from this, measures of the duration of typical price shocks. These authors find that on average shocks to commodity prices are very long-lasting. For instance, they find that the length of time until the impulse response of a unit shock to an economic time series is half its initial magnitude is almost 4 years for wheat, 9 years for (free market) sugar, 8 years for rice, and 12 years for cotton. The policy implications of such results are important, as they suggest that measures aimed at stabilising domestic prices, including explicit or implicit stabilisation schemes, are unlikely to be optimal, because very costly to the budget, or in terms of welfare and allocative efficiency.

We view these findings as consistent with our unit root tests, and therefore will argue that deviations from the (weak) law of one price, as a result of attempts to de-link domestic prices from developments in the international prices for the purpose of protecting the consumers or producers are unlikely to be welfare or efficiency improving in the long run.

¹³ Equation (8) can be re-written as:

$$(7^*) \ln p = a_0 + (a_1 - a_2 - a_3) \ln e + a_2 (\ln p^* + \ln e) + a_3 (\ln \underline{p}^* + \ln e) + \mathbf{v}$$

in which all time series are in fact I(1). The co-integration test and as estimated under the Johansen approach for Equation (7*) turn out to be the same as those for Equation (7).

Table 2
Unit-Root Tests on Individual Series

$$y_t = \mu + \beta_t + \gamma y_{t-1} + \sum_{j=1}^p \gamma_j \Delta y_{t-j} + \varepsilon_t^1$$

Variables	Level ADF	1st Difference ADF	Order of Integration
Exchange Rate			
Ln(e) ²	-1.22	-9.37***	I(1)
Ln(e) ³	-1.80	-8.83***	I(1)
Wheat			
Ln(p)	-0.35	-11.02***	I(1)
Ln(p*)	-2.92**	-	I(0)
Ln(p*)	-2.23	-15.35***	I(1)
Rice			
Ln(p)	-0.99	-10.70***	I(1)
Ln(p*)	-3.56**	-	I(0)
Cotton			
Ln(p)	-2.46	-10.42***	I(1)
Ln(p*)	-2.60*	-	I(0)
Sugar			
Ln(p)	-0.74	-15.77***	I(1)
Ln(p*)	-1.71	-10.25***	I(1)

Note: *, ** and *** indicates the significance at 10 percent, 5 percent and 1 percent respectively.
¹ The optimal lag length p for conducting ADF tests is found by the Schwartz information criteria (SIC). The maximum lag length is 14 in case of 216 observations and 13 in case of 177 observations.
² For Wheat and Rice: total observations 216.
³ For Cotton and Sugar: total observations 177.

Now, proceeding most generally, we give a VAR representation to the Equation (7), as follows:

$$z_t = \mu + \sum_{\tau=1}^k \Pi_{\tau} z_{t-\tau} + \varepsilon_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (9)$$

where $z_t' = [ln p_t, ln e_t, ln p_t^*]$; $\mu' = [\mu_1, \mu_2, \mu_3,]$ is a vector of constants (linear trend in at least some of the variables); and $c_t' = [e_{1t}, e_{2t}, e_{3t}]$.¹⁴ Reparameterisation of expression (9) yields:

$$\Delta z_t = \mu + \sum_{\tau=1}^{k-1} \Gamma_{\tau} \Delta z_{t-\tau} + \Gamma_k z_{t-1} + \varepsilon_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (10)$$

where the matrix $\Gamma_1 = -\Pi_{t+1} - \Pi_{t+2} - \dots - \Pi_k$, and $\Gamma_k = -(I - \Pi_1 - \Pi_2 - \dots - \Pi_k)$. If all z_t are at most I(1), then their first difference is I(0), and therefore the lefthand side of expression (10) is clearly stationary. Whether the righthand side of expression (10), including the estimated ε_t , is stationary will critically depend on the estimated parameters in the matrix Γ_k . Essentially, we are looking for a matrix of vectors, β (the co-integrating vectors), with $a \beta' = \Gamma_k$ (where a is a matrix of adjustment coefficients) that will ensure that $\Gamma_k z_{t-1} = a \beta' z_{t-1}$ is stationary, and thus also the estimated vector of residuals ε_t . These co-integrating vectors will define the long-run relationship between the elements of z_t . We follow the Johansen's approach, based on maximum likelihood estimation.

