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# Estimating the Pass-Through of Agricultural Policy Reforms

AN APPLICATION TO BRAZILIAN COMMODITY  
MARKETS

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# **Estimating the Pass-Through of Agricultural Policy Reforms: an Application to Brazilian Commodity Markets**

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## **1. Introduction**

The ultimate impact of multilateral and own-country agricultural policy reforms will depend on the extent to which those reforms “pass-through” across national borders, within countries, and from local markets down to the household level. At the heart of policy pass-through is the question of “price transmission”, i.e. the extent to which price changes in one market lead to price changes in another market.

Estimates of price transmission are built, either explicitly or implicitly, into multi-market partial equilibrium models, general equilibrium models, and narrower partial equilibrium studies, such as those used to estimate the effects of reform on particular markets or categories of household.<sup>2</sup> An understanding of price transmission is a prerequisite for any meaningful quantification of how different constituencies will be affected by reform. To what extent are producers actually linked into local markets? Are those markets linked to other markets nearer the border? Are urban consumers more linked to international markets than rural producers? None of these questions can be answered without estimates of price transmission.

The aim of the paper is therefore to provide estimates of cross-border and within country price transmission in Brazil, and at the same time suggest an approach that can be applied relatively easily to other countries and commodities. The fundamental dilemma is that it is difficult to obtain robust estimates without good data on both prices and traded volumes, and even then the econometric techniques available may not be capable of providing accurate ex ante predictions of price transmission. This paper discusses some of the difficulties in applying time series techniques, drawing on applications using Brazilian data, and suggests some general guidelines for predicting price transmission and the pass-through of policy reforms. It therefore complements a wider OECD project examining the distributional impacts of agricultural policy

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<sup>2</sup> In the case of general equilibrium models, price transmission is typically captured implicitly via imperfect substitutability between both domestic products and imports, and exports and domestically produced goods sold on the domestic market. See Bautista et al. (1998) for a discussion of partial versus general equilibrium concepts of price transmission.

reforms in which Brazil is a specific case study, and where the aim is to track the consequences of international and national policy reforms down to the micro (household) level.

The paper is structured as follows. In Section 2 we summarise briefly recent developments in the estimation of price transmission, and the extent to which insights from this analysis are reflected into policy analysis. In section 3 we focus on the role of transactions costs and consider the potential value of threshold models, which can account for the implied discontinuities in price transmission. Section 4 then evaluates the empirical evidence for several Brazilian commodity markets, while Section 5 concludes with some suggestions for how improved price transmission estimates can be built into wider applications, be they cross-sectional models such as those used for distributional analysis or multi-market models such as those used for medium-term outlook projections.

## ***2. The shortcomings of standard measurement approaches***

The earliest methods used for estimating price transmission were correlations between price series (e.g. Timmer et al., 1983) and regressions of one price series on another. These techniques have been shown to produce invalid test results and misleading estimates when the price data are “non-stationary” (as is often the case). Essentially, this is because there is a tendency to wrongly attribute co-movements in prices to causality. Since the late 1980s, cointegration techniques have been the standard tool for estimating price transmission. The first applications (e.g. Ardeni, 1989) were used to test the “law of one price”, on the assumption (incorrect when there are transactions costs) that if a good is perfectly tradable, then prices on world and domestic markets should be equal (plus or minus transport costs and other margins) and changes in world prices should be fully translated into changes in domestic prices.<sup>3</sup> More recently, these studies have themselves been called into question because they do not allow for transfer costs between markets. Recent studies (e.g. Baulch, 1987; Barrett and Li, 2002) have suggested modified procedures that allow for the fact that price transmission will only occur when there is an incentive for arbitrage, i.e. the price difference between two markets exceeds the transfer cost – otherwise it will be zero.

The estimation of an unrestricted cointegration equation often involves “averaging” across periods when there is both an incentive for arbitrage and when there is not. Thus apparently “weak” price transmission may merely reflect price gaps that are narrow relative to transfer costs, rather than inefficiencies in the arbitrage process itself.

Moreover, Colman (1995) has noted that the concept of an elasticity of price transmission itself needs to be treated carefully. In particular, equating perfect price transmission with an elasticity of one only makes sense if all duties and transport costs are proportional to price (which is unlikely to be the case). In the case of an import, we would expect the domestic price to be higher than the world price before transport costs are paid, so perfect price transmission would imply an elasticity of less than one. In the case of an export, perfect price transmission would correspond to an elasticity greater than one. In addition, elasticity estimates are subject to the Lucas critique, in that policy reform should increase observed price transmission, making

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<sup>3</sup> Ardeni found that the law of one price did not hold for several important commodities in Australia, Canada, the United Kingdom and the United States.

estimates based on higher rates of protection biased downwards. The use (and misuse) of price transmission estimates is discussed by Sharma (2003).

Cluff (2003) provides a review of how the issue of price transmission is addressed in the main multi-country multi-market models used for medium term outlook projections. Often, a “guesstimated” elasticity of price transmission (possibly originating from an original empirical estimate for some other country or commodity) is used. Such rough-and-ready techniques are unavoidable in large models, but are one cause of wide variations in the estimates that are obtained (another being fundamentally different specifications of price formation).<sup>4</sup> For disaggregated analysis using cross-section data, McCulloch (2002), recognising the empirical and interpretive difficulties, suggests that in some case it may be best to dispense with estimation altogether, and assume perfect price transmission, on the grounds that this represents a “worst case scenario” for sectors and households that stand to lose from reform.

Threshold models, which can account for transactions costs, represent a possible solution. So why aren’t such techniques used more widely? One reason is that these developments in the literature are relatively recent. Just as importantly, however, studies which recognise the importance of transactions costs are complex, in some cases computationally expensive, and are difficult to apply readily to a range of markets and commodities. There are also reasons for doubting whether they are even capable of providing robust estimates of price transmission that can be used for forward looking analysis.

A question this paper addresses is whether some of the important insights deriving from threshold models can be incorporated into analysis that is not destined for academic journals, but can be undertaken relatively easily for purposes of disaggregated policy analysis.

### **3. Accounting for transactions costs**

How can estimates of price transmission be improved? To investigate this question it is helpful to trace through the basic principle of arbitrage. Suppose that a given commodity sells for a price of  $P_w$  on world markets, or (more precisely) that this is the traded price facing the country for which we wish to estimate the degree of price transmission.

Take the case where this commodity is a net import first. Suppose that imports face an *ad valorem* tariff of  $t$ , as well as transfer costs  $T_m$  that may be attributable to both policy factors (including non-tariff barriers of various kinds) and non-policy factors (transport costs, handling charges, and information costs).<sup>5</sup> Then, for homogeneous products in perfect competition, there is an incentive for imports if the following arbitrage condition is met:

$$R_m = P_d - (1 + t)P_w - T_m \geq 0 \quad (1)$$

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<sup>4</sup> In several cases, one model has an elasticity of zero (or nearly zero) while another has an elasticity of one (or nearly one) for a given country / commodity.

