

# **Monetary policy and agricultural prices**

## **Implications of the overshooting hypothesis for agriculture in a model with non-tradables**

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### **Abstract**

The analysis in this paper extends the theoretical works of Frankel, Stamoulis and Rausser and Saghaian, Reed and Marchant of monetary policy and its influence on the agricultural sector. Both agricultural and non-agricultural sectors are divided into tradables and non-tradables in order to analyze the effects of money supply shocks on agricultural prices and the food supply. Using a Vector Error Correction model, quarterly data for Bolivia and Japan are employed to test for money neutrality, overshooting and relative flexibility of prices, highlighting the differences between developed and developing countries. The results indicate that monetary policy is not neutral in the short-run or the long-run and that money supply has a real effect on the economy. Results for Bolivia show that agricultural prices have stronger responses in the short-run (overshoot), but they do not necessarily return faster than non-agricultural prices to their long-run equilibrium while, in Japan, agricultural prices have stronger reactions to money shocks and return faster.

Key words: overshooting, agricultural prices, non-tradables, vector error correction, food supply, flexible prices, monetary shocks.

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### **1. Introduction**

Macroeconomic policy affects directly and indirectly the agricultural sector. As Schiff and Valdés [24] have pointed out, loose monetary policy tends to subsidize agriculture while tight monetary policy tends to tax agriculture in the short-run. Monetary policy becomes more important in the event of macroeconomic instabilities that require structural adjustments. The history of structural adjustments in developing countries is long and very well documented (Easterly [10]). However, detailed studies of how these structural adjustments have affected the agricultural sector are not abundant. Evaluations of structural adjustments often conclude that the adjustment was not only beneficial for the country as a whole, but especially for the poor (Dollar and Kray [8]). On the other hand, critics of these processes argue that developing countries performed worse after the adjustment than before the adjustment (Weinsbrot [26]). This controversy is reinforced in the perspective that structural adjustments will be needed in the future. The debate in the economic literature raises several questions. Are structural adjustments beneficial for the agricultural sector? How are the responses of the different sub-sectors that comprise the agricultural sector?

To answer these questions we investigate one of the tools used for macroeconomic adjustments: Monetary policy. We aim to investigate the effects of monetary shocks on agricultural prices by applying Dornbusch's [9] overshooting hypothesis to test for money neutrality and relative flexibility in agricultural and non-agricultural prices. Unlike previous studies, we will further divide the agricultural and non-agricultural sectors into tradables and non-tradables. In this way we will be able to assess the effects of monetary shocks in two

groups for each sector. By sub-dividing the economy we gain insight in the behavior of different prices both in the agricultural and non-agricultural prices. We assume that non-tradable prices represent the flexible sector and that tradable prices represent the sluggish sector. It is possible that if money is not neutral, sectoral prices do not move in the expected direction even though the general price index shows a normal behavior. Redistribution and compensation effects within each sector could be hiding important characteristics of the response of tradables and non-tradable prices. Also, it is possible that the relative weight of non-tradables in the economy determines the validity of some standard assumptions that researchers use. For example, the assumption that agricultural prices are more flexible than non-agricultural prices. The implications of over/under-shooting for the agricultural sector are quite important due to the fact that non-tradable producers (assuming that non-tradables are produced mainly by small farmers) will have to bear most of the burden of the adjustment process. Although price flexibility is the main source of overshooting, the assumption that agricultural prices are more flexible than non-agricultural prices has yet to be determined<sup>1)</sup>. This paper attempts to offer a more consistent test, differentiating also the relative flexibility between tradables and non-tradables in both agricultural and non-agricultural sectors.

The overshooting model developed by Dornbusch [9] theoretically analyzes the effects of a monetary shock. Frankel [12] applied Dornbusch model to the agricultural sector which was extended by Stamoulis and Rausser [25] assuming that agriculture is a flex-price sector and manufactures and services are assumed to be sticky-price markets. These two models are still theoretical, and they do not provide any empirical analyzes. The basic idea behind these theoretical models is that when there are differences in the speed of adjustment of prices to monetary shocks, money neutrality does not hold; therefore, money has a real effect on the economy. The difference in speed in price movements creates an over/under-shooting of prices, which is consistent with rational expectations (Dornbusch [9], Frankel [12]). These models recognize that agriculture has some sub-sectors with rigid prices and the non-agriculture group also has sub-sectors with flexible prices but they do not provide any

specific analysis either theoretically or empirically. If the agricultural sector is divided into tradables and non-tradables, it is possible to assess indirectly the effects of monetary shocks on the food supply. This extension of the analysis is important for developing countries that have a large non-agricultural sector. Knowledge about the behavior of agricultural prices, and especially non-tradables prices might help to understand the redistributive effects of macroeconomic adjustments. This kind of approach has not been addressed in the literature before.

Empirical analyzes of the overshooting hypothesis have been tested for the U.S. case, with a good review in Belongia [1] for the New Zealand case, Robertson and Orden [21] provided coefficients for the short-/long-run scenarios. Finally Saghaian, Reed and Marchant [23] for the U.S. data and Saghaian, Hasan and Reed [22] for the Southeast Asian countries are the latest empirical tests. All this research efforts divided the economy into agriculture (flexible) and non-agriculture (sluggish), without further detail. No analysis is reported for Latin American countries, except Bessler [2] Brazil.

The organization of this paper is as follows: Section 2 describes the theoretical model where we use the exchange rate and money supply as the macroeconomic policy tools. This theoretical analysis extends previous studies dividing the agricultural and non-agricultural sectors into tradables and non-tradables. The results of Section 2 are later used in the econometrical model, which is detailed in Section 4. The structure of the theoretical equations system fits very well in the time series theory and makes it ideal for conducting an empirical analysis. The series are tested for unit roots with the Augmented Dickey-Fuller test and for the presence of cointegration following Johansen's [16] procedure. Once the number of cointegrating equations is determined, the VEC model is estimated in order to retrieve the short-/long-run coefficients which are discussed later in Section 5. Section 6 presents some final remarks.