¹⁴These vectors are easily generalised for the case where a support price variable is added.

Johansen proposes a test to identify how many linearly independent co-integrating vectors might exist, if any; this number is the rank of the (estimated) matrix Γ_k .¹⁵

Table 3 presents the results of the Johansen co-integration test. For all commodities, we conclude that there is at most one co-integrating vector. In the case of wheat, co-integration is established under the Max Eigen Value test and the Trace test at 5 percent confidence. In the case of cotton, co-integration is established at 5 percent confidence only under the Trace test. And for sugar and rice, the co-integration is established only at 10 percent, and only under the Max Eigen value test for sugar.

Table 4 lists the co-integrating equations. Note that we have also allowed for an intercept in the co-integrating equations. For wheat, all estimated parameters, i.e. elasticities, have the right sign; they are close to 1 with high t -statistic for $\ln e$; somewhat above 1 with high t -statistic for $\ln p^*$; and surprisingly small with low t -statistic for $\ln p$. The results suggest that the domestic support price (in US\$) is a key determinant of the domestic price, quite independent from the international price, even in the long-run. Indeed, we verified that the Johansen co-integration tests fail to suggest co-integration when the price equation excludes the support price variable and considers only the international price variable.

We should recognise that the parameter values for $\ln p^*$ and $\ln p$ are not fully consistent with the theoretical prior in Equation (6) since they add up to more, rather than less, than 1. With reference to the theoretical prediction about the pass-through, everything else remaining the same, of an exchange rate depreciation onto the domestic price of wheat, those estimated parameter values would suggest a deflationary rather than inflationary effect in the long term.

In the case of sugar, the parameters are close to 1 for $\ln e$ but very low for $\ln p^*$ with high t -statistic. In contrast, in the case of cotton and rice, the parameters for $\ln e$ and $\ln p^*$ are all close to 1 and with high t -statistics.

We formally test the hypothesis that the vector of coefficients $[1, -1, -1, 0]$ for z_t , consistent with the "weak" law of one price, belongs to the co-integrating space by looking at the ratio between the likelihood function at these values and the maximum likelihood value of the Johansen test; this ratio has a χ^2 distribution. The nul hypothesis that the "weak" law of one price applies is, not surprisingly, strongly rejected in the case of wheat and sugar, while it cannot be rejected in the case of rice and cotton (see last right-hand side column of Table 2).

Empirical studies have looked at the applicability of the law of one price in the case of individual homogenous commodities (see for instance Ardeni, (*op-cit.*) and Mundlak and Larson (1992). How do our results compared with results obtained for the same agricultural commodities among countries which can perhaps be considered models in terms of competitive market functioning? Ardeni found that while the estimated elasticities for a group of domestic commodity prices in the United States, United Kingdom, and Australia with respect to import parity prices are generally close to unity, including in the case of wheat and sugar, co-integration tests in fact often failed to

¹⁵Note that the lag length in expression (10) will be selected using the Hannan-Quinn and Schwartz Information Criterion.

Table 3

Table 4
Cointegrating Equations

	Wheat	Cotton	Sugar	Rice
A. Number of cointegrating vectors	r = 1	r = 1	r = 1	r = 1
B. coefficients on cointegrating vector variables	Vector 1	Vector 1	Vector 1	Vector 1
Constant	0.61	2.18	-2.14	1.13
ln(e)	-0.94 (-22.80)	-1.28 (-11.69)	-1.04 (-11.36)	-1.15 (-16.06)
ln(p*)	-1.50 (-8.19)	-	-	-
ln(p*)	-0.04 (-0.48)	-1.26 (-7.93)	-0.29 (-2.69)	-1.06 (-6.32)
ln(p)	1.00	1.00	1.00	1.00
Log Likelihood	1909.17	1042.26	975.57	1385.51

Note: Numbers in parenthesis are *t*-statistics.

suggest co-integration.¹⁶ But there were exceptions, including for wheat and tea, for which co-integration was established (at 5 percent confidence).

Mundlak and Larson found that domestic prices elasticities with respect to the international prices (in US dollars) and the exchange rate for a group of 57 countries and 60 commodities had median values of 0.95 and 0.97, respectively, suggesting strong transmission.¹⁷ For wheat alone, they found that while the elasticity of the domestic price (this time expressed in US\$) with respect to the international price (in US\$) averaged 0.65 among the same group of countries, it was only 0.10 in Pakistan, by far the lowest within that group. This result is consistent with ours.