<sup>5</sup> The assumption of constant transactions costs will be restrictive in cases where costs are either increasing or decreasing over time (the latter being the case in Brazil as the country’s infrastructure improves).

where  $P_d$  is the domestic price of the comparable product and  $R_m$  is the associated rent per unit from arbitrage. In the case of an exported product receiving an export subsidy  $e$ , with transfer costs of  $T_x$ , the equivalent condition for export arbitrage is given by:

$$R_x = P_d(1 - e) + T_x - P_w \leq 0 \quad (2)$$

Another way of restating the arbitrage condition is to note that there is no incentive for arbitrage when world prices fall within the following range, and that within these bounds we would expect price transmission onto domestic markets to be zero:

$$\frac{1}{1+t} [P_d - T_m] < P_w < P_d(1 - e) + T_x \quad (3)$$

Barrett and Li make a logical distinction between market integration (where there is an incentive for arbitrage and arbitrage occurs) and competitive equilibrium (where any potential gains from arbitrage are fully exploited). This distinction enables them to categorise four states:

- i. *perfect integration*, where there are no rents left to be dissipated (i.e. equations 1 and 2 hold with equality) and arbitraging trade may or may not occur.
- ii. *segmented equilibrium*, where there is no incentive for arbitrage (i.e. the signs in 1 and 2 are reversed) and so no trade occurs
- iii. *imperfect integration*, where arbitrage rents exist (i.e. 1 and 2 hold with inequality) and arbitraging trade occurs.
- iv. *segmented disequilibrium*, where the incentive for arbitrage exists but is not exploited.

In this context, how do we estimate price transmission? A convenient assumption is to rule out case iv, i.e. to assume that trade always occurs if there is sufficient incentive. This is perfectly reasonable, since an absence of arbitrage can always be interpreted as unobserved costs. Now take the case of a product that is periodically imported, and for which the world price falls from  $P_w^0$  to  $P_w^1$  (analogous reasoning follows in the case of a tariff change holding world prices constant, and similar argumentation applies in the case of exports).

Define the following initial rent to import arbitrage:

$$R_0 = P_d^0 - (1+t)P_w^0 - T_m \quad (4)$$

Then we will have the following arbitrage conditions:  $M > 0$  when  $R \geq 0$  and  $M = 0$  when  $R < 0$ . Note that we can also effectively rule out Barrett and Li's case i by assuming that  $M > 0$  when  $R = 0$ .

Take the equilibrium case where we already have arbitrage and that all rents are dissipated, so that  $R_0 = 0$ . Then a fall in the world price to  $P_w^1$  creates the following arbitrage rent  $R_0'$  at the existing domestic price  $P_d^0$ :

$$R_0' = P_d^0 - (1+t)P_w^1 - T_m > 0 \quad (5)$$

If domestic prices adjust perfectly, such that a fall in the world price yields

$$R_l = P_d^l - (1+t)P_w^l - T_m = 0 \quad (6)$$

then the domestic price change is given by

$$\Delta P_d = (1+t) \Delta P_w \quad (7)$$

But what if there is no initial incentive for arbitrage, yet a fall in world prices creates arbitrage rents at *existing* domestic prices, and domestic markets continue to adjust perfectly and instantaneously?

Then the initial condition is given by

$$R_0 = P_d^0 - (1+t) P_w^0 - T_m < 0 \quad (8)$$

In contrast, arbitrage rents open up at the lower world price

$$R_0' = P_d^0 - (1+t) P_w^l - T_m > 0 \quad (9)$$

and the new equilibrium is given by

$$R_l = P_d^l - (1+t) P_w^l - T_m = 0. \quad (10)$$

In this case, we have

$$\Delta P_d = (1+t) \Delta P_w - R_0 \quad (11)$$

i.e. the domestic price goes down by an amount equal to the tariff markup  $(1+t)$  times the fall in the world price less the initial level of arbitrage rent  $R_0$ .

The key point here is that even in perfectly adjusting markets, we should not always expect policy changes (or world price changes) to be fully passed through. In Table 1 we present comparable expressions for perfect and imperfect arbitrage, as import and export markets adjust to world price movements, and to tariffs and export subsidies changes respectively.

Table 1: **Perfect and imperfect price transmission with efficient arbitrage**

	<i>Import case</i>		<i>Export case</i>	
Variable changed:	World price, $P_w$	Tariff, $t$	World price, $P_w$	Export subsidy, $e$
<i>Perfect price transmission</i> $\Delta P_d$	$(1+t)\Delta P_w$	$\Delta t P_w$	$\left(\frac{1}{1-e}\right) \Delta P_w$	$\left(\frac{P_d \Delta e}{1-e^1}\right)$
<i>Imperfect price transmission</i> $\Delta P_d$	$(1+t)\Delta P_w - R_0$	$\Delta t P_w - R_0$	$\left(\frac{1}{1-e}\right) [\Delta P_w + R_0]$	$\left(\frac{P_d \Delta e + R_0}{1-e^1}\right)$

### *Threshold models*

With such a structure, what are the estimation possibilities? Threshold models are needed in order to accommodate discontinuities in the arbitrage process and hence in price transmission. This section outlines how transactions costs affect the nature of price transmission and considers how well a specific group of models designed to accommodate these costs (“thresholds” models) performs in terms of providing superior estimates than those that would be obtained using standard techniques.

Barrett and Li assume that the incentive to arbitrage – i.e. the values of the expressions in equations (1) and (2) – and the values of imports or exports have a joint probabilistic distribution. Formally, they use maximum likelihood techniques to estimate a mixed distribution model using monthly data on prices, transport costs and trade flows. The difficulties of applying this approach more widely stem from (a) high frequency data requirements, and (b) a relatively sophisticated econometric specification.

Other threshold models have the advantage of only using price data. However, such models are not capable of discriminating between transactions costs and other possible causes of threshold effects, such as structural breaks and policy shifts.

Balke and Fomby (1997) have formulated a threshold model that is broadly consistent with the arbitrage argument outlined earlier, with price changes in one market only transmitted to another market when the price difference between the two market exceeds a threshold level. This type of model has been developed by Hansen and Seo (2003) and Seo (2003), while similar models have been applied to agricultural price transmission by Goodwin and Piggott (2001) and Sephton (2003).

The common approach for dealing with thresholds is to test for a long run relationship between two prices series and cointegration over the full sample range of the data. In the case where there is a relationship, thresholds are estimated as a second step. This approach is not satisfactory as the original tests may find no evidence of a cointegrating relationship because when there are thresholds there should be no such relationship over the period where the price gap is insufficient for arbitrage (trade) to occur.<sup>6</sup>

Moreover, as Balcombe (2003) points out, these threshold models all miss a key component of threshold behaviour, namely that there may be two (or more) distinct equilibrium relationships between prices. In the context of transactions costs one would expect two distinct equilibria, with either the upper bound of the threshold the point of attraction or the lower bound – but not the middle as assumed in existing studies.