## 2. Analytical framework

Some researchers argue that time series analyzes lack of economic theory ([11]). To solve this problem, we develop a theoretical model that builds on the original overshooting model presented by Dornbush [9]. Dornbusch's applied his overshooting hypothesis to exchange rates and the stock market. Later, Frankel [12] applied Dornbusch's overshooting model to the agricultural sector by assuming that agricultural prices represent the flexible sector and non-agricultural prices represent the sluggish sector in a closed economy model. His work was complemented by Stamoulis and Rausser [25] for an open economy. In this paper we extend the models by Stamoulis and Rausser [25] and Saghaian, Reed and Marchant [23] to include two more sectors: agricultural sluggish (non-tradables) and non-agricultural flexible (manufactures). The importance of this extension is not only theoretical, but it has important implications for policy makers. If the inclusion of non-tradables reveals that money is not neutral, then some redistribution effects occur within the agricultural sector. We are interested in finding out which sector gains and which sector loses with monetary policy. In this way it is possible to suggest compensatory solutions to policy makers. Moreover, as pointed out by Stamoulis and Rausser [25], the importance for agricultural economists is not the overshooting per se, but the possibility that farm prices can be affected negatively by monetary policy. By extending the agricultural sector into tradables and non-tradables we are able to differentiate the effects on small farmers (producers of non-tradables) and exporters (producers of tradables). Table 1 shows some recent literature that used monetary shocks to analyze the response of agricultural prices.

(Table 1)

The overshooting hypothesis is based on the assumption that there are differences in the speed of reaction of prices to monetary shocks. The existence of sluggish and flexible prices

has been addressed in the literature (Bordo [3]), with the most common opinion being that sluggish prices are the result of rigid contracts. Structural constraints (price ceilings, tariffs and other price controls) also help to create sluggish prices. In the absence of controls, providing perfect foresight and absence of monopolies, relative prices should not change after a monetary shock, which means that prices should increase by the same rate of increases in money. The agricultural sector is characterized (although not always) as a highly competitive sector mostly because of the presence of homogeneous products and abundance of producers and consumers, making agricultural prices highly flexible. However, the size of the economy and price controls create the “wedge” between flexible and sluggish prices due to the fact that the bigger the country the stronger its influence in international markets.

In this study we assume that non-tradables prices represent the flexible sector. This assumption is based on the observation that besides a handful of exceptions, most countries cannot affect international prices. Therefore, prices are fixed for the tradable sector in the short-run. For a fixed exchange rate system, international prices will remain constant unless there is a devaluation/ revaluation. With a completely flexible exchange rate, international prices measured in domestic currency might not be constant, but still their flexibility will be constrained by the relative movement of exchange rates. In most developing countries exchange rates are either fixed or influenced by government policies (dirty floating).

Equations (1a) through (1h') describe the theoretical model, where  $r$  is the domestic (nominal) interest rate, endogenous;  $r^*$  is the foreign (nominal) rate of interest, exogenous;  $x$  is expected rate of exchange rate depreciation; and  $u$  is expected secular rate of inflation. Also,  $e$  is the current exchange rate measured in units of domestic currency per dollar (foreign currency), endogenous;  $m$  is the domestic nominal money supply, exogenous;  $p$  is the domestic price level, endogenous;  $y$  is the domestic real output, taken to be fixed and exogenous;  $p_{AF}$  and  $p_{AS}$  are prices of flexible and sluggish agricultural products, respectively;  $p_{NAF}$  and  $p_{NAS}$  are prices of flexible and sluggish non-agricultural products, respectively.  $p^*$  is the foreign price level, exogenous;  $\alpha$  is the share of flexible (agricultural=1, non-

agricultural=2) and sluggish (agricultural=3, non-agricultural=4) prices on the general index;  $\chi$  and  $\lambda$  represent the elasticity of money demand and the semielasticity of money demand with respect to the interest rate respectively. Superscripts stand for supply (s) and demand (d) and subscripts stand for agricultural-flexible (AF), agricultural-sluggish (AS), non-agricultural flexible (NAF) and non-agricultural sluggish (NAS).

$$r = r^* + x \quad \text{Uncovered interest parity assumption representation (perfect capital mobility),} \quad (1a)$$

$$x = \dot{e} \quad \text{Perfect foresight,} \quad (1b)$$

$$m - p = \chi y - \lambda r \quad \text{Money market equilibrium of the LM curve,} \quad (1c)$$

$$p = \alpha_1 p_{AF} + \alpha_2 p_{NAF} + \alpha_3 p_{AS} + \alpha_4 p_{NAS} \quad \text{General price index,} \quad (1d)$$

$$y_{AF}^d = y_{AF}^s = f\left(\frac{e \cdot p^*}{p_{AF}}, \frac{p_{AS}}{p_{AF}}, \frac{p_{NAS}}{p_{AF}}, \frac{r}{\dot{p}}, y\right) \quad \text{Equilibrium in the agricultural flexible, sector, instantaneous} \quad (1e)$$

$$y_{NAF}^d = y_{NAF}^s = f\left(\frac{e \cdot p^*}{p_{NAF}}, \frac{p_{AS}}{p_{NAF}}, \frac{p_{NAS}}{p_{NAF}}, \frac{r}{\dot{p}}, y\right) \quad \text{adjustment, Equilibrium in the non-agricultural flexible sector,} \quad (1f)$$

$$y_{AS}^s = f\left(\frac{e \cdot p^*}{p_{AS}}, \frac{p_{AF}}{p_{AS}}, \frac{p_{NAS}}{p_{AS}}, \frac{r}{\dot{p}}, y\right) \quad \text{instantaneous adjustment, Supply in the sluggish agricultural} \quad (1g)$$

$$y_{NAS}^s = f\left(\frac{e \cdot p^*}{p_{NAS}}, \frac{p_{AF}}{p_{NAS}}, \frac{p_{AS}}{p_{NAS}}, \frac{r}{\dot{p}}, y\right) \quad \text{sector, Supply in the sluggish non-agricultural sector,} \quad (1g')$$

$$\dot{p}_{AS} = f\left(\frac{y_{AS}^s}{y_{AS}^d}, u\right) \quad \text{Equilibrium in the sluggish agricultural sector,} \quad (1h)$$

$$\dot{p}_{NAS} = f\left(\frac{y_{NAS}^s}{y_{NAS}^d}, u\right) \quad \text{Equilibrium in the sluggish non-agricultural sector,} \quad (1h')$$

