Doctoral Dissertation

MACROECONOMIC ADJUSTMENTS AND THE AGRICULTURE

AN ANALYSIS OF EXCHANGE RATE AND MONEY SUPPLY SHOCKS IN A MODEL WITH NON-TRADABLES

マクロ経済の調整とその農業への影響に関する研究
ー　非貿易産物に対する為替レート及びマネーサプライモデル分析　ー

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Table of Contents

Index of Figures

Index of Tables

Chapter 1

1. Introduction

The present study offers detailed analyzes of the effects of macroeconomic policies on the agricultural sector. It also presents a framework to understand how Rural Development Programs (RDP) can help to reduce the negative effects of macroeconomic policy on the agricultural sector. To attain this objective we need to structure the analyzes within a context. For the present study, we will use macroeconomic adjustments as the context and the exchange rate and monetary policy as the macroeconomic tools. Moreover, we will concentrate our analytical analysis on developing countries. Developing countries have experienced the most dramatic macroeconomic adjustments in the recent economic history, and most likely, they will continue to face structural instabilities that will require some adjustment.

Macroeconomic adjustments have been an important part of the economic history of developing countries in the last twenty five years or so. Obviously, there are many kinds of macroeconomic adjustments, depending on the country and degree of macroeconomic and microeconomic disarray. Some countries needed just one (usually painful) adjustment, some others carried out several programs, but at the end of the 20th century developing countries were more or less stable in terms of financial and economic variables. Researchers from all over the world dedicated many papers, books and reviews to the topic because each adjustment was a great country-wide economical experiment, usually not available to economists. Most evaluations of these adjustment programs concluded that the country was better off after the adjustment than before (Ingco, 1997; Agénor, 2002 and Dollar and Kraay, 2002). Usually these evaluations concentrated on a few variables like per-capita income, economic growth, trade, fiscal stability and some socioeconomic variables like education and health rates. However, some other studies encountered questionable results, especially when the analysis goes beyond the surface of simple observation of macroeconomic indicators (Weisbrot, et. al., 2001). Some researchers argue that income distribution has worsened, that the number of poor people (total numbers) is larger than before and that economic growth is almost zero for the period after the adjustment compared with the situation before the macroeconomic adjustment. This ambiguity in the literature is a great incentive for research on specific issues of macroeconomic policy and macroeconomic adjustments in general (Davis, Thomas and Amposah, 2001).

Two components of the macroeconomic adjustment package are of particular interest. Exchange rate devaluations and money supply management. Exchange rate devaluations[1] are one of the tools used to increase exports, which is one of the main objectives of macroeconomic adjustments. The more exports the country has, the less pressure on domestic variables, like interest rates and inflation. Policy makers used two strategies to increase exports. First, they reduced the overall tariff rate and simplified the system to open the country to foreign trade[2]. This process was carried

[1] In the economic literature it is customary to use the term "devaluation" when the analysis is related to fixed exchange rates. The term "depreciation" is used when researchers analyze flexible exchange rates. However, our study is focused on the developing country case, where for some periods flexible exchange rate schemes were used and for some other periods fixed exchange rates were in place. In this sense, we will use both terms interchangeably through this study.

[2] Complementary, as trade volumes increased as a consequence of the macroeconomic stabilization, also the "free trade" policy came under scrutiny because researchers started to doubt about its success as a development strategy.

out by most developing countries in a unilateral basis, independently of the Uruguay Round negotiations (Goldin and van der Mensbrusche, 1994). The second strategy was to devaluate the exchange rate, thus, making exports more competitive in international markets.

In the case of money supply management, a tight and strict control of public expenditure was introduced. This control was reflected in the elimination or drastic reduction of subsidies and closing of public companies in most developing countries. For developing countries this policy meant a big negative monetary shock. The population felt the negative monetary shock through the reduction of the circulating money and a reduction in the velocity of the creation of money.

As with macroeconomic adjustments, there are doubts about the success of either policy. Some researchers argue that the liberalization process does not directly benefit the country, but benefits go to multinational companies and that devaluations are used as a negotiating leverage and not as a counter-cycle tool (de Melo and Dhar, 1992).

Moreover, some researchers indicate that macroeconomic adjustments are part of history and that there is no need to continue the analysis of their effects. Recent events have demonstrated (Asian crisis, Argentinean and Brazilian debt problems) that macroeconomic instability is a continuous, almost cyclical, phenomenon that will continue to happen in the future. Under this scenario, knowing how different sectors of a specific economy will react to, for example, exchange rate devaluations, will be invaluable to make decisions for policy design. The macroeconomic linkages, specifically the impact of macroeconomic shocks can be traced directly to the agricultural sector (Shane and Liefert, 2000). The negative impacts of macroeconomic shocks are usually price instability and distorted market signs, but direct policies, like governmental programs, can also be negative under some scenarios.

Soon after the economy was stabilized policy markers realized the need for some kind of support or compensation for the sectors that had experienced net income losses. The chosen strategy was to continue with Rural Development Programs (RDP), which had been in use since the 1960s. However, policy makers changed the focus of RDPs to include health, education and infrastructure to complement the traditional agricultural component. This means that the usual research-extension strategy was discarded due to the lack of success in the previous decades. Although RDPs were designed to help small farmers and focused on the poorest group of them, results were discouraging. The rate of migration, income, life expectancy and income per capita have not met expectations, neither for small farmers nor policy makers. This raises a fundamental question: Is there an economical explanation that can be traced to macroeconomic policy to explain this failure?

We believe that exchange rate devaluations and negative monetary shocks are important factors in the determination of prices and therefore, quantities[3]. Moreover, the negative impacts of these two policy tools on the agricultural sector reduced or eliminated the benefits of RDPs. We will see that by focusing on non-tradables, RDP does not contribute to the income-generation process, but on the contrary, increases the pressure on non-tradables prices. Possible economic explanations for this phenomena can be found in the intrinsic characteristics of the agricultural sector and their relation with international trade. In the early stages of

[3] As Barret (1999) points out, this issue is of considerable importance given contemporary emphasis on both macroeconomic adjustment and agricultural development in low-income economies. Although his paper is focused on the Sub-Saharan countries, the fact that real exchange rate devaluation has been the most common and substantial corrective introduced in structural adjustment programs is still true for the rest of developing countries.

development, the quantity of traded goods is a small part of the total production/ consumption of goods. As the country develops, tradables become more important both in volume and in value. But, non-tradables still exist. In the context of most developing countries, they still represent a significant share of total production both in the agricultural and non-agricultural sectors. Moreover, non-tradables are produced by small farmers. Then, the ambiguities about the success of macroeconomic adjustment, the drawbacks of the policy and invisible negative effects might have concentrated on this sector. In short, policies that stimulate production of tradables could have been harming producers of non-tradables (UNCTAD, 2000).