Accordingly, Balcombe develops a threshold model that allows (but does not require) the boundaries of the thresholds to be the points of attraction, and applies this model to consider price transmission onto Brazilian markets (from Argentina and the United States) for wheat, maize and

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<sup>6</sup> In an earlier paper (Brooks and Melyukhina, 2003) using price and trade data for Russian crops, contrasted the results of cointegration analysis over a full sample range and a more limited range where there was systemic trade in a given direction. The authors found that, despite a loss in degrees of freedom, the results were much stronger if the analysis was limited to those periods of continuous trade.

soya. The model uses a Bayesian, as opposed to classical, approach, on the grounds that the former poses numerous estimation difficulties. In particular if maximum likelihood estimation methods are used, the likelihood function is jagged and potentially bimodal, which prevents inference based on derivative methods. For an exposition of the model and a discussion of the implications of the choice of technique, the reader is referred to Balcombe.

In general, it is very difficult to obtain reliable estimates using threshold models, certainly in a way that can be replicated for multiple countries, regions and commodities. The following sections review estimation approaches in the case of Brazilian commodity markets, and suggest some practical guidelines for obtaining price transmission estimates and gauging the anticipated pass-through of policy reforms.

#### ***4. Evidence from Brazilian agricultural markets***

In order to understand the likely degree of price transmission onto Brazilian commodity markets, it is instructive to examine contemporaneous movements in domestic prices, external (reference) prices, and traded volumes. In the case of Brazil, we are fortunate to have monthly data on all three.

An inspection of high frequency data is valuable because it can reveal discontinuities in trade and reversals in the direction of trade, both of which indicate whether the role of transactions costs is likely to have an impact on price transmission and appropriate estimation procedures. It can also pinpoint other likely structural breaks, which may be important if price-only threshold models are estimated. In the case of Brazil, policy was progressively liberalised from the late 1980s, while the Mercosur Agreement in 1995 led to the elimination of tariffs on agro-imports originating from the Mercosur area and a reduction in the common external tariff.

Figures 1 to 9 in the Annex show domestic prices, relevant international prices, and traded volumes for a range of Brazilian commodities between 1989 and 2003. The product list includes four commodities that have traditionally been imported (wheat, maize, rice and beans) and five that are exported (soybeans, coffee, beef, pigmeat and poultry).

***Wheat*** (Figure 1) is currently Brazil's main imported staple, with the vast majority of these imports coming from Argentina. Liberalisation led to a rapid growth in import volumes, although since 1998 imports have been relatively stable on an annual basis. Domestic prices have become less volatile and have tracked Argentine FOB prices more closely in the post reform period, suggesting that price transmission should be estimated over this interval.

***Maize*** (Figure 2) has traditionally been imported into Brazil, albeit in relatively low volumes (less than one million tonnes per year). However, since 2001 a net export position has emerged, largely due to the opening up of new agricultural areas in the Centre-West. Over the import period, it is notable that domestic prices were typically lower than US or Argentine FOB prices in those months where imports were close to zero, with substantial price gaps emerging in some instances. Hence, maize demonstrates the value of focusing on transactions costs as a determinant of price transmission. Furthermore, the domestic price appears to respond in a subdued manner to Argentine and US price changes (i.e. there is a relatively small adjustment to a large shock). It is not clear where existing price transmission models can capture this phenomenon.



**Rice** (Figure 3) is another import, again with relatively low traded volumes (typically less than 200,000 tonnes per year). Until 1999, farmgate prices were consistently lower than FOB import prices, suggesting that there was little incentive for imports. As in the case of wheat, there appear to be two distinct phases of price transmission, with domestic price tracking import prices much more closely since 1999.

Brazil imports **dry beans** (Figure 4) in relatively low quantities on a seasonal basis. As with rice, there is a tendency for the domestic price to be lower than the FOB import price when imports are close to zero, and for smaller shocks to be more fully transmitted than large ones. Prices have stabilised since 1999, and domestic and import prices have tracked each other more closely, again suggesting two distinct phases of price transmission.

Brazil is the world's second largest exporter of **soybeans** (Figure 5). Domestic prices tracked US prices very closely throughout the 1989-2003 period, although there has been some narrowing of price differences. Note that export prices have spiked occasionally when exports are close to zero, which suggests that, for estimation purposes, it may be best to eliminate from the sample those months in which no trade takes place. In addition, the gap between farmgate price and traded prices has narrowed, probably as a result of lower internal transport costs. This may need to be accommodated via a trend term when estimating the price relationship.

Brazil is the world's largest supplier of **coffee** (Figure 6). As in the case of soybeans, Brazilian and world coffee prices show a clear co-movement over the whole period. However, there were world price spikes in 1994-1995 and 1997-1998 that were not matched in the Brazilian market, possibly because of traders withholding some of the benefits to domestic producers.

**Poultry** (Figure 7) is an increasingly important export product for Brazil. Domestic prices have been more stable and have tracked international prices more closely as exports have grown. It therefore makes sense to limit estimation to more recent years (post 1995).

**Pigmeat** (Figure 8) has emerged as a significant export in the last few years. Domestic and export prices have moved together quite closely in the post-reform period, and there is evidence of the price gap narrowing progressively over that period, which is again suggestive of a reduction in transport and other transactions costs.

**Beef** (Figure 9) has shown a similar pattern of development to other meats. Exports, which were of marginal importance until the end of the 1990s, have grown rapidly, while domestic prices demonstrated a greater stability.

### ***Cointegration results.***

We examine the degree of international to domestic price transmission for the commodities discussed above using monthly price data from January 1989 to October 2003 (see Annex for data description). The objective of this exercise is not to obtain robust estimates of price transmission, but simply to demonstrate the sensitivity of the results to incorporation of arbitrage incentives.

In each case, we first applied the standard Augmented Dickey-Fuller (ADF) unit root test, using the Schwarz criteria to select the appropriate number of lags. The test results are reported in Table 2. Most of the price series were found to be non-stationary in levels and stationary in first

differences (at a significance level of 5%), although for importables in particular there were some cases where the ADF t-values were at or close to their critical values. Domestic bean prices were an exception, with clear evidence of stationarity in price levels. On the strength of the evidence, it was decided not to proceed with cointegration tests for maize and beans.