In Eq. 1h and 1h' a point over a variable ( $\dot{\cdot}$ ) denotes change in time, meaning that sluggish prices adjust according with excess demand and that this adjustment process requires some time, *i.e.* it is not instantaneous. Flexible prices (non-tradables) adjust immediately to changes in supply and demand conditions. We use the interest rate relationship (1a) and the money supply equation (1b) to create the initial point of the derivation. Then,

$$m - (\alpha_1 p_{AF} + \alpha_2 p_{NAF} + \alpha_3 p_{AS} + \alpha_4 p_{NAS}) = \chi y - \lambda (r' + \dot{e}) \quad (2)$$

Equation (2) represents that general equilibrium level. We use the long-run values of (2) assuming that in the long-run  $r^*=0$ . By combining the short- and long-run relationships we can calculate the overshooting coefficients. We further assume that in the long-run  $m=\bar{m}$ ,  $r=r'$  and  $y=\bar{y}$ <sup>2)</sup>. By further rearranging of equations in (1) we have:

$$\begin{bmatrix} \dot{e}(t) \\ \dot{p}_{AF}(t) \\ \dot{p}_{AS}(t) \\ \dot{p}_{NAF}(t) \\ \dot{p}_{NAS}(t) \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} & z_{13} & z_{14} & z_{15} \\ z_{21} & z_{22} & z_{23} & z_{24} & z_{25} \\ z_{31} & z_{32} & z_{33} & z_{34} & z_{35} \\ z_{41} & z_{42} & z_{43} & z_{44} & z_{45} \\ z_{51} & z_{52} & z_{53} & z_{54} & z_{55} \end{bmatrix} \cdot \begin{bmatrix} (e-\bar{e}) \\ (p_{AF}-\bar{p}_{AF}) \\ (p_{AS}-\bar{p}_{AS}) \\ (p_{NAF}-\bar{p}_{NAF}) \\ (p_{NAS}-\bar{p}_{NAS}) \end{bmatrix} + \begin{bmatrix} 0 \\ h_2 \\ h_3 \\ h_4 \\ h_5 \end{bmatrix} \cdot u \quad (3)$$

where in (3), coefficients  $z_{ij}$  are linear and nonlinear relations of coefficients in (1);  $h_i$  are linear relations of the shares of each price on the total index and bars over the variables indicate the long run values. The difference equations in (3) can be expressed in a rate of change form, allowing us to estimate the overshooting coefficients. This is accomplished by obtaining the solutions of (3) and then differentiate each equation (throwing away the positive solutions for stability).

$$\begin{aligned} \frac{de}{dm} &= 1 - \frac{1}{\beta\lambda} \left[ \alpha_1 \frac{dp_{AF}}{dm} + \alpha_2 \frac{dp_{NAF}}{dm} - 1 \right] \\ \frac{dp_{AF}}{dm} &= \frac{1}{\alpha_1} \left\{ 1 + \beta\lambda \left( 1 - \frac{de}{dm} \right) - \alpha_2 \frac{dp_{NAF}}{dm} \right\} \\ \frac{dp_{NAF}}{dm} &= \frac{1}{\alpha_2} \left\{ 1 + \beta\lambda \left( 1 - \frac{de}{dm} \right) - \alpha_1 \frac{dp_{AF}}{dm} \right\} \end{aligned} \quad (4)$$

The coefficients  $\beta$  in (4) are the solutions to the system in Eq. (3). Equations (4) indicate that if we ignore the overshooting of the exchange rate ( $de/dm=1$ ) and the overshooting of non-agricultural flexible prices ( $dp_{NAF}/dm=1$ ), then the monetary shock clearly generates an overshooting in agricultural prices, everything else constant. If the exchange rate overshoots, the degree of overshooting in agricultural prices is smaller than in the previous case. And if the exchange rate undershoots, agricultural prices definitely overshoot. The usefulness of extending the theoretical analysis is now evident. Even if one of the flexible sectors is neutral

to money neutrality, the other flexible sector might overshoot its long-run trend. Then, even if the whole agricultural sector is benefited with an expansive monetary policy, some sectors might concentrate the benefits leaving the other sector in disadvantage. Moreover, it is fair to say that under these results, the assumption that “all prices are flexible” is not accurate when the share of non-tradables is significant in the economy.

### **3. Data**

To test of our theoretical findings we developed a econometrical analysis based on time series theory and cointegration. For this purpose, we selected data from two countries: Bolivia and Japan. The selection of these two countries is by no means random. Bolivia is a developing country that has faced severe macroeconomic unbalances with a “dirty floating” exchange rate system. Japan, on the other hand has enjoyed a fast growth and macroeconomic stability during the 80s and 90s. However, recently pressure from some macroeconomic variables has prompted financial authorities to accelerate the speed of creation of money. Data requirements for the VEC model restrict the number of countries that can be included in the analysis, however, a broader comparison could help to understand, for example, differences in the response of the agricultural sector in different continents.

The series were structured in a quarterly basis for the period 1985:1 to 2001:4. For Bolivia, agricultural non-tradable’s price ( $P_{ANT}$ ) is the food and beverage component of the CPI, proxy for agricultural flexible prices; agricultural tradables ( $P_{AT}$ ) are the producer prices of soybeans and sugar, the principal agricultural export products (CAO [4]), proxy for sluggish prices; services ( $P_{SE}$ ) and industrial prices ( $P_{IN}$ ) are the correspondent component of the Bolivian CPI<sup>3)</sup> (INE [13]), proxies for flexible and sluggish prices respectively. The exchange rate ( $\epsilon r$ ) is the official exchange rate (national currency per U.S. dollar, average of the period – line **rf** in the IMF FSY [14] and money supply is the M1 component (narrow

Money, **line 34** in the IMF FSY – comprising transferable deposits and currency outside deposit money banks), deflated by the CPI. Exchange rates and M1 were extracted from the IMF statistical data base (IMF [14] and <http://ifs.apdi.net/imf/>).

For Japan, the price of agricultural non-tradables is represented by the producer rice price (average); tradables price is the average of the other agricultural products<sup>4)</sup>. Price indexes of industrial and services are their corresponded component of the CPI (MPMHAPT – Japan [20]). As in Bolivia, exchange rate is the official figure, money supply is M1 and proxies for sluggish and flexible prices are the same.