However, although the effects of macroeconomic policies, macroeconomic adjustments and RDP can be negative for small farmers, they may be positive for the food security of the country. It is possible that if tradables have a better response to these policies, the quantity of available food may be better under this scenario than under the alternative one. Therefore, policies that promote liberalization (like exchange rate devaluations) are, in an indirect way, beneficial for the country as food security improves. The question of the viability of small farmers as participants in the agricultural business remains and some policy has to be designed to help them during the transition.

Now the principal motivations for the present study have been exposed. The description of macroeconomic adjustments, their relation with RDPs and the link with international trade have left important questions unanswered. The most important problem with previous research efforts is that non-tradables have been ignored completely on econometric and theoretical analyzes, even though several authors (Dornbusch, 1973; Derevan, Lewis and Robinson, 1993; Lane and Milesi-Ferreti, 2002 and Strauss, 1999, among others) highlighted their importance in the price determination process. This means that most research reports assume that agricultural products are tradables and in this way they neglect the important implications of the equilibrium determination in a model with non-tradables. Barret (1999) recognizes that although the agricultural sector is often modeled as fully tradable, important sub-sectors in virtually all economies are non-tradable due to non-zero market intermediation costs. In this study it is acknowledged that the term "non-tradable" is temporary by definition. Some products may be non-tradable for a specific time frame due to transport costs or any production-marketing restriction. But if the characteristic of non-tradability is related to habits or tastes of a particular country, it is possible that the product may remain "non-tradable" for a long time. If these products become valuable, eventually they can be produced in a different country and become "tradable".

There are some research reports that included the exchange rate as an explanatory variable (Jaeger, 1994; Lamb, 2000), but none that also presented a theoretical background for the empirical analysis. This is a serious weakness in this kind of analysis, the empirical results cannot be traced back and therefore it is not possible to analyze fundamental variables or the production structure of the country under study. Related with this issue, is that research on developing countries has focused on the African situation only. Therefore, reliable data from other countries, results, elasticities and other figures of importance to policy makers are not easy to find. This fact is surprising considering that developing countries in Latin America and Asia are important players in the international market of agricultural products. Besides that, even though evaluations of the macroeconomic adjustments and their effects on the economy exist for a wide variety of countries, detailed analyses of sector-specific characteristics are scarce.

The lack of analysis of non-tradables (either agricultural or non-agricultural), when discussing monetary shocks is also notorious. Both in the theoretical and empirical fields researchers divide the country into agricultural and non-agricultural sectors, assuming that all products are tradables in the agricultural sector. We will see that the introduction of non-tradables in the analysis supports not only the view that agricultural products are more flexible in the short run, but also that non-tradables are more flexible than tradables, in a small country. Researchers also assume that monetary policy has a neutral effect on prices, therefore prices need to be analyzed in "real" terms. However, if prices are not neutral, monetary policy has a real effect on the economy, which is the case in developing countries. This omission might have misdirected policy makers and caused the failure of some development and adjustment programs.

As in the case of non-tradables, we find that the food supply (FS) is not an intrinsic part of theoretical or empirical research. This is true even though food supply is a key topic in any discussion of development of poverty alleviation. The treatment of the food supply has been limited to a discussion of its level, tendency, characteristics, and so on. But direct econometric analysis or even indirect analysis of its determinants is difficult to find in the literature. Once we understand how the underlying components of the food supply behave after a macroeconomic shock, it is possible to translate this interpretation to the food supply. Also, it is possible to analyze directly the food supply with structural or time series models, depending on the availability of data and scope of the research. Therefore, the understanding of how macroeconomic shocks affect the agricultural sector can help us not only to suggest policy action to compensate for the loss in income but to address food security issues, one of the principal topics of current discussions on the World Trade Organization round of negotiations.

Therefore, the principal objective of the present study is:

> ***"To study the response of agricultural variables to macroeconomic shocks and re-distributive effects when non-tradables are included in the analysis"***

Behind this principal objective there are two facts that help to connect our research with the real world. First, macroeconomic shocks were common, are common and will be part of the life of most countries since they are part of normal macroeconomic cycles. This fact is more important for developing countries since their economies are less resistant to internal and external unbalances. Second, the agricultural sector is highly susceptible to changes in the macroeconomy, especially the tradable sector. Governments trying to improve the country's trade balance will likely favor tradables, which adds to the negative effects of macroeconomic adjustments on the non-tradable sector.

The principal objective is attained by developing our secondary objectives. As we pointed before, macroeconomic shocks have different forms, but some variables are common to all of them. We are interested in two of them. The exchange rate, and the money supply. In this way our secondary objectives are:

1. To investigate the effects of exchange rate devaluations (revaluations) on agricultural production and the food supply in a model with non-tradables
2. To investigate the effects of monetary shocks on agricultural and non-agricultural prices in a model with non-tradables
3. To design a rural development program that includes the findings of the theoretical and empirical analyzes

Each of our three secondary objectives is analyzed in a different Chapter. We can also think that the third secondary objective is a practical application of the findings in the previous Chapters. In other words, we use the results of the exchange rate and monetary policy analyzes to structure a clear rural development program which is different to the previous programs implemented in developing countries.

Although our theoretical models can be applied to a wide range of circumstances, empirical analyzes need to concentrate in a certain geographical location. We will use four South American countries for the analysis of exchange rate shocks, all developing countries. For the analysis of monetary shocks we will use data from Japan and Bolivia. Later, we will concentrate on the Bolivian case, understanding that this case study can be generalized to most developing countries with some restrictions.

The methodology that we will use in this study aims to address the previous questions and ambiguities. Chapter 2 introduces the countries that will be studied in Chapters 3 and 4, and offers a brief description of their macroeconomic characteristics along with specific details that will help to understand the results of the econometrical estimation. As explained before, the exchange rate and money supply are fundamental tools, not only to execute macroeconomic adjustments but as a day to day tool for macroeconomic corrections and incentives. In this sense we have devoted one Chapter to each variable, which will address its theoretical and practical relation with the agricultural sector, and also with the food supply.