Table 2. Results of Augmented Dickey-Fuller Unit Root Test\*\*

	ADF test t-statistic values				Stationarity of series	Johansen co-integration test: performed (yes)/not performed (no)
	Series in levels		First-differenced series			
	no time trend	time trend	no time trend	time trend		
<b>WHEAT</b>						
PD	-3.18*	-3.17	-9.29	-9.28	I(0)	
PW - Argentina	-2.61	-2.68	-8.44	-8.44	I(1)	yes
<b>MAIZE</b>						
PD	-2.97*	-3.37	-9.60	-9.57	I(1)	
PW - Argentina	-3.38*	-3.36	-8.38	-8.36	I(1)	no
<b>RICE</b>						
PD	-2.20	-2.20	-3.88	-4.09	I(1)	
PW - Thailand	-1.92	-2.75	-7.13	-7.12	I(1)	yes
<b>BEANS</b>						
PD	-3.65*	-3.84*	-8.71	-8.68	I(0)	
PW - Brazil import	-2.71	-3.32	-9.70	-9.67	I(1)	no
<b>SOYBEANS</b>						
PD	-2.85	-2.83	-10.12	-10.16	I(1)	
PW - US CBOT	-2.49	-2.35	-10.45	-10.50	I(1)	yes
<b>COFFEE</b>						
PD	-1.77	-1.76	-7.26	-7.24	I(1)	
PW - ICO composite price	-1.69	-1.74	-6.99	-6.94	I(1)	yes
<b>POULTRY</b>						
PD	-2.01	3.65*	-5.70	-9.30	I(0)	
PW - Brazil export	-1.48	-1.91	-5.57	-5.59	I(1)	yes
<b>PIGMEAT</b>						
PD	-2.57	-2.98	-6.27	-6.27	I(1)	
PW - Brazil export	-1.37	-2.05	-7.44	-7.46	I(1)	yes
<b>BEEF</b>						
PD	-1.59	-2.19	-5.78	-5.78	I(1)	
PW - Australia	-1.65	-1.54	-7.51	-7.52	I(1)	yes
T-statistic critical values: 5%						
	-2.88	-3.44	-2.88	-3.44	-	-
10%						
	-2.57	-3.14	-2.57	-3.14	-	-

PD - Brazilian domestic price; PW - world price

(\*) Denotes significance at 5% confidence level

(\*\*) All results relate to full time series from January 1989 to October 2003.

For other products, wheat, rice, soybeans, poultry, pigmeat, and beef we used the Johansen procedure to test for cointegration. Where we found evidence of a cointegrating equation we then estimated the following error correction model:

$$\Delta PD_t = \alpha_0 + \alpha_{11} * \Delta PD_{t-1} + \dots + \alpha_{1n} * \Delta PD_{t-n} + \alpha_{21} * \Delta PW_{t-1} + \dots + \alpha_{2n} * \Delta PW_{t-n} + \phi * [PD_{t-1} - \beta_0 - \beta_1 * PW_{t-1}]$$

where  $PD$  and  $PW$  are domestic and world prices,  $\alpha_0$  is an intercept,  $\alpha_1$  and  $\alpha_2$  are short-run coefficients,  $n$  is the number of lags,  $PD_t = \beta_0 + \beta_1 * PW_t$  is the long-run cointegrating relationship, and  $\phi$  is the speed-of-adjustment parameter.

The results of cointegration test are reported in Tables 3 and 4. In each case we made estimations for the full period, 1989-2003, and for two sub-periods: 1989-1995 and the post-reform period of 1996-2003. The finding of higher significance over the most recent sub-range would appear to support our suggested interpretation of discontinuous price transmission, notwithstanding the loss of degrees of freedom. Where cointegration was present, a Granger causality test was performed, which in all cases showed that world prices Granger-cause domestic prices.

For *rice* and *beef* we could find no evidence of cointegration over the whole period or the sub-periods. The result for beef seems consistent with the fact that prior to 2000 trade was very small relative to the size of the domestic market (note the 1992-1995 period of interrupted trade). The exposure of the domestic rice market to international price signals appears to have been similarly weak until recently. These results, however, once again confirm the limitations of the traditional estimations of price transmission based on long-run time series. The overall absence of cointegration seems to contradict the casual evidence from and inspection of price movements and trade flows.

For *wheat* and *poultry* we found a cointegrating relation over the whole sample, but this result appears to disguise quite diverging situations before and after 1995, with a cointegrating relationship between domestic and external prices found only for the more recent sub-period. For both products we estimated the VEC equations for the full period and for 1996-2003. In the case of wheat the VEC co-efficients determining the long-run relationship between domestic and world price ( $\beta_1$ ) and the speed of adjustment ( $\phi$ ) to their long-run equilibrium had almost the same values, showing only a marginally higher speed of adjustment with the restricted sample. However, the tests reveal the difference in the short-run adjustment in that domestic prices appear to respond much stronger to the short-term world price changes when only a recent sub-period is considered. The estimated co-efficients for poultry provide somewhat counter-intuitive evidence showing practically the same speed of adjustment and a stronger long-term price relationship over the full time range than over the recent sub-period. This equates to the greater importance of lags over the restricted period. It may also reflect the fact that domestic export prices, while remaining lower than export prices, have moved closer, so a given absolute degree of price transmission is reflected in a lower elasticity.

Table 3. Results of Johansen Cointegration and Granger Causality Tests  
(based on logged series)

	Full period: 1989:01 to 2003:10	Sub-period 1: 1989:01 to 1995:12	Sub-period 2: 1996:01 to 2003:10	Granger causality test
<b>WHEAT</b>	X	--	X	PW gc PD
<b>RICE</b>	--	--	--	-
<b>SOYBEANS</b>	X	X	X	PW gc PD
<b>BEEF</b>	--	--	--	-
<b>PIGMEAT</b>	X	X	X	PW gc PD
<b>POULTRY</b>	X	--	X	PW gc PD

PD: Brazilian domestic price; PW: world price

X: series cointegrated; -- : series not cointegrated

PW gc PD: world price Granger-causes domestic price

Table 4. Results of Vector Error Correction Model Estimation  
(based on logged series)

	$\alpha_0$	$\alpha_1$	$\alpha_2$	$\beta_1$	$\phi$	$\beta_0$
<b>WHEAT</b>						
Full period	0.00	-0.22	-0.03	0.69	0.20	1.48
Sub-period 1	--	--	--	--	--	--
Sub-period 2	0.00	-0.12	0.11	0.68	0.22	1.60
<b>SOYBEANS</b>						
Full period	0.00	-0.11	-0.06	1.15	0.26	0.00
Sub-period 1	0.00	-0.09	0.07	0.58	0.38	-0.00
Sub-period 2	0.00	-0.29	-0.19	1.07	0.16	-0.53
<b>POULTRY</b>						
Full period	0.00	-0.15; 0.07; -0.00; 0.05; 0.23; -0.07*	0.02; 0.15; 0.08; - 0.17; 0.03; 0.34*	1.52	0.02	-3.85
Sub-period 1	--	--	--	--	--	--
Sub-period 2	0.00	-0.39; 0.17; 0.03; - 0.06; 0.04; -0.05*	-0.07; 0.10; -0.15; 0.19; 0.15; -0.19*	1.18	0.01	-1.69
<b>PIGMEAT</b>						
Full period	0.00	-0.35	-0.03	0.89	0.14	0.14
Sub-period 1	0.00	-0.32	0.04	0.70	0.17	1.63
Sub-period 2	0.00	-0.49	-0.16	0.84	0.14	0.45

Full period corresponds to 1989:01 - 2003:10; sub-period 1 to 1989:01 - 1995:12; and sub-period 2 to 1996:01 - 2003:10.

\* Six lags are included in VEC for poultry.