We conclude from these comparisons that the very large departures from the (weak) law of one price for wheat and sugar in Pakistan appear to reflect Pakistan-specific market imperfections in the case of these two commodities rather than a more general failure.

There is a close relationship between co-integration and error correction models in the sense that error correction models generally “underpin” co-integration, although co-integration could exist without strong evidence of an error correction model at work. The estimated error correction model directly associated with the Johansen co-integration test and the co-integrating equations reported in Tables 3 and 4 are shown in Table 5. These short-run equations for Δz_t coincide to expression (10) estimated at the co-integrating vector. All the estimated coefficients attached to the error correction term are of the right (negative) sign with fairly high *t*-statistics (except in the case of rice). The standard errors of the equation are not bad for wheat and rice but rather high for cotton and sugar; and the R^2 are low, except perhaps for wheat.

The conclusion is that these error correction models only partially represent the complex short-run price dynamics. Needless to say, this conclusion correlates with the relative weak evidence of co-integration. Nevertheless, the short-run equations for Δz_t could still be used for period-ahead forecasting.

¹⁶Unfortunately, cotton and rice are not part of the author’s sample of commodities.

¹⁷For Pakistan, the elasticities are, respectively, 0.82 and 0.44. The latter is somewhat at variance with the results we obtained here, which consistently suggest an elasticity with respect to the exchange rate closer to one. But this may be due to the very different exchange rate system prevailing in Pakistan during the period covered by the data in Mundlak and Larson study (1968–1978).

Table 5

VECM Estimates

Error Correction Variables	Wheat	Cotton	Sugar	Rice
<i>Dependent Variable</i>				
$\Delta \ln(p)$				
<i>Independent Variables</i>				
Constant	0.01 (3.74)	0.01 (1.01)	0.01 (0.74)	0.00 (2.21)
$\Delta \ln(e_{-1})$	-0.11 (-0.81)	0.07 (0.15)	0.65 (1.72)	0.05 (0.38)
$\Delta \ln(e_{-2})$	0.03 (0.19)	-0.20 (-0.45)	-0.07 (-0.19)	-0.03 (-0.22)
$\Delta \ln(p^*_{-1})$	-0.04 (-0.88)	-	-	-
$\Delta \ln(p^*_{-2})$	-0.05 (-1.12)	-	-	-
$\Delta \ln(p^*_{-1})$	-0.03 (-0.95)	0.38 (2.45)	0.13 (1.85)	-0.03 (-1.55)
$\Delta \ln(p^*_{-2})$	0.07 (2.10)	-0.04 (-0.26)	0.09 (1.26)	0.01 (0.64)
$\Delta \ln(p_{-1})$	0.24 (3.69)	0.19 (2.21)	-0.15 (-1.78)	0.26 (3.77)
$\Delta \ln(p_{-2})$	-0.07 (-1.19)	-0.12 (-1.36)	0.03 (0.32)	0.18 (2.56)
ECT1	-0.10 (-5.40)	-0.12 (-2.51)	-0.09 (-1.95)	-0.00 (-0.12)
<i>Key Statistics</i>				
S.E. of Equation	0.02	0.07	0.06	0.02
R ²	0.22	0.15	0.11	0.13

Note: Numbers in parenthesis are *t*-statistics.

5. CONCLUSIONS AND POLICY IMPLICATIONS

There is only weak evidence of the existence of long-run co-integrating equations between domestic price, international price, exchange rate, and (when applicable) domestic support price (in foreign currency terms) for key agricultural commodities in Pakistan. The co-integration tests appear especially weak for sugar and rice, while in the case of wheat, the stronger evidence of co-integration is mostly on account of the inclusion of the support price.

Within co-integration, domestic prices, at least for wheat and sugar *do* seem to have a “life of their own” in the sense that they are far from directly reflecting the prevailing international parity prices, even in the long-run, and allowing for a systematic wedge between domestic and international parity prices. The long-run elasticities to changes in international prices are very low for both these commodities. In the case of wheat, the empirical analysis suggests that the domestic support price (in foreign currency terms) has been a key *independent* explanatory variable, even in the long-run.