Although the macroeconomic variables in this study have different characteristics and behaviors, we want to concentrate on three of them. For the exchange rate, we are interested in how currency devaluations (revaluations) affect the agricultural sector and the food supply. And for the money supply, we are interested in its property of “neutrality” and the implicit effect that this assumption has on prices, that is, that they are completely flexible.

In this way, in Chapter 3, we analyze the theoretical background that supports our empirical model. In the case of exchange rate devaluations and their interactions with the agricultural sector, we start with the Dornbusch (1973) model which divides the economy into tradables and non-tradables. The theoretical results indicate that an exchange rate devaluation in the home country will depress non-tradables prices, which translated into the food supply relation (coupled with the effects on the tradable sector) indicate that the food supply will fall, if non-tradables are inferior goods. The econometrical analysis aims to test those theoretical findings by using a structural model that includes all the components of the food supply and endogenizing per-capita income and the real exchange rate but assuming that the agricultural sector is small compared with the other sectors of the economy. That means that equations for the non-agricultural sector are not included. We use annual data for Bolivia, Argentina, Brazil and Venezuela, and all developing countries but with distinct agricultural sectors and production structures.

Chapter 4 follows the same vein. We use Stamoulis and Rausser (1988) and Saghaian, Reed and Marchant (2002) theoretical models to analyze the effects of monetary shocks on agricultural prices. There are two issues to study in this chapter. First, we want to determine the existence or not of overshooting and its magnitude and second, if money is neutral in the short- and long-run. These two issues are deeply related with macroeconomic policy and usually overlooked in the literature. If money is not neutral (as assumed), then monetary shocks have real effects on agricultural prices and will create a difference in their speed of reaction (overshooting). Our theoretical model extends previous research efforts introducing non-tradables in the analysis, assuming that they represent the “buffer sector”, in other words, the “flexible sector”. As in previous studies, the theoretical results indicate that a positive monetary shock depreciates the exchange rate and overshoots flexible prices. The degree of overshooting depends on the overshooting of the exchange rate and the share of flexible prices on the general price index. To test these theoretical findings we use Time Series theory, applying cointegration and the Vector Error Correction model to quarterly data of Bolivia and Japan. Time Series theory allows us not only to test for the existence of overshooting but also to test for the neutrality of money, implicitly assumed in macroeconomic models.

After the econometric estimation and discussion of the effects of each variable on the agricultural sector, we continue with a different analysis of the econometrical results, that is, using results of Chapter 3 and 4, we perform some quantification of macroeconomic shocks on the agricultural sector. To do so, we use the average shock for the period of analysis for each country and a one percent shock. For the exchange rate we are interested in calculating the quantities of non-tradables and food supply that are affected by currency devaluations. For the money supply, we are interested in the effects on agricultural prices, specifically, on non-tradables' prices. By using our previous results we can estimate the amount of misalignment of agricultural prices in relation to their long-run trend.

The usefulness of the calculations is exemplified by sketching an alternative Rural Development Program (RDP), which is termed in this study as a "pro-trade RDP". Both the results of the exchange rate and money supply analyzes are used to backup the proposal. The main idea behind the pro-trade RDP is to acknowledge the fact that producers of non-tradables will face a continuous negative environment if developing countries continue pushing for trade liberalization and macroeconomic stability. This fact has been recognized (Schuh, 2000) and it is in line with the historical development of the agricultural sector. Fighting against this natural process is costly and sends mixed signs to the markets distorting the incentives that farmers receive. Moreover, considering that RDPs are funded with public resources, the misallocation of financial and human resources can create severe burdens on future generations, because they will have to pay for the loans.

Finally, Chapter 7 offers some concluding remarks. The first part of the conclusions describes the theoretical and empirical results of Chapters 3 and 4. It emphasizes the importance of both shocks (exchange rate and money supply) on the agricultural sector, detailing how macroeconomic adjustments affected agricultural production and food supply. The close relation between the theoretical analysis and the empirical calculations is then presented as an "integrated model", where the theoretical discussion offers all the economic background for the system estimation, both in the structural model and the Time Series model. The econometric results not only backup the theoretical findings but also highlight the differences between developing countries and developed countries and between a highly technified agricultural sector and a labor intensive agricultural sector. The proposal for a new RDP, which has to be "pro-trade", serves as a corollary for the Chapter.

Chapter 2

2. Countries selected for the present study

The previous Chapter introduced the principal ideas that serve as a backbone for the present study. Now we offer a more detailed description of the macroeconomic background and some details of the countries selected for this study, information that are necessary to understand the importance of the theoretical and empirical findings.

2.1. Socioeconomic outline of selected countries

Figure 2.1 Countries selected for the present study (marked in orange)

The countries selected for the present study are Argentina, Bolivia, Brazil, Venezuela and Japan (see Figure 2.1). The first four are classified by the World Bank as "middle-high" developing countries and Japan is classified as a developed country. The indicators used for the classification vary, although in general policy makers and researchers use per capita income, human development and socio-economic indicators.

The selection of these countries is by no means random. The four developing countries are located in South America. All of them experienced one to three macroeconomic adjustments during the 80's and at the beginning of the 90's (sponsored by the World Bank, International Monetary Fund (IMF) and other international financial institutions). Japan is a developed country that enjoyed a strong growth for the most part of the 80's and 90's but stagnated at the end of the decade and is facing some of the problems that developing countries had to face before the macroeconomic adjustment.

Table 2.1 shows some indicators of development for the countries selected for the present study. We can see that there is a wide difference between their per capita income (measured in U.S. dollars per person per year), trade, average growth rate and agricultural production.