Overall, the cointegration tests for Brazilian prices support the hypothesis of discontinuous price transmission. In particular, they are suggestive of different regimes following policy reforms in the mid-1990s. Some domestic markets (wheat and poultry) already developed strong links to external markets, while for others (notably rice and beef) this transformation appears to be still underway. Finally, markets historically integrated into international trade (soybeans and pigmeat) became more strongly dependent on world prices in the long and short-run. Overall, the cointegration test revealed the sensitivity of results to the choice of the sample range (i.e., on different arbitrage and policy conditions). The standard price transmission estimates based on time series seem unable to capture these differences and therefore to provide an accurate key for price predictions.

### *Within country price transmission*

González-Rivera and Helfand (2001) develop an approach for estimating within country price transmission which they apply to the Brazilian rice market.

The advantage of this application is that it uses a multivariate approach to identify which regions in Brazil belong to a common market. This task cannot be accomplished properly using bivariate techniques. The authors also acknowledge the role of transactions costs via a two-step procedure under which the first requirement for a given market to be integrated is that all locations share the same trade commodity. Thus if it is estimated that a region neither imports nor exports the commodity, then price transmission into that market is assumed to be zero. The second step is to test for those regions which share the same long-run information (i.e. there is one integrating factor common to all price series).

The authors find that 15 of 19 states in Brazil belong to the same rice market, but that the degree of price transmission varies widely among these 15 states.

### **6. A suggested approach**

The preceding applications for Brazil suggest some principles which should guide the estimation of price transmission and policy pass-through in applications intended for further disaggregated analysis.

First, in some (but not all) cases, it is important to acknowledge the role of transactions costs. In these cases, standard cointegration techniques are likely to be unsatisfactory.

If threshold models are used in order to accommodate transactions costs, there is a choice to be made between methods that make use of information on both prices and trade quantities (e.g. Barrett and Li; González-Rivera and Helfand) and those which only use price data (e.g. Goodwin and Piggott; Sephton; Balcombe). The former are naturally to be preferred if data on traded quantities are available or can be estimated reliably. One shortcoming of price-only based threshold models is that they cannot distinguish the role of transactions costs from other causes of threshold effects.

Threshold models may provide important insights, but they are difficult to apply and the evidence from Brazil (where price transmission appears to have improved in recent years) suggests that they may not provide good predictions of future price transmission.

One alternative to threshold models is to estimate transfer costs and hence the bounds within which price transmission will occur. This can be done either directly, by collecting data on transport, handling and other observable costs, or indirectly by observing the minimum price gap which is sufficient for arbitrage to occur (an inspection of the data for Brazil suggests that the latter is a difficult task).

Price transmission could then be characterised via a switching model which embodies the logic introduced in Section 3. Given the unreliability of threshold models, it is possibly even an improvement to assume efficient arbitrage and specify three different values for price

transmission coefficients: zero, perfect and imperfect, with the values for perfect and imperfect transmission corresponding to those in Table 1. Another approach would be to impute price transmission of zero when the reform is insufficient to create an incentive for arbitrage, but to go back and re-estimate price transmission coefficients over intervals where trade occurs.

A further advantage of such a specification is that, unlike point estimates of price transmission, it has a clear economic interpretation.

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## **Annex: Brazilian data description**

### **Price Series**

All series represent monthly prices from January 1989 to October 2003 in USD/MT. All Brazilian domestic prices are from Getulio Vargas Foundation, converted from national currency (\$R) into USD using free exchange rates published by the Central Bank of Brazil.

#### **Wheat**

*Domestic price:* Average price received by producers.

*World price:* Argentina fob Trigo Pan (International Grains Council).

#### **Maize**

*Domestic price:* Average price received by producers.

*World price:* Argentina fob Rosario (International Grains Council).

#### **Rice**

*Domestic price:* Average price received by producers.

*World price:* Thai fob Bangkok White Rice 100% B second grade (FAO/ESC world price database).

#### **Beans**

*Domestic price:* Average price received by producers.

*World price:* Unit fob values of Brazilian import of dry beans (total value of imported dry beans of various varieties, excluding seed beans, divided by total volume of import) (Brazilian Ministry of Development, Industry and Foreign Trade, Alice Web trade database).

#### **Soybeans**

*Domestic price:* Average price received by producers.

*World price:* US No 1 Yellow (Chicago Board of Trade).

#### **Coffee**

*Domestic price:* Average price received by producers.

*World price:* Composite green coffee price (International Coffee Organisation).

#### **Beef**

*Domestic price:* Average price received by producers.

*World price:* Australian boneless beef, cif USA (FAO/ESC world price database).

#### **Pigmeat**

*Domestic price:* Average price received by producers.

*World price:* Unit fob values of Brazilian export of pigmeat (total value of exported pigmeat divided by total volume of export) (Brazilian Ministry of Development, Industry and Foreign Trade, Alice Web trade database).

#### **Poultry**

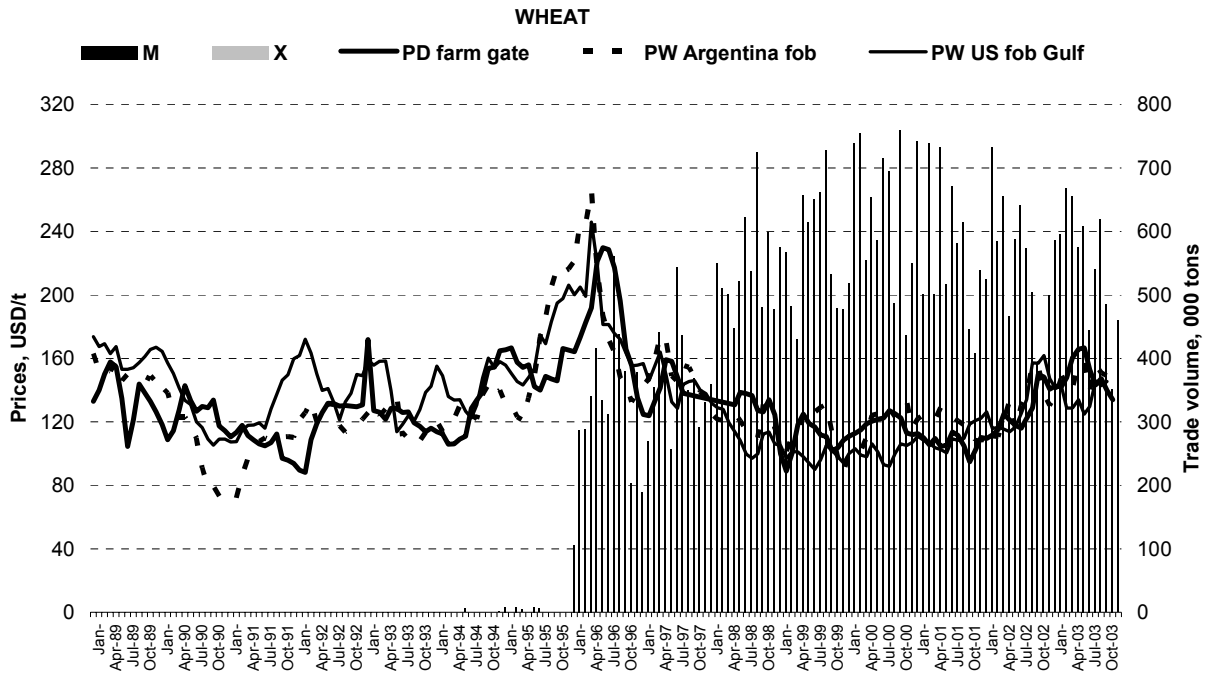
*Domestic price:* Average price received by producers.