The separation of tradables and non-tradables is based on the Food and Agriculture Organization's (FAO) food balance sheets, average for the years 1980-2000. Tradables are those crops that were either equal to domestic production (in the case of imports) or at least 10% of domestic production (exported), the rest was classified as non-tradables. All variables are introduced as indexes, base year 1995:1=100 in logarithmic form. In the case of aggregated indexes, a simple average was used without weights (Mattos, Ito and Usami [18]).

Almost all of previous studies used the M1 as a proxy for money supply, although a broader definition is also a possibility. The use of M1 is preferred because it implies a faster reaction to any monetary policy. The use of the CPI and its components as proxies for prices is also common. However, other variables such as producer prices, industrial prices and other kinds of indexes have been used (Belongia [1], Robertson and Orden [21], Devados and Myers [6] and Saghaian, Reed and Marchant [23]).

## **4. Results**

### **1) The ADF test**

The Vector Error Correction (VEC) model requires non-stationary series (contains a unit root) and at least one cointegrating equation, otherwise the system can be estimated with traditional VAR procedures. Table 2 shows the results of the Augmented Dickey-Fuller

(ADF) test, which is standard in the literature to identify unit roots in time series. Following Cuddington and Liang [5] and Enders [11], the “general to specific” methodology was used. Both reports suggest starting the test with enough lags to eliminate the risk of autocorrelation; Cuddington and Liang indicate that the square root of the number of observations is usually a good start. In this sense, the tenth lag was the starting point of analysis.

The first part of Table 2 shows results for test on the levels of the variables (no first difference). None of the ADF values were able to reject the null hypothesis of non-stationarity; therefore, a first-difference test was performed, and the results are shown in the lower part of Table 2<sup>5</sup>. The ADF test controls for higher order serial correlation than one. The estimated coefficients for the first-different test are statistically significant at the 1% level of confidence, indicating that the series is integrated of first order or I(1).

(Table 2)

Alternative tests were conducted to confirm the results from the ADF analysis. The Phillips-Perron test had the same results as the ADF test (not reported here). Moreover, as Table 2 shows, lags of the ADF test were analyzed as Cuddington and Liang [5] suggest, and most of the estimated coefficients were significant either at the 1% or 5% level. Only Agricultural prices of tradables ( $P_{AT}$ ) were not significant at the 10% level for Bolivia and the same for industrial prices ( $P_{IN}$ ) for Japan.

## 2) Johansen’s cointegration test

If each series is an I(1) process, the possibility of an equilibrium is examined using Johansen’s [16] cointegration test. Johansen’s test is a likelihood ratio test designed to determine the number of cointegration vectors in the system or the cointegrating rank. Formally, the model is expressed as follows:

$$\Delta x_i = \sum_{i=1}^j A_i \Delta x_{t-i} + \sum_{k=1}^s \omega_k \varepsilon_{t-1} + e_i \quad (5)$$

were,  $\mathbf{x}$  is a (nx1) matrix of endogenous variables (prices and exchange rates),  $\Delta$  represents first-difference,  $\mathbf{A}$  is (nxn) matrix of coefficients,  $\omega_k$  is a vector of coefficients,  $\varepsilon_{t-1}$  is the cointegrating relation and  $\mathbf{e}_i$  is the error term. The Johansen's test analyzes the rank of matrix  $\mathbf{A}$ , which is equal to the number of cointegrating equations ( $\mathbf{s}$ ). If the system has one or more cointegrating equations (CE), then a long-run relationship between the endogenous variables exists. For our purposes, we want to prove that prices and exchange rates are cointegrated with the money supply.

Table 3 shows the results of the Johansen's cointegration test. The lag lengths were determined with the help of the ADF test, Akaike Info-Criterion and Schwarz Criterion. For both Bolivia and Japan, four lags were used. The test indicates that there are at most five cointegrating equations (CE) at the 1% level of confidence for Bolivia and four for Japan. Several structures were tested to determine the one that explains better our data sets. For the Bolivian data we used a quadratic deterministic trend in the data, and an intercept and trend in the CE. The Japanese CE were estimated with an intercept and trend in the CE but no intercept in the VAR.

(Table 3)

The existence of 5 and 4 CE for Bolivia and Japan, respectively, indicates that prices and the exchange rate are cointegrated with the money supply in the long-run; in this sense the vector of error correction terms represents the long run hypothesis for the money neutrality, therefore:

$$\begin{aligned} \text{Bolivia: } P_{it-1} &= \pi_i + \gamma_i t + \tau_i \cdot m_{t-1} \\ er_{t-1} &= \pi_i + \gamma_i t + \tau_i \cdot m_{t-1}, \\ \text{Japan: } P_{it-1} &= \pi_i + \tau_1 i + \tau_2 i \cdot m_{t-1}, \end{aligned} \tag{6}$$

where in (6)  $P_i$  represents agricultural and non-agricultural prices;  $m$  is money supply and  $er$  is the exchange rate. The neutrality of money is tested through coefficient  $\tau$ . If  $\tau = 1$ ,

then monetary shocks do not affect relative prices, meaning that the increase in the money supply will be fully transmitted to prices. This means that this coefficient represents the long-run equilibrium relationship between prices and  $\epsilon_r$  with the money supply<sup>6</sup>). It is important to understand that  $\tau$  represents the effect of money supply on prices, a positive number indicates that money supply increases prices (inflationary). The sign and magnitude of the coefficients of  $\epsilon$ , ( $\omega_k$ ), indicates whether prices over- or under-shoot, showing us the direction of the adjustment in the long-run (see equation (5)).

### 3) The VEC

The system in (5) has the form of a VAR augmented by an error correction factor (the  $\omega_k$  components of (5)). The dependent variables respond to the lagged values of the endogenous variables ( $\mathbf{A}_i$ ) and the deviation from the long-run trend ( $\omega_k$ ).