Table 2.1 Some socioeconomic indicators for the selected countries, 2001[b]

Indicator	Argentina	Bolivia	Brazil	Venezuela	Japan
Population (million)	37.5	8.5	172.4	24.6	127
Population Growth (%)	1.2	2.1	1.2	1.9	0.1
% of rural population on total population[4]	11.67	37.12	18.27	21.11	12.82
% of Agricultural Population on Tot. Pop	9.89	42.72	15.91	3.65	9.15
Life expectation (at birth)	74.1	63.1	68.3	73.5	81.1
Surface area (million Km^2.)	2.8	1.1	8.5	912.1	377.8
Forest Area (thousands Ha.)	346.5	530.7	5.3[c]	495.1	240.8
Annual deforestation (% of change)	0.8	0.3	0.4	0.4	-0.01
% Agricultural Area	63.66	33.62	30.82	13.76	23.74
% Arable Land	12.12	2.64	6.89	11.77	2.85

4 For definitions of "rural population" and "agricultural population", visit the FAO website at http://www.fao.org/waicent/faostat/agricult/Elements-e.htm

Indicator	Argentina	Bolivia	Brazil	Venezuela	Japan
GDP at market prices (billions)	268.6	8.0	502.5	124.9	4.1[a]
GDP growth annual (% of change)	-4.5	1.2	1.5	2.7	-0.6
GNI per capita (market prices – Atlas method)	6,940	950	3,070	4,760	35,610
Agriculture value added (% of GDP)	4.8	15.7	9.3	5.0	1.4
Industry value added (% of GDP)	26.6	28.6	33.9	50.4	31.8
Exports of goods and services (% of GDP)	11.4	18.3	13.4	22.7	10.4
Imports of goods and services (% of GDP)	10.2	24.5	14.4	17.6	9.8
Gross capital formation (%of GDP)	14.1	13.0	21.0	18.7	25.5
Trade in goods as a share of GDP (%)	17.5	37.8	23.2	36.4	18.2

[a] Trillions

[b] When data not available for 2001, data from the year 2000 was used

[c] Thousands of square kilometers

While Brazil and Bolivia have the biggest share of agricultural value added on the GDP, Japan has the smallest. This fact is a natural result of the development process of a country, where in the initial stages, agriculture plays an important role but it reduces its participation as human and capital resources move towards the non-agricultural sector. In general it is possible to say that this relation is also correlated with per capita income. Another fact that reinforces the previous statement is that trade plays an important role in developing/small countries, while developed countries rely more on domestic consumption and services as the principal engines of the economy.

We can also observe that, as it is shown in Table 2.1, the developing countries included in this study have a higher percentage of rural population than Japan, this is especially true for Bolivia and Venezuela. However, data for the percentage of the population that has the agriculture as the primary source for income indicates that Venezuela has the smallest share. The land use structure also follows the previous description of the population, land under cultivation is higher for the South American countries (on average) than in Japan. Finally it is important to note that the four South American countries are important players in the international market of agricultural products, and although agriculture is less than 10% of total GDP (on average), it still plays an important role in the exports and domestic sectors of the economy.

2.2. Macroeconomic adjustments and the agricultural sector

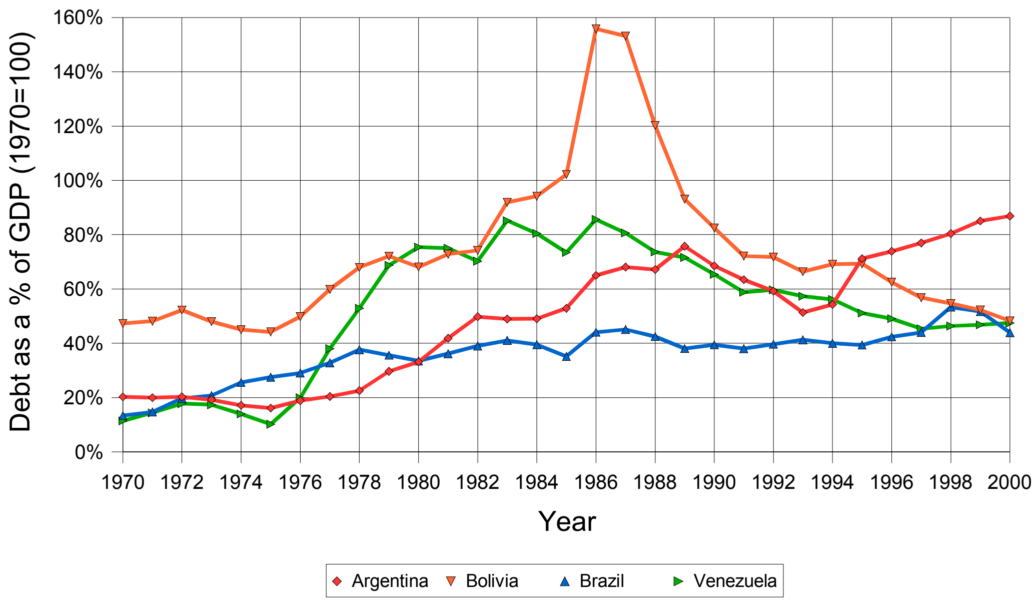

Figure 2.2 External debt as a percentage of GDP (1970 = 100)

As outlined in the previous chapter, macroeconomic adjustments and their implications for the agricultural sector are the principal motivations for the present study. The four developing countries described above share the common fact that at the beginning of the 80's they had to face severe macroeconomic unbalances. The problem originated from two sources. First, the inward policy of developing countries, especially Latin American countries, created an inefficient industrial sector while taxed the highly competitive agricultural sector. Second, the high levels of borrowing of the 1970s increased the debt burden to unsustainable levels which reached a breaking point when interest rates increased sharply at the beginning of the 1980s (Easterly, 2000).

Figure 2.2 shows time-series data for the debt service (interests plus principal) as a percentage of GDP. Before the debt crisis of 1981-1982 the easy access to foreign financial resources influenced governments to borrow money that was not invested