*World price:* Unit fob values of Brazilian export of poultry meat (total value of exported poultry meat divided by total volume of export) (Brazilian Ministry of Development, Industry and Foreign Trade, Alice Web trade database).

### **Trade data**

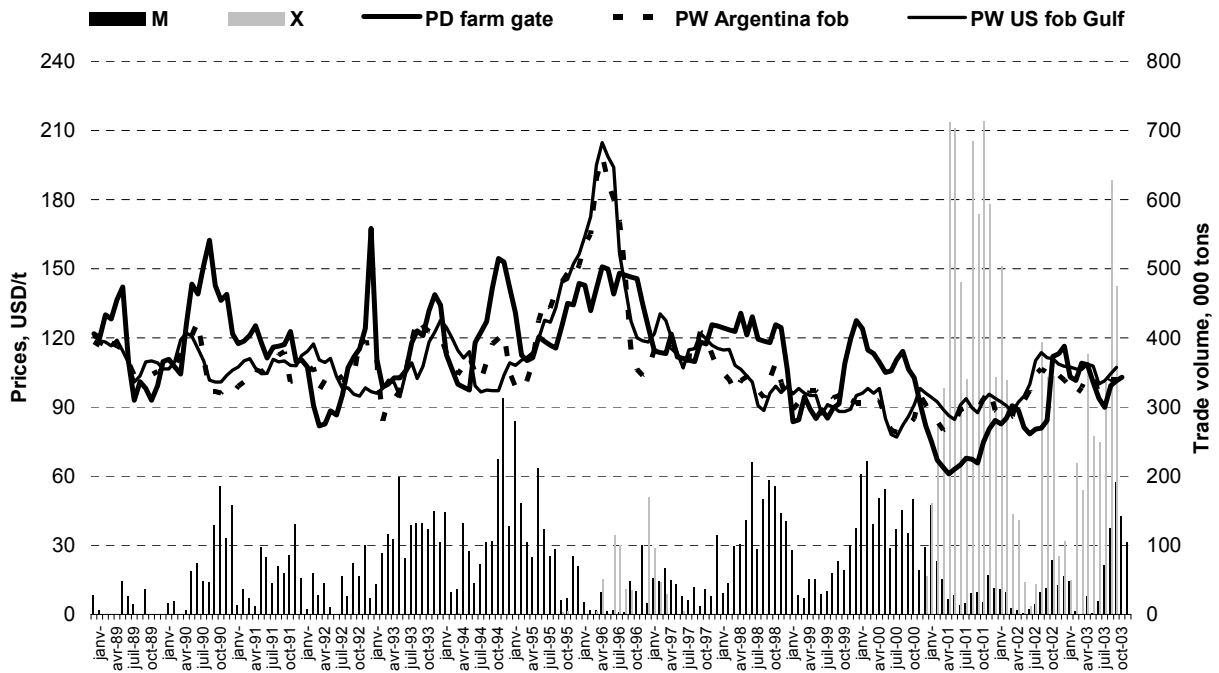
All Brazilian trade data is taken from the official *Alice Web* trade database of the Brazilian Ministry of Development, Industry and Foreign Trade. This official source reports both import and export values on a fob basis.

Graph 1. WHEAT : Monthly domestic and import prices

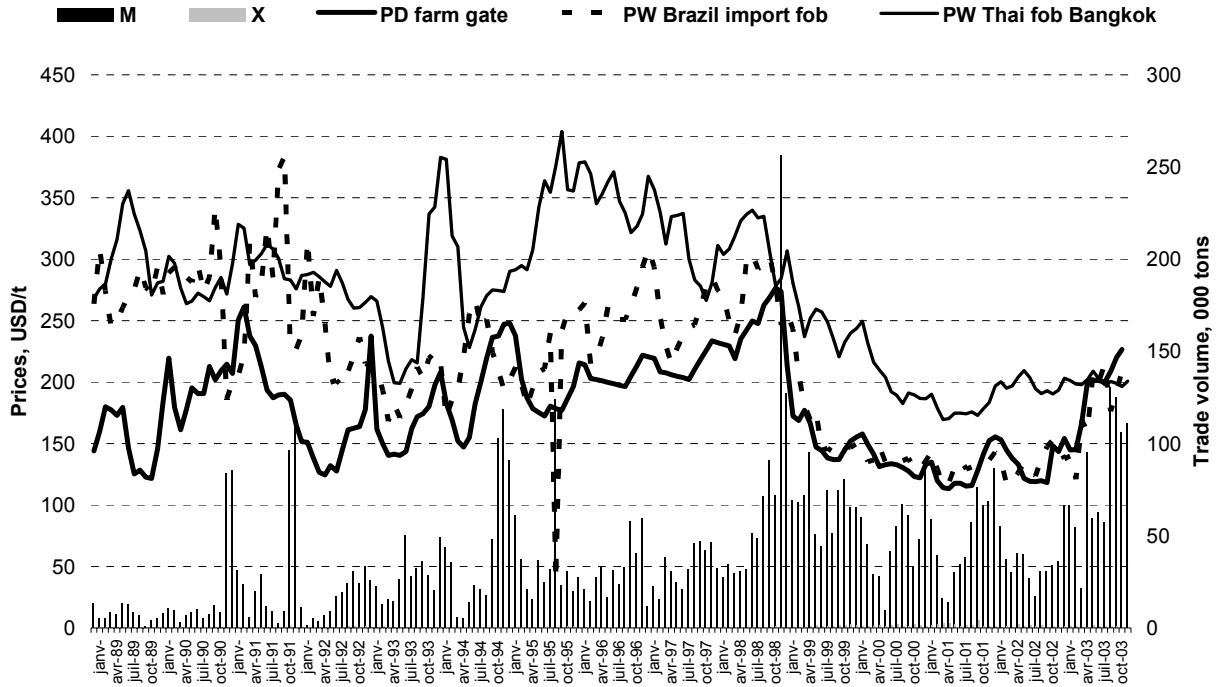


Note: Monthly data on wheat trade flows are not available for the period 1989:01 to 1995:12 .