The CE are replaced in (5) to built the final structure of the VEC. The CE for Japan include the exchange rate because there are only four cointegrating equations. For both countries the estimation uses the standard Cholesky decomposition (Enders, [11]). Therefore, the VEC will have the form:

$$\begin{aligned} \Delta x_i &= a_{i1} \Delta x_{it-1} + a_{i2} \Delta x_{it-2} + a_{i3} \Delta x_{it-3} + a_{i4} \Delta x_{it-4} + \omega_{i1} \epsilon_{1t-1} + \omega_{i2} \epsilon_{2t-1} + \omega_{i3} \epsilon_{3t-1} + \omega_{i4} \epsilon_{4t-1} + \omega_{i5} \epsilon_{5t-1} + e_{it} \\ \Delta x_i &= a_{i1} \Delta x_{it-1} + a_{i2} \Delta x_{it-2} + a_{i3} \Delta x_{it-3} + a_{i4} \Delta x_{it-4} + \omega_{i1} \epsilon_{1t-1} + \omega_{i2} \epsilon_{2t-1} + \omega_{i3} \epsilon_{3t-1} + \omega_{i4} \epsilon_{4t-1} + e_{it} \end{aligned} \quad (7)$$

where in (7)  $\mathbf{x}_i$  represents our endogenous variables described above and the  $\epsilon$  are the terms described in (6). The first equation in (7) represents the VEC for Bolivia (five cointegrating terms) and the second equation represents the VEC for Japan (four cointegrating equations). Using the same assumptions as in the Johansen's cointegration test, coefficients for (6) were obtained by estimation of the VEC system and they are showed partially in Table 4. Some other coefficients are shown in for better exposition. The figures in Table 4 are the estimated coefficients  $\pi$ ,  $\gamma$  and  $\tau$  from (6).

(Table 4)

Previous studies neglected the presence of cointegration. VAR analyzes (Bessler [2]) assume that endogenous variables are not affected by deviations from their long-run trend. This study uses cointegration not only to test for money neutrality but also to test for the relative flexibility of prices in the short- and long-run.

## **5. Discussion of the results**

### **1) Long-run money cointegration for Bolivia**

All coefficients estimated in Eq. 5 were significant at the 1% or 5% level, except for  $P_N$  (Table 4). All the coefficients are less than unity, indicating that they are affected by changes in the money supply but less than proportionately<sup>7</sup>. As expected, all signs are positive (see footnote 6), confirming that money supply is inflationary. Prices of agricultural tradables ( $P_{AT}$ ) show the strongest response, increasing by 8.19% for each 10% increase in the money supply, with everything else held constant. Industrial prices have the weakest reaction, increasing only 0.73% for 10% increase in the money supply. The long-run relations between agricultural and non-agricultural prices indicate that money neutrality does not hold in the long-run with the assumptions of the model. As predicted by the theoretical analysis in section 2, the exchange rate depreciates after an increase in the money supply, although this change is small compared with changes in agricultural prices. This is the same empirical result as in Saghaian, Reed and Marchant [23] for the U.S. case and confirms the hypothesis of Dornbusch [9]. After a monetary shock, people move away from the assets in domestic currency, anticipating a future appreciation, overshooting the spot exchange rate.

Prices increase after the money supply in the neoclassical model basically because money supply increases the aggregate demand. People holding more money adjust their present consumption by increasing their present expenditure. The increase in the aggregate demand pushes prices upwards in the short-run. Moreover, neoclassical theory assumes that this adjustment is instantaneous because all prices are flexible. Estimated coefficients in

Table 4 also show that there is a considerable difference in the reaction of agricultural prices compared with non-agricultural prices in Bolivia in the long-run<sup>8</sup>).  $P_{AT}$  react more to changes in the money supply basically because they are composed of commodities (soybeans and sugar) which are cultivated extensively with high inputs of tradables. Another reason is the high integration of tradables with the rest of the economy (loans, financial markets and international prices) makes them highly susceptible to changes in the overall economy. Also, the depreciation of the exchange rate increases prices of commodities, measured in domestic currency. Finally, tradables have close substitutes both in the domestic and international markets. Those are problems that non-tradables do not have to face in the short-run.

Moreover, non-tradables are less integrated with the economy, mostly produced by small farmers that do not rely on credits or foreign inputs, making their reaction smaller than  $P_{AT}$  to changes in the money supply. Besides that, as Mattos, Ito and Usami [18] noted, depreciations of the exchange rate push prices of non-tradables downwards reducing the effect of positive money supply shocks.

## **2) Long-run money cointegration for Japan**

As it can be seen in Table 4,  $P_{AT}$  and non-agricultural prices have positive coefficients, indicating the inflationary character of money supply, with  $P_{AT}$  being slightly bigger than one. The price of agricultural non-tradables has a negative sign, meaning that  $P_{ANT}$  decreases when money supply increases. This is a special case and mostly related with the characteristics of this group in Japan.  $P_{ANT}$  is basically rice which is heavily protected from imports. As production of rice is protected and prices decline year by year, consumers expect rice prices to fall in the future even if there a monetary expansion<sup>9</sup>). Moreover, as in the case of Bolivia, non-tradables prices have a pressure downward from the depreciation of the exchange rate.

Comparing the response of agricultural prices with non-agricultural prices, results are quite similar to those reported for Bolivia. In average, agricultural prices have a stronger response to changes in the money supply than non-agricultural prices. For example, if  $M1$  increases by 10%,  $P_{AT}$  increases 10.05% but  $P_{IN}$  increases only 3.71%, everything else

constant. This relative stronger response to money supply changes indicates relatively more sensitive prices in the agricultural sector. As in the analysis of Bolivian data, the relative “strength” of the reaction to money supply was tested with the Wald Test, being the differences significant at the 1% level.

The results in Table 4 indicate in general that, as in the case of Bolivia, money neutrality does not hold in the long-run for the present model and data set. The only case where the coefficient of M1 is close to unity is for agricultural tradables,  $\tau = 1.057$  which is significant at the 1% level (see Footnote 8). This may be indicating that money neutrality holds for tradables in the agricultural sector in the long-run. However, if we consider the reaction of the other prices to monetary shocks, money neutrality does not hold for a composite price index.