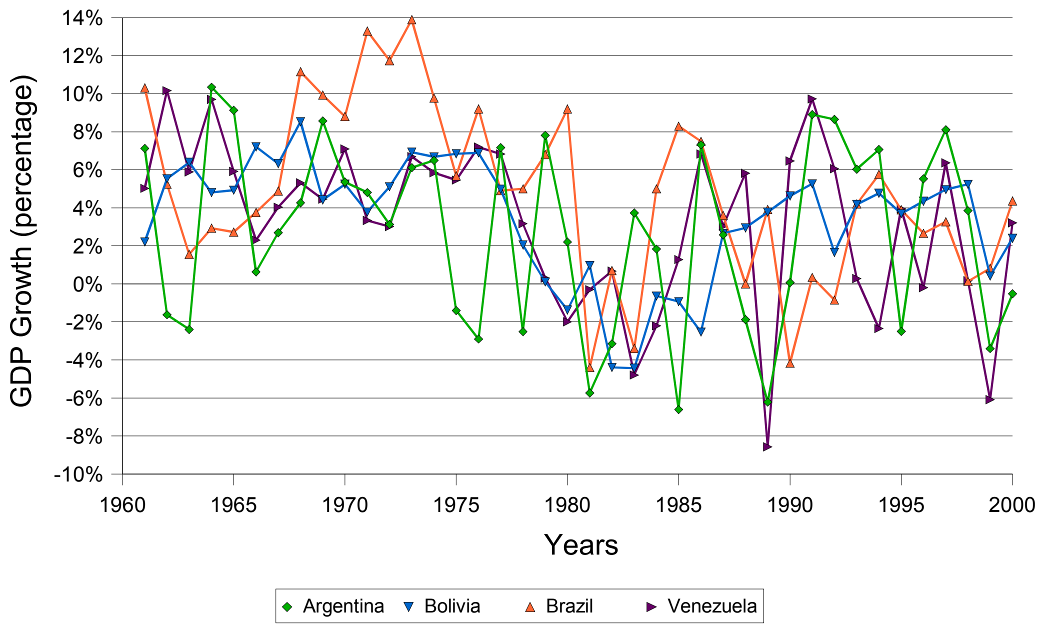

Figure 2.3 Total GDP Growth for selected countries (percentage, 1970=100)

in productive projects. Therefore, returns to investments were not big enough to cope with the higher interest rates. The debt crisis had different patterns across our four developing countries and was managed in many different ways. However, it was clear for local policy makers and international institutions that a profound re-shaping of the economy was necessary in order to regain positive economic growth. Also from Figure 2.2, we can see that some countries (Bolivia and Venezuela) made efforts to reduce their bilateral and multilateral debt, while, Argentina and Brazil increased their obligations for the whole series.

All four economies experienced a sharp decline in their income per capita and total income (see Figure 2.3). As a result, income per capita at the end of the 90's was at the same level as before the debt crisis in real terms. Figure 2.3 shows clearly the pattern for economic growth and the differences between the 1970s and the adjustment period (1980-1990). The positive growth was more constant before the crisis than after the crisis. In fact, only Bolivia shows a constant positive growth for the period of 1985-2000. However, we must remember that the figure indicates total growth which is different than per capita growth. In that case, the negative growth is prevalent for most years from 1980 through 1990.

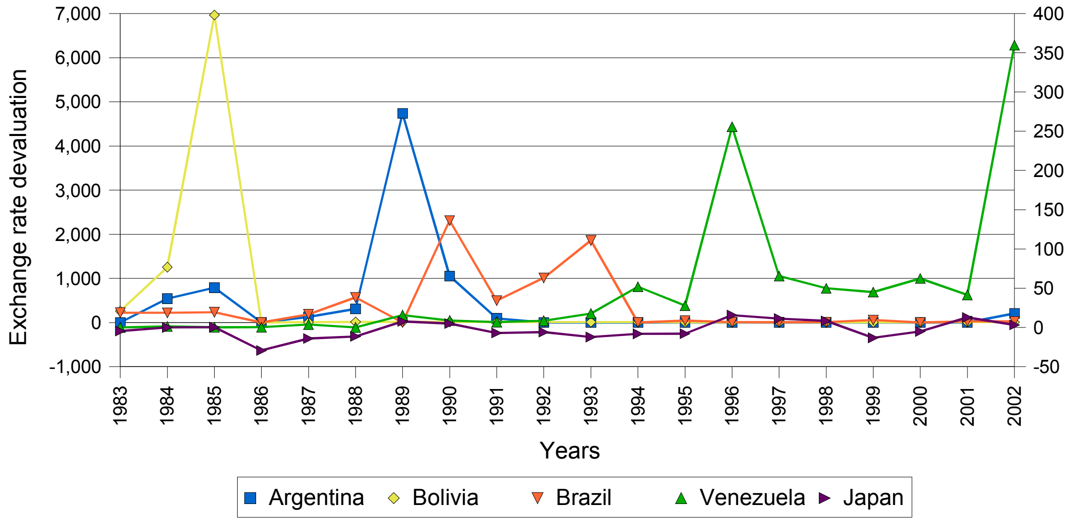

Figure 2.4 Pattern of domestic exchange rates in selected countries

Figure 2.4 helps us to date the macroeconomic adjustment in our developing countries. The time-series in Figure 2.4 are domestic exchange rates per US$ dollar between 1970 and 2000. We also show Japanese data for comparison. Before 1980 all exchange rates had a normal development. However, as the debt crisis started governments found themselves short of financial resources for domestic and international obligations. Therefore, they started printing more money which triggered sharp devaluations in all countries. Argentina felt the phenomenon first, and in 1982 had to devaluate their currency from 2,6$ per US$ to 10$ per US dollar (unified currency). These high inflation rates are known in the literature as "hyperinflations", common in South America in the 1980's. Bolivia followed Argentina, and after a couple of years of battling inflation and hyperinflation a macroeconomic adjustment was inevitable The Bolivian currency was devaluated by

14,000% in 1985 (annual average). As it was common in these kind of programs, devaluations were accompanied by a "change of currency", to simplify the process and create confidence in the population.

Although Argentina performed their adjustment first, it was the last country to reach a reasonable macroeconomic equilibrium. Argentina needed three programs to stabilize the economy. Brazil needed two adjustment programs and three changes in their currency (Figure 2.4). The "date of the adjustment" is easy to identify by the spikes in the graph. As Easterly (2000) described, the success of the program depended on many variables, including the political strength of the government, which made macroeconomic adjustments an economic and a socioeconomic experiment. The lack of before-hand information compromised those programs. And in several cases the initial package had to be corrected on the way to avoid problems with other variables.

Although being different in practice, all macroeconomic adjustments had a common pattern that has been studied extensively in the literature[5]. The principal components of a standard package are,

1. Simplification of the tax system
2. Simplification of the tariff system that in practice meant the reduction (unilateral) of most tariffs to unprecedented low levels.
3. Privatization of public companies
4. Liberalization of domestic prices
5. Reduction or elimination of subsidies

[5] For a throughout description and analysis of the Argentinean adjustment process, Leviatan and Leviatan (1992) and de Melo and Dhar (1992) are a good source. For the Brazilian case, Kiguel and Liviatan (1992) and Coes (1995); for the Bolivian case, Kharas and Pinto (1989) and for the Venezuelan adjustment, The World Bank (1998a) is a good reference.