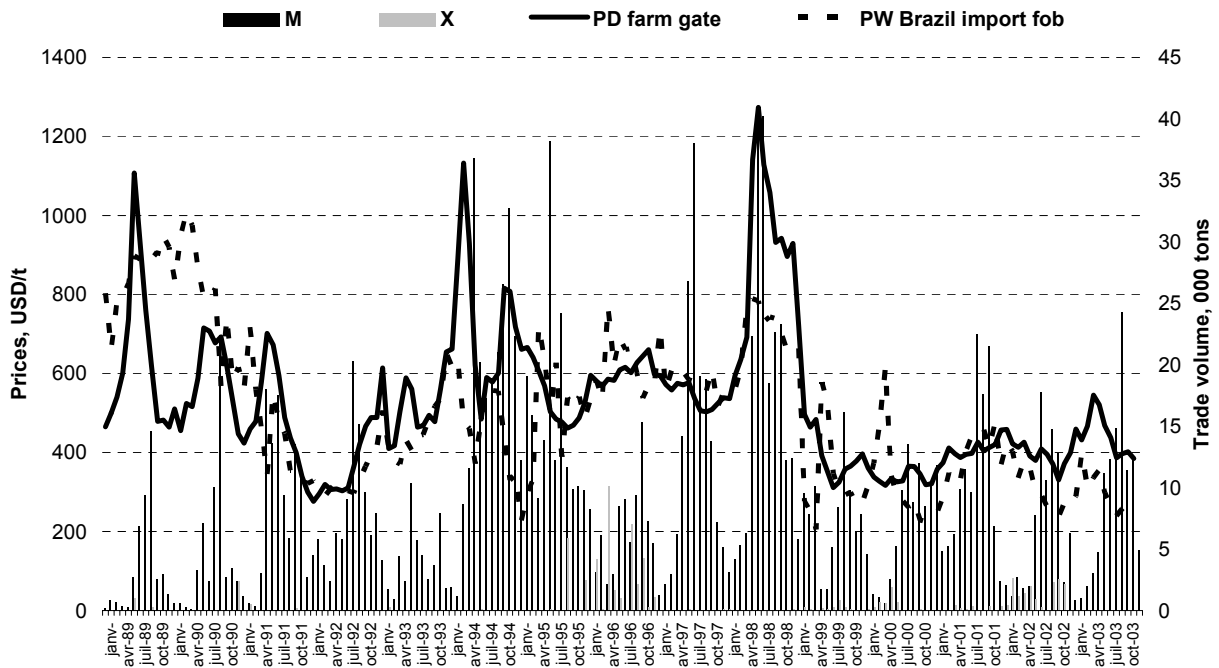
Graph 2. MAIZE: Monthly domestic and import prices



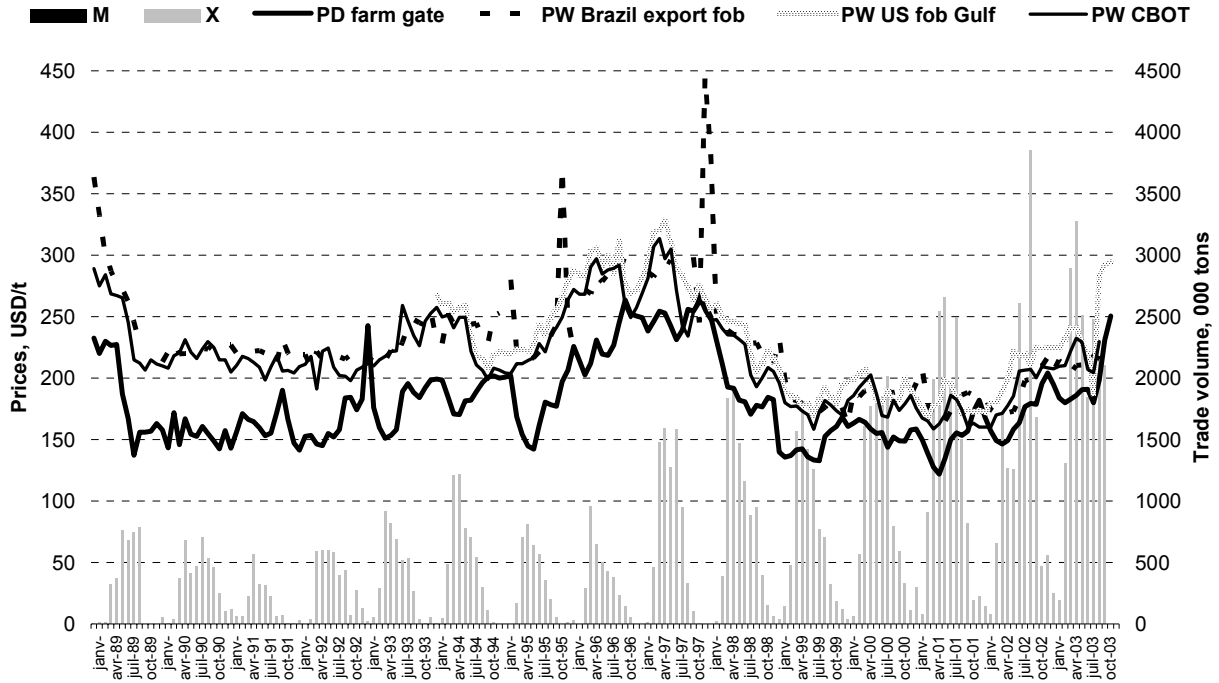
Graph 3. RICE : Monthly domestic and import prices



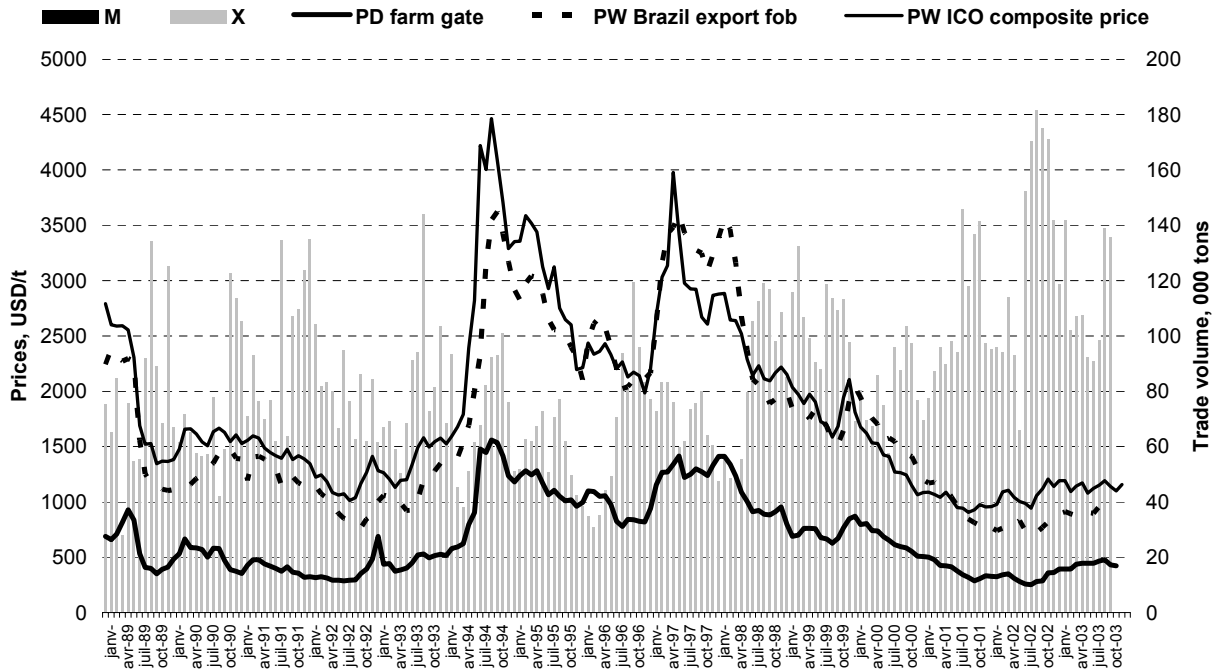
Graph 4. DRY BEANS: Monthly domestic and import prices