### **3) Overshooting and short-/long-run relationships**

#### **(1) Bolivia**

The various  $\omega_k$  coefficients of (5) can be understood as “speeds of adjustment” (Enders, [11]). The magnitude of each coefficient indicates how fast the variable returns to its long-run equilibrium; also importantly, the direction of the deviation. The “overshooting” or “undershooting” of the dependent variable is determined by the sign of  $\omega_k$ . For example, a negative sign indicates that the variable will have to increase in the short-run and to fall in the future to return to its long-run equilibrium level.

Table 5 shows that signs are negative for agricultural and non-agricultural prices for their own departures from the long-run equilibrium, and positive for the exchange rate. The interpretation is straight. For example, in the case of  $P_{ANT}$ , the negative sign is indicating that prices on this sector will overshoot requiring prices to fall to the long-run equilibrium in the future. The speed of adjustment is quite different for agricultural and non-agricultural prices which seem to return faster to their long-run equilibrium than agricultural prices. Agricultural tradables have the smallest coefficient indicating some rigidity in this market, probably related to the scale of production in the tradables sector and its relation with

financial and input markets. Once a big production is started, it is difficult to scale it back, especially when it demands a development of new land. Small farms with small production (and often in a multi-crop style) have more flexibility to change production patterns.

It is interesting to note that agricultural prices appear to react more to monetary shocks but non-agricultural prices return faster to the long-run equilibrium, almost instantaneously. This could be due to the relative high share of food in the budget of the average household in Bolivia. If the household spends a large share of its budget on food, they should be more susceptible to changes in food prices. In the event of having more cash in hand, they may spend it on more food. Once prices start to rise, they adjust their expectations and wait for them to fall. On the other hand, industrial prices react to money shocks in the long-run, but modestly, mainly because they do not expect individuals to increase the purchase of industrial goods even when there is more money available.

(Table 5)

## **(2) Japan**

The estimated coefficients for  $\omega_i$  in Japan indicate that agricultural prices and the price of services ( $P_{SE}$ ) overshoot but  $P_{IN}$  undershoots its long-run trend, although with a very small coefficient (Table 5).  $P_{IN}$  positive sign indicates that industrial prices will fall in the short-run to increase later towards its long-run equilibrium value. Moreover, long-run effects of monetary shocks are positive (see Table 4); therefore, the short-run fall is more than compensated in the long-run, indicating that  $P_{IN}$  is below its long-run equilibrium level. In the case of  $P_{ANT}$ , as a result of a monetary shock, prices increase in the short-run and fall later. This process of adjustment takes about 3 quarters to a year, the fastest among Japanese coefficients.  $P_{ANT}$  has to fall in the long-run as indicated in Table 4, but in short-run  $P_{ANT}$  will increase for a while as a momentary effect.  $P_{AT}$  has a stronger reaction in the long-run to monetary shocks but is slower to return to its long-run equilibrium level compared with  $P_{ANT}$ .

Results for Japan show that agricultural prices are sensitive to the previous deviations from the long-run equilibrium of all variables. The existence of four CE determines that the long-run relationship for the exchange rate is contained in the CE. Therefore, there is no specific CE for the *er*. The exchange rate coefficient is bigger for non-agricultural prices, indicating the relative importance of this sector in the economy, especially in the tradable sector.

### **(3) Comparison between Japan and Bolivia**

The differences in the results between Bolivia and Japan originate from several reasons. The money neutrality ( $\tau_i$ ) coefficients are consistently higher for Japan than for Bolivia, for all variables. The sign of  $\tau_i$  for the  $P_{AT}$  equation shows a negative sign for Bolivia (inflation) and a positive sign for Japan (deflation). This result may be due to the differences in the relative expectations of the economic agents. In Bolivia, agents expect the effects of monetary shocks to be permanent but bigger than it looks, mostly because of the unstable macroeconomic environment. In Japan agents expect the effect to be temporal and small, which, in part, can be related with the historical stability and strong commitment of the Japan Central Bank against inflation. The individuals, in this case, start spending even after the money shock happens in order to optimize their long-run consumption. This behavior increases prices and reinforces the money shock, thus creating overshooting. However, in the case of Japan, the continuous policy of keeping the inflation down and restricting monetary policy hints consumers that money increases will not be permanent. Then, they adjust their consumption levels but in a lesser degree, and they wait for the prices to keep falling in order to optimize their budgets.

Money policy is only neutral if all prices adjust by the same level at the same period, or if in the long-run, they respond by the same degree to money shocks. Therefore, money neutrality is highly related with the assumption of perfect information. If it is not possible to anticipate 100% the money shock, price movements could be sluggish in some markets. In markets where there is more information available, prices will adjust faster (flexible prices)

compared with markets where information is restricted to all actors (sluggish prices). This could explain why agricultural prices in Japan return faster to their long-run equilibrium than Bolivian prices. Information requires less time to reach consumers and producers in Japan.

## **6. Concluding remarks**

The contributions of these paper are twofold. First, we extended and applied the overshooting hypothesis on the agricultural sector in order to incorporate tradables (sluggish) and non-tradables (flexible) into the traditional agricultural and non-agricultural sectors of the economy. Second, we applied time series and cointegration theory to analyze data from Bolivia and Japan. Both approaches are new to agricultural economics, especially for developing countries.

The theoretical analysis indicates that prices in the flexible groups will overshoot their long-run trend, and that this result depends on the exchange rate reaction to money shocks. Even if exchange rates and one flexible price are neutral to monetary shocks, the other flexible price might still overshoot. This indicates us that monetary policy is not neutral as assumed by scholars and policy makers. More importantly, important redistribution effects can be generated by these policies.

Time series theory allows us to analyze empirically the theoretical model with enough flexibility to test for money neutrality, overshooting and price flexibility. The Johansen's test found five and four cointegrating relationships for Bolivia and Japan, respectively. The existence of cointegrating terms allows us to use the Vector Error Correction (VEC) model. Money neutrality is rejected with the data analyzed in this paper. Bolivian and Japanese data indicates that in the long-run, prices do not increase proportionately to money increases. This result confirms the assumptions of the theoretical model, in other words, the four prices studied here have different speeds of reaction to money shocks which create the

overshooting in the short-run. These findings demonstrate the importance of considering the side effects of monetary policies on the agricultural sector. The overshoot in the agricultural sector may force agricultural non-tradable prices out of its long-run trend, reducing the quantity of food available to consumers in the short-run (Mattos, Ito and Usami [18]). The effect is stronger if agricultural tradable prices undershoot. If monetary shocks is negative, however, production of agricultural non-tradables will likely fall. This result is important for policy makers, especially in food importing developing countries.