6. Reduction of the governmental apparatus

7. Unification of exchange rate and liberalization of trade and capital flows

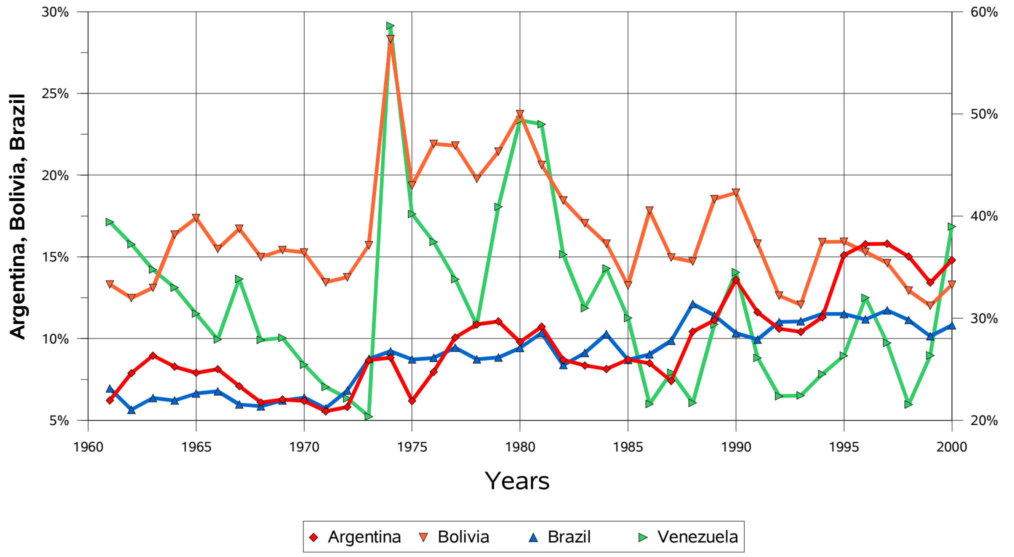

Figure 2.5 Exports of goods as a percentage of GDP (1970=100)

Therefore, as a package, macroeconomic adjustments meant the transition from an inward looking economy towards a free-trade system. This was accomplished basically through the tariff system and the exchange rate. Immediate results were incredibly successful. As we can observe in Figure 2.5, trade increased in the four South American countries by 176% from the year of the adjustment, on average.

Although per capita income did not recover as expected, general macroeconomic indicators convinced policy makers that the current economic system was working. After the "shock years", voices of discontent started to arise. Some new data showed that although the macro economy was doing fine, the situation of the poorest section of the population was deteriorating. Even more striking is the fact that income distribution has deteriorated in all countries that experienced macroeconomic adjustments in Latin America (Michapopoulos, 1999).

Some researchers argue that one of the reasons for these contradictions is that macroeconomic adjustments redistribute wealth and the net beneficiaries are the owners of capital and land. However, the evidence of this is not available in the economic literature. Others argued that trade liberalization *per se* is not beneficial to the poor, and aggressive counter-measures should be designed to bring those benefits to the poor. Advocates of liberalization and macroeconomic adjustments argue that the benefits of these changes will not be perceived for the present generations, but they secure a better future for all (Dollar and Kraay, 2002). This basically assumes that once the privileged reach some steady state, they will redistribute naturally to the other sectors of the population. In other words, it is a question of time, not a problem of the model. However, the needs of the poorest groups of the population are more urgent that in the other groups which creates social conflicts and, of course, questions about the capacity of governments to manage the country.

2.3. Tradables and non-tradables for the selected countries

Until this point we have described the macroeconomic environment before and after the macroeconomic adjustments. Now we want to describe the agricultural sector of the countries involved in this study, including the non-tradable sector. We divide the agricultural sector in two groups: tradables and non-tradables. As discussed in the economic literature, these two groups coexist in any economy and they also follow the development stages mentioned before.

Figure 2.6 shows some data for agricultural tradables and non-tradables for the countries of interest. Both graphs use the Food and Agricultural Organization's (FAO) data for agricultural products grouped by our definition of tradables and non-

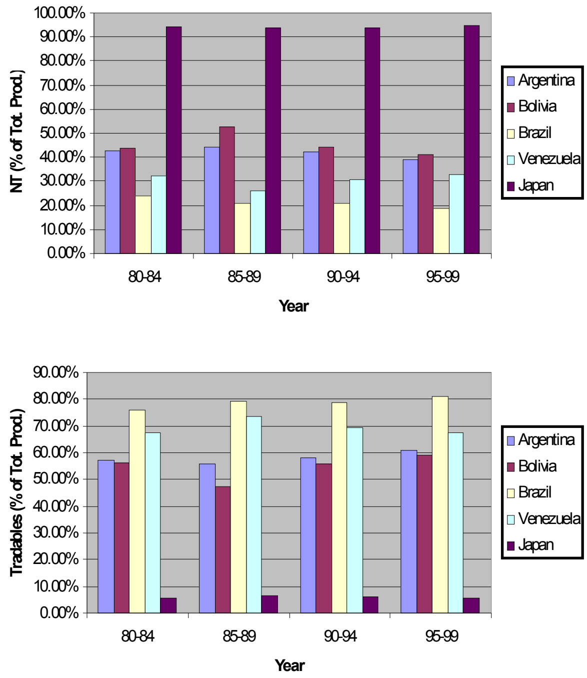

Figure 2.6 Tradables and non-tradables as a percentage of total production

tradables for the years 1980-2000[6]. It is easy to see that the four developing countries share of NT on total production is larger than the share of Japan's NT. Moreover, among our four developing countries, Argentina and Brazil have the biggest share of tradables, and Bolivia and Venezuela the largest non-tradables sector. For Bolivia and Brazil, the non-tradable sector has been declining constantly since the mid 1980's. In all developing countries except Venezuela, the tradable sector has been increasing for the same period. This trend supports the assumption that macroeconomic adjustments benefited the tradable sector more than the non-tradable sector.

Of course, there are specific characteristics of the data that are related with the particular characteristics of each country. For example, non-tradables in the case of Argentina include sugar cane, which amounts for half of non-tradable production (as in the case of Venezuela), and influence the final figures. In the same sense, Japan's non-tradable sector is represented by rice, which is heavily protected from international trade. In this case, the "non-tradability" of the products comes from the tariff regime and not from transportation or other related costs.