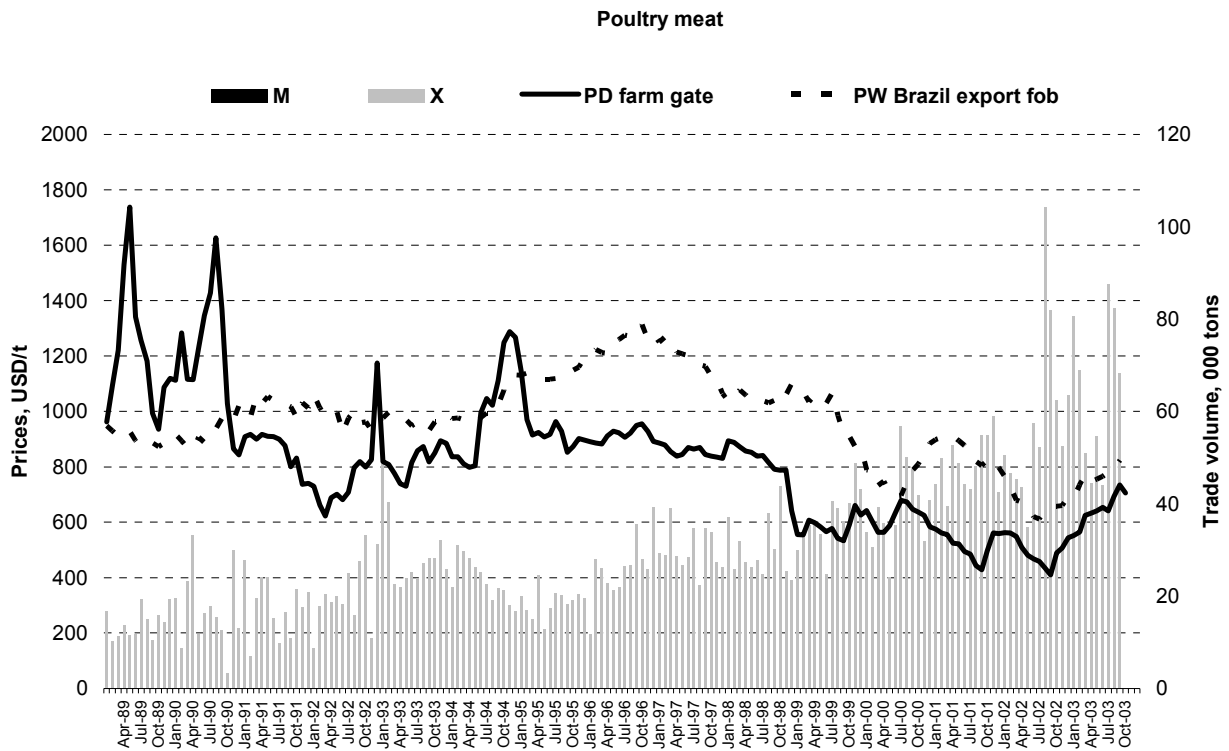
Graph 5. SOYBEANS: Monthly domestic and export prices



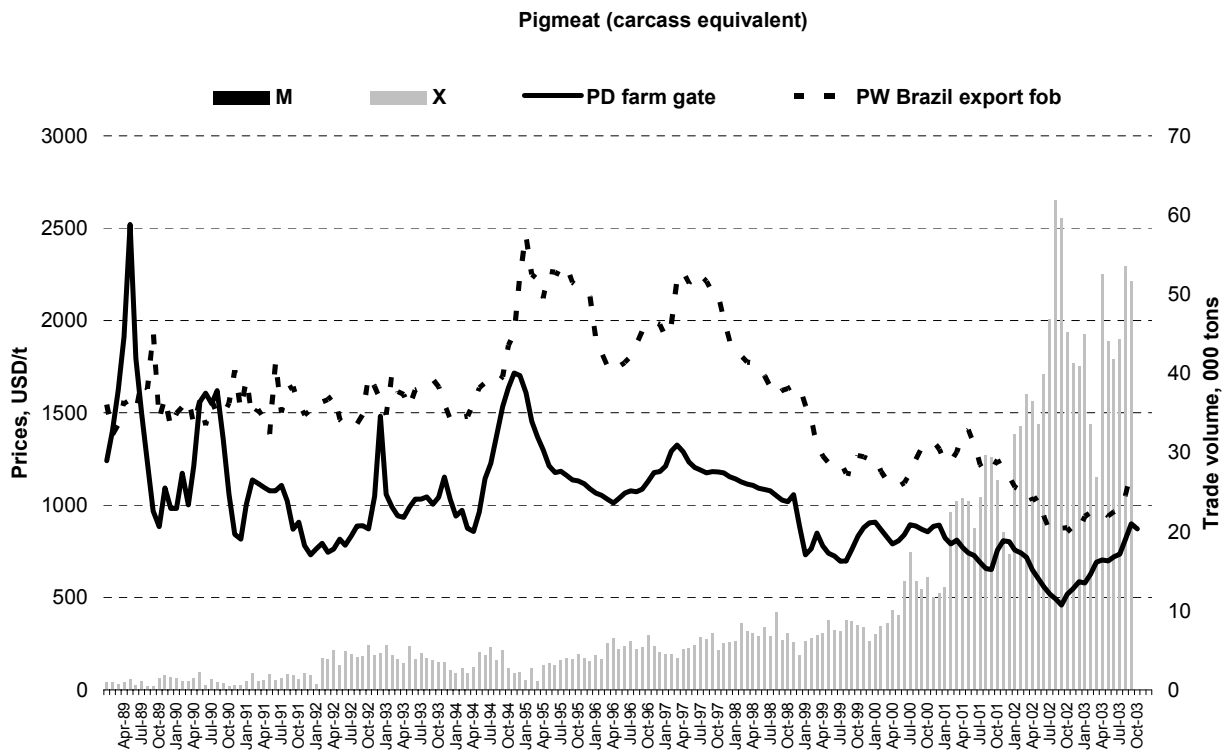
Graph 6. COFFEE (GREEN) : Monthly domestic and export prices



Graph 7. POULTRY : Monthly domestic and export prices



Graph 8. PIGMEAT: Monthly domestic and export prices



Graph 9. BEEF: Monthly domestic and export prices