There are some restrictions on the interpretation of the results of this paper. First, the theoretical model implies perfect foresight in the exchange market, which is certainly not true for small farmers who are not usually close to financial centers. Second, the VEC model is rather simple; however, the inclusion of more variables greatly reduces the degrees of freedom and there are restrictions in the management of the data. Finally, the division between tradables and non-tradables is not permanent and the status of the products can be changed depending on the economic and social circumstances.

Nevertheless, results of this paper indicate that macroeconomic policies, and especially monetary policy, are very important for the agricultural sector and for the food supply. Even when agriculture is a small part of the GDP, as in the case of Japan, short- and long-run movements of prices can be expected as a result of a monetary shock. Policy makers should consider these effects in advance and improve the design and the policy for the agricultural sector. This is more important if we consider that the unfavorable effects of any policy are usually borne by the poorest of the poor.

<sup>1)</sup> It is of course possible that prices might undershoot. In this sense, we use the term “overshoot” when prices depart from their long-run trend more than expected. We use the term “undershoot” when prices increase, but less than expected. The same definition applies when prices decrease.

<sup>2)</sup> Details of the mathematical development for a model with two goods can be found in Stamoulis and Rausser [25] and Saghaian, Reed and Marchant [23] or from the authors.

<sup>3)</sup> A December 2002 the CPI in Bolivia was composed of: Food and Beverages, Footwear and clothing, Housing, Furnishing and home related expenses, Health, Transports and communications, Education, Entertainment and culture and other goods and services, INE [13].

<sup>4)</sup> Based on data of the Monthly Statistics of Agriculture, Forestry & Fisheries of the Japanese Ministry of Agriculture: 1985-2002 (MAFF [19]). The "Price indexes of commodities in rural areas" (producer prices) is divided into: Rice (General, Rationed, Jishuryutsumai and Non-rationed), Wheat, Pulses, Potatoes and sweet potatoes, vegetables, fruits, industrial crops, flowering, cocoons, livestock products and rice straw. Flowers, cocoons, livestock products and rice straw were not included in the Japanese agricultural tradables index.

<sup>5)</sup> The statistical software used for the estimation (QMS's EViews) reports Mackinnon [17] critical values and not those tabulated by Dickey and Fuller.

<sup>6)</sup> In the long-run,  $\varepsilon$  in (5) equals zero, then (6) is introduced in (5) in the form  $\varepsilon_{it-1} = P_{it-1} - \pi_i - \gamma_i t - \tau_i m_{t-1}$  for Bolivia and  $\varepsilon_{it-1} = P_{it-1} - \pi_i - \tau_{1i} er - \tau_{2i} m_{t-1}$  for Japan.

<sup>7)</sup> To test if the coefficients were statistically different from one, or statistically different between them, we used the Wald test as described by Dolado and Lütkepohl [7]. All differences were statistically significant at the 5% level.

<sup>8)</sup> The relative difference between coefficients, both for Japan and Bolivia, was tested with the Wald test. All possible combinations were analyzed, being significant at the 1% level. The Wald test uses a  $\chi^2$  distribution.

<sup>9)</sup> The interpretation is easier if we take into account the income effects of more real money in the hands of consumers and more exports. As Ito, Peterson and Grant [15] indicated, rice has become an inferior good in Japan, meaning that prices will depress as income increases, *ceteris paribus*.

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Table 1. Previous studies of money supply shocks on agricultural prices

<b>Authors (year)</b>	<b>Variables</b>	<b>Sample period</b>	<b>Data frequency</b>	<b>Long-run neutrality</b>
Chambers (1984)	CPI food and non-food. M1	1976-1982	Monthly	Not tested
Starleaf (1982)	Prices received, prices paid. Inflation rate	1930-1983	Annual	Not tested
Devadoss and Myers (1987)	Prices received, index of industrial prices. M1	1960-1985	Monthly	Non-neutral
Taylor and Spriggs (1989) <sup>1)</sup>	Index of farm product prices. M1	1959-1984	Quarterly	Ambiguous
Tegene (1990)	PPI farm output, PPI nonfarm output. M1	1934-1987	Annual	Non-neutral
Robertson and Orden (1990) <sup>2)</sup>	Nominal out prices both for Agriculture and Industry. M1.	1963-1987	Quarterly	Neutral
Han, et. al.	Index of farm prices. M1	1960-1985	Quarterly	Non-neutral
Belongia (1991)	Farm price received, PPI. M1	1976-1990	Quarterly	Neutral (little effect of monetary policy)
Saghaian, Reed and Marchant (2002)	Agricultural PPI, Industrial PPI. M1	1975-1999	Monthly	Non-neutral
Saghaian, Hasan, Reed (2002) <sup>3)</sup>	Agricultural PI, industrial PI. M1.	1985-1997	Monthly	Non-neutral

<sup>1)</sup> Canadian<sup>2)</sup> New Zealand<sup>3)</sup> Korea, Philippines, Thailand and Indonesian

Table 2. ADF test and Mackinnon critical values\*

Description	Japan				Bolivia			
	Lag	Value	Probability (%)		Lag	Value	Probability (%)	
			M**	Lag			M**	Lag
<b>Levels</b>								
<b>P<sub>ANT</sub></b>	5	-3.711	5.0		1	-0.863		
<b>P<sub>AT</sub></b>	5	-2.933			3	-0.640		
<b>P<sub>IN</sub></b>	2	-5.914			5	-2.211		
<b>P<sub>SE</sub></b>	2	-1.262			5	-0.027		
<b>er</b>	2	-3.174	10.0		3	-2.599		
<b>M1</b>	2	0.678			3	-0.977		
<b>First difference</b>								
<b>P<sub>ANT</sub></b>	5	-4.396	1.0	1.1	1	-8.340	1	0.01
<b>P<sub>AT</sub></b>	5	-5.391	1.0	1.2	3	-4.204	1	11.54
<b>P<sub>IN</sub></b>	2	-5.914	1.0	14.4	5	-5.044	1	2.17
<b>P<sub>SE</sub></b>	2	-4.431	1.0	3.1	5	-5.470	1	0.21
<b>er</b>	2	-3.644	5.0	1.7	3	-13.275	1	1.26
<b>M1</b>	2	-9.507	1.0	0.0	3	-4.748	1	0.37

\*Series were analyzed with the assumption of the existence of intercept and a trend.