[6] The definition and the process of separating tradables from non-tradables will be discussed in Chapter 3.

2.4. The food supply for the selected countries

As defined by the FAO, the food supply can be characterized by total domestic production (net of exports) plus imports. Using FAO's Food Balance Sheets, it is possible not only to investigate the direct effects of other variables on the food supply, but to investigate its components. Figure 2.7 shows the time-series for the food supply as defined in Chapter 3 (only crops) for the countries selected for the present study. We can observe that the trend for Bolivia and Venezuela is decreasing; while the trend for Argentina and Brazil is positive. The data for Japan indicates a static food supply around the base year, 1995 = 100. It is interesting to note that countries that have larger non-tradable sectors had (somehow) seen their Food Supply fall through the years, and that countries with larger tradable sectors have a better performance. In the case of Japan it is possible to see a small negative trend. In this case it can be related with the negative income-elasticity of rice in Japan (Ito, et. al. 1989).

We concede that not only economic variables affect the food supply. For example, weather variables affect crops and yields (Figure 2.7), where the drought of 1982-1983 in Bolivia reduced the food supply by 30%. But also, as in the case of tradables and non-tradables production, the food supply responds to economic variables. These variables are not restricted only to prices but also economic indicators (expressed as expectations) like the exchange rate, interest rates, inflation and others. The degree and the direction of the response of those variables are important information that policy makers should take into account when designing policy for the agricultural sector.

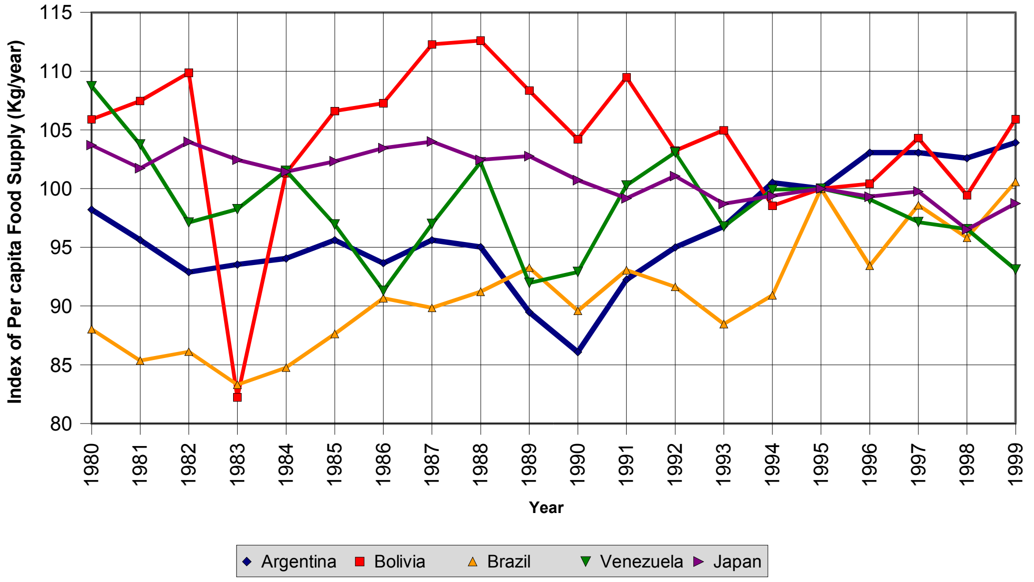

Figure 2.7 Indexes of food supply (Kg/person/year) for selected countries

Chapter 3

3. The exchange rates and the food supply

3.1. Introduction

This Chapter will analyze the effects of exchange rate devaluations on the agricultural sector using a structural model with non-tradables. As described in the previous Chapter, exchange rate devaluation is a basic tool for macroeconomic adjustment processes and although they help tradable products to compete internationally, they also trigger re-distributive effects that can be negative for small farmers, usually the poorest group in developing countries. The theoretical and econometrical models of this Chapter emphasize the effects of exchange rate devaluations as a way to improve the trade balance that at the same time pressure non-tradable prices downwards. In this framework, the food supply (understood as the domestic production of foodstuff net of tradables) might decrease along with the decrease in non-tradables production.

Previous research efforts failed in recognize the importance of non-tradables on the determination of equilibrium. Moreover, if we consider the food supply as composed of several items, it is possible to track down the reasons for negative/positive effects of macroeconomic adjustments, and in this chapter, exchange rate depreciations.

3.2. Previous research efforts

The analysis of the relationships between the agricultural sector and macroeconomic policy has a short history. Before the paper of Schuh (1974), it was assumed, in general, that agricultural output was determined basically by microeconomic variables. That way of reasoning is understandable for several reasons. First, most of the research about agricultural economics was done in the U.S. and other developed countries where the agricultural sector's share of the GDP is comparatively small, therefore, most "macro" variables were considered exogenous. Second, the sector was considered highly competitive, meaning that the usual assumptions about market clearance, price determination and homogeneity were taken by default. Third, the availability of data at the microeconomic level, including food consumptions and expenditure, made the agricultural sector an only-microeconomics field of study.

However, after the breakthrough paper of Schuh (1974), researchers and scholars considered macroeconomic variables more carefully. Although the paper of Schuh (1974) was basically an exercise of analysis, it noted two basic issues: 1) Even though competitive, the agricultural sector can be affected negatively by the macroeconomic policy and 2) Some assumptions about the reaction of agriculture to this policy are not true when macroeconomic variables are introduced in the traditional microeconomic model.

Besides the works of Shuch on the theoretical field, no other report can be found on the literature that analyzes exchange rate from the agricultural perspective. However, some empirical efforts were reported at the beginning of the 80's. Chambers and Just (1981) developed a model for the U.S. agricultural sector and its response to exchange rate dynamics. Later, Frankel (1986) analyzed the response of commodity prices to money and exchange variations. He found that the correlation is high and indicates that further research is needed on this field to verify the assertions of Schuh. On the other hand, Bela Balassa (1990) presented some results of econometric models for the Sub-Saharan Africa region with exchange rate and macroeconomic variables as exogenous determinants of production. He finds that exports in general, but agricultural exports in particular are responsive to variations on determinants like prices and exchange rates.