In the case of rice and cotton, the long-run elasticities to changes in international prices are much larger, and close to unity.

For all commodities, the long-run elasticities to changes in the exchange rate are around unity.

The above findings are consistent with the theory we proposed to explain how domestic prices adjust to domestic and external shocks. They generally support the theoretical prediction that monetary/ exchange shocks are more likely to be passed-through than real (including international price) shocks. Nevertheless a “weak” applicability of the law of one price in the long-run *cannot* be rejected for cotton and rice under some standard confidence interval.

Estimation of equations governing the short-run domestic price dynamics are imbedded in the Johansen co-integration test based on a VAR, and have the form of an error correction mechanism. These equations could be used for period-ahead forecasting based on full information up to then. Admittedly, however, the explanatory power of these short-run equations is rather weak, except in the case of wheat.

Policy implications of this paper are twofold.

The first relates to market efficiency. The fact that the departures from the law of one price even in the long-run appear to be very substantial in the case of wheat and sugar in Pakistan, significantly more so than elsewhere, point to the role of government interventions and weaknesses of competitive mechanisms on these markets, and the room for further market-oriented reforms in these areas. While, the government might argue that it intervenes as a price stabiliser (for both the consumer and producer), the well established long-lasting effect of shocks to international prices for these and other commodities have casted doubts on whether such price stabiliser function is optimal from the welfare and efficiency point of view. In any case, it is not clear why short-run interventions should pre-empt the long-run applicability of the law of one price.

The second relate to inflation forecasting. Under the current *modus operandi* of commodity markets in Pakistan, any monetary policy framework, say inflation targeting, cannot take for granted the assumption that domestic prices of even highly homogenous traded goods such as agricultural commodities will directly reflect the exchange rate and international price. Rather, how changes in these variables will be passed-through into the domestic prices could depend on the sources of such changes and the prevailing political economy of markets functioning and related government interventions. The short-run price equations modeled in this paper are examples of dynamic price equations which could be part of an inflation forecasting model.

Finally, the attempt to isolate domestic prices for agricultural commodities from variations in the international prices, for wheat in particular through the support price mechanism, would hamper the macroeconomic adjustment to terms of trade shocks (international prices of wheat, cotton, rice, and sugar relative to the international prices for major imported inputs). Specifically, the expected equilibrium real appreciation/ depreciation of the currency as a result of a positive/ adverse terms of trade shock¹⁸ might not take place, resulting in greater instability of the trade balance.

¹⁸See for instance Cashin, *et al.* (2002).

Annex I
Definition of Variables and Sources

		<i>Source</i>
Exchange Rate		
e	Official exchange rate (annual average PRs per US Dollar)	International Financial Statistics (IFS)
Wheat		
p	Domestic Price of Wheat (PRs/40kgs)	Ministry of Food, Agriculture & Livestock (Minfal)
p*	Wheat US Gulf Price (US\$/40kgs)	International Financial Statistics (IFS)
p*	Support Price of Wheat (US\$/40kgs) ¹⁹	Ministry of Food, Agriculture & Livestock (Minfal)
Rice		
p	Domestic Price of Irri-Rice (PRs/40kgs)	Ministry of Food, Agriculture & Livestock (Minfal)
p*	Thailand: Rice Price (US\$/40kgs)	International Financial Statistics (IFS)
Cotton		
p	Domestic Cotton Spot Price (PRs/40kgs)	Federal Bureau of Statistics (FBS)
p*	Cotton Liverpool Price (US\$/40kgs)	International Financial Statistics (IFS)
Sugar		
p	Domestic Refined Sugar (PRs/50kgs)	Federal Bureau of Statistics (FBS)
p*	Caribbean Sugar Price (US\$/50kgs)	International Financial Statistics (IFS)

Time Period

The data used for all the commodities is on monthly basis.

Wheat : 1987M01 – 2004M12 (216 observations)

Rice : 1987M01 – 2004M12 (216 observations)

Cotton : 1991M07 – 2006M03 (177 observations)

Sugar : 1991M07 – 2006M03 (177 observations)

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¹⁹Converted to US dollars by using the official exchange rate (annual average PRs per US Dollar, as reported in IFS).

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