\*\*The null hypothesis of a unit root is rejected against the one-sided alternative if the value (t-statistic) is less than the critical value reported by Mackinnon [17]. **M** indicates the probability for the associated Mackinnon critical value. **Lag** indicates the probability of the t-value for the associated lag.

Table 3. Johansen's cointegration test (Obsterwald - Lenun critical values)

	<b>Coint. Rank</b>	<b>Eigenvalue</b>	<b>Likelihood Ratio</b>	<b>5 Percent Critical Value</b>	<b>1 Percent Critical Value</b>
Bolivia <sup>a)</sup>	k≤1	0.776	219.638	104.94	114.36
	k≤2	0.676	143.315	77.74	85.78
	k≤3	0.485	85.858	54.64	61.24
	k≤4	0.419	52.020	34.55	40.49
	k≤5	0.341	24.290	18.17	23.46
	k≤6	0.058	3.030	3.74	6.40
Japan <sup>b)</sup>	k≤1	0.662	174.278	102.14	111.01
	k≤2	0.511	110.341	76.07	84.45
	k≤3	0.407	68.130	53.12	60.16
	k≤4	0.270	37.296	34.91	41.07
	k≤5	0.190	18.757	19.96	24.60
	k≤6	0.101	6.296	9.24	12.97

<sup>a)</sup> Test assumes quadratic deterministic trend in data. Intercept and trend in CE, linear trend in VAR. Results with four lags.

<sup>b)</sup> Test assumes no deterministic trend in data. Intercept (no trend) in CE, no intercept in VAR. Results with four lags.

Table 4. Parameters for cointegrating equations\*

	Bolivia					Japan			
	$\varepsilon_{1t-1}$	$\varepsilon_{2t-1}$	$\varepsilon_{3t-1}$	$\varepsilon_{4t-1}$	$\varepsilon_{5t-1}$	$\varepsilon_{1t-1}$	$\varepsilon_{2t-1}$	$\varepsilon_{3t-1}$	$\varepsilon_{4t-1}$
$\mathbf{P}_{ANT}$	1	0	0	0	0	1	0	0	0
$\mathbf{P}_{AT}$	0	1	0	0	0	0	1	0	0
$\mathbf{P}_{IN}$	0	0	1	0	0	0	0	1	0
$\mathbf{P}_{SE}$	0	0	0	1	0	0	0	0	1
$Er(\tau_{it})$	0	0	0	0	1	-0.120 (-0.849)	0.806** (1.763)	0.374** (3.520)	0.476** (3.867)
$\mathbf{Money}(\tau_i - \tau_{2i})$	-0.212* (-1.883)	-0.819** (-4.194)	-0.073 (-1.063)	-0.116** (-2.743)	-0.151** (-2.753)	0.642** (3.732)	-1.057** (-1.902)	-0.371** (-2.877)	-0.607** (-4.053)
$\mathbf{TREND}(\gamma_i)$	-0.0178	0.022	-0.022	-0.017	-0.015				
$\mathbf{Constant}(\pi)$	-2.522	0.953	-3.108	-2.957	0.263	-7.412** (-10.882)	-2.372 (-1.078)	-4.362** (-8.534)	-3.700** (-6.242)

\*Numbers in parenthesis are t-statistics. A \* indicates 5% significance and \*\* indicates 1% significance.

Table 5 Vector Error Correction (VEC) results – Overshooting coefficients <sup>a)</sup>

	<b>Bolivia</b>						<b>Japan</b>					
	$\Delta P_{ANT}$	$\Delta P_{AT}$	$\Delta P_{IN}$	$\Delta P_{SE}$	$\Delta er$	$\Delta M1$	$\Delta P_{ANT}$	$\Delta P_{AT}$	$\Delta P_{IN}$	$\Delta P_{SE}$	$\Delta er$	$\Delta M1$
$\omega_1$	-0.497** (-1.559)	-0.599 (-0.896)	0.216** (1.505)	0.208** (1.549)	0.358* (2.457)	-1.802** (-1.331)	-0.864* (-3.171)	-0.162 (-0.438)	-0.034 (-1.133)	-0.018 (-1.018)	-0.043 (-0.151)	-0.163 (-1.120)
$\omega_2$	0.027 (0.338)	-0.173 (-1.021)	-0.052** (-1.412)	0.006 (0.187)	-0.038 (-1.027)	0.429 (1.246)	-0.281* (-2.297)	-0.273** (-1.642)	-0.001 (-0.051)	0.008 (0.970)	0.335* (2.591)	0.006 (0.087)
$\omega_3$	-0.682 (-0.934)	1.293 (0.845)	-1.027* (-3.119)	0.078 (0.253)	-0.207 (-0.621)	2.509 (0.809)	0.336 (0.348)	1.929** (1.467)	0.063 (0.589)	0.078 (1.248)	-1.659** (-1.624)	-1.936* (-3.758)
$\omega_4$	2.710* (2.300)	-2.444 (-0.989)	1.072* (2.015)	-0.842** (-1.691)	-1.204* (-2.232)	-3.330 (-0.665)	-0.436 (-0.575)	-0.990 (-0.961)	-0.051 (-0.615)	-0.077** (-1.572)	0.094 (0.118)	1.489* (3.690)
$\omega_5$	-0.748 (-1.881)	1.263** (1.513)	-0.121 (-0.675)	0.146 (0.870)	0.305** (1.673)	3.481* (2.057)						
R <sup>2</sup>	0.826	0.814	0.908	0.889	0.930	0.725	0.760	0.616	0.910	0.849	0.654	0.887
F	3.157	2.909	6.563	5.318	8.866	1.753	3.635	1.839	11.644	6.455	2.171	8.976
Obs.	51	51	51	51	51	51	59	59	59	59	59	59

<sup>a)</sup> Numbers in parenthesis are t-statistics. A \* indicates 5% confidence and \*\* indicates 10% confidence.