Derevajan and Lewis (1990) and Derevajan, Lewis and Robinson (1993) are the first on introducing non-tradables on models with exchange rates. However, their model does not recognize the existence of import substitutes. Their results are in line with previous theoretical efforts and econometric estimations. Although their main objective is to investigate the equilibrium real exchange rate, they recognize the importance of non-tradables in the determination of prices, especially in developing countries. Jaeger (1992) is the first one to use the Real Exchange Rate as a explanatory variable in a model for the agricultural sector, although his approach is *ad hoc* and does not account for all variables that determine the food supply. His study uses exports, imports and domestic production to justify macroeconomic adjustments by finding that exportables did not crowded out domestic production, and therefore, food supply was not affected.

Lamb (2000) presents the latest results for the Sub-Saharan Africa region, with a model that includes the exchange rate but does not offer any theoretical background. As in the case of Jaegger (1992), the equations for exports and total production are used to discuss negative effects of macroeconomic adjustments and specifically the substitution of scarce resource to produce tradables diminishing domestic production of agricultural crops for food. In a similar fashion, Aboagye and Gunjal (2000) present another analysis of the Sub-Saharan situation in a model that only includes macroeconomic variables (including the exchange rate) to study the performance of individual countries before and after macroeconomic adjustments. They highlight the agricultural sector as a net loser of the process. In the studies of Lamb, Jaeger and Aboagye and Gunjal the agricultural sector is assumed completely tradable, therefore, non-tradables are not introduced in the analysis.

Finally, Kim and Koo (2002) study the different responses of agricultural and non-agricultural variables to exchange rate fluctuations. They use U.S. data to analyze short and long-run impacts of exchange rate shocks, and they find that the agricultural sector is more sensitive to changes on the exchange rate.

In Table 3.1 we have some results from studies that used the RXR as an explanatory variable. The first two studies described in Table 3.1 found that total production reacts positively to exchange rate devaluations, but only Jaeger (1992) estimated a coefficient for the food supply, which also increases with exchange rate devaluations. In all cases, the coefficients reported are small, and not always significant. Moreover, only Jaeger (1992) reports results for individual countries, and only for total production, there is no further analysis of the food supply.

Table 3.1 Recent studies that included the RXR as an explanatory variable

Author	Years	Coverage	Method	Report	Results
Jaeger, K. William. 1992	1970-87	21 Sub-Saharan African countries	3SLS	Country and regional aggregated results	Aggregated: TP, RXR=-0.104. Exports, RXR=-0.045, FS, RXR=-0.013, M, RXR=-0.0065. For Annual crop producing countries TP, RXR=-0.110, FS', RXR=0.085

Author	Years	Coverage	Method	Report	Results
Lamb, L. Russell. 2000	1975-90	14 African countries	Weighted 2SLS	Aggregated results	TP, RXR=-0.17
Aboagye, A. and K. Gunjal. 2000	1981-93	19 Sub-Saharan countries	Generalized LS	Aggregated by groups	Exports, RXR=0.038 (large), 0.070 (small) and –0.010 (poor) respectively[1].

1) The terms "large, small and poor" correspond to the scale of macroeconomic adjustments, where "poor" is used to describe "zero or negative" adjustment (Aboagye and Gunjal, 2000).

Based on his results, Jaeger (1992) concluded that the food supply increases as the exchange rate devaluates, therefore, macroeconomic adjustments in Africa did not crowd-out domestic production for food consumption. On the other hand, based on indirect results, Lamb (2000) concluded that evidence suggests that while aggregate agricultural output responds positively to increases in food prices, it responds negatively to increases in export prices, in the short run. A possible explanation is that increases in export price lead farmers to shift resources into production of export crops and out of food crops. Moreover, while the negative impact on domestic production of food is immediate (annual or short-term crops), the positive impact of devaluations on export crops can take several years to materialize, given de lags in production considering that usually export crops require years to mature (for example in the case of sugar or coffee).

These results for Africa highlight the importance of particular production characteristics on the interpretation of econometrical parameters. For example, in Bolivia, more than 70% of agricultural exports (in value) are comprised of annual crops (oil complex and some minor crops) and only 30% correspond to multi-annual crops (coffee and sugar), then, in the short-run, the reduction in the production of food is compensated with the production of export crops. Then the figure for total production might show a positive reaction, even though the redistribution inside the agricultural sector could be biased towards the production of export crops.

3.3. Redistribution effects of exchange rate devaluations

The intuition behind the analysis of the effects of the exchange rate on the agricultural sector is quite simple. Following Tweeten (1992) we can describe exchange rate movements with traditional static microeconomics. Let us consider an exchange rate depreciation (domestic currency per foreign currency). That means that, measured in domestic currency, prices of tradables (exportables and importables) rise.

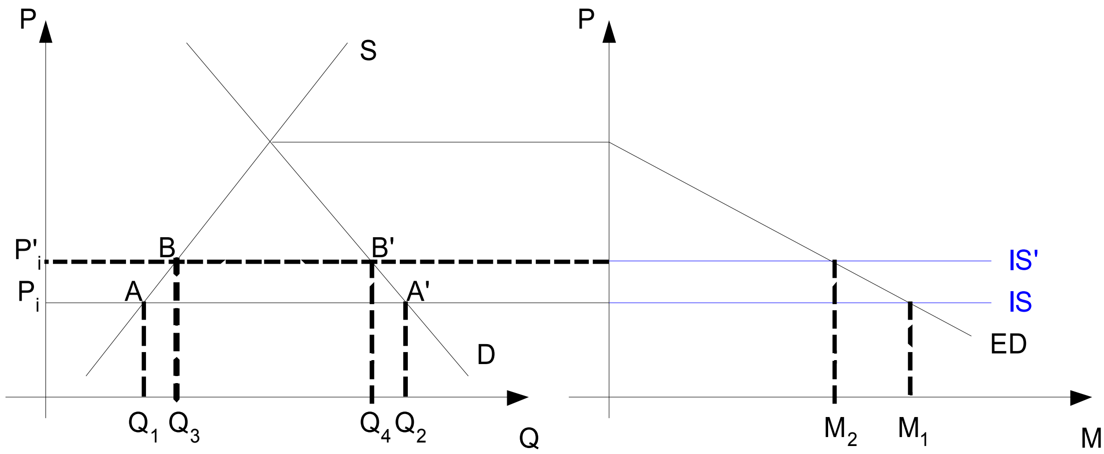

Figure 3.1 Effects of an exchange rate devaluation on the imports market in a small country.

As it can be seen in Figure 3.1 the domestic price increases after a devaluation on the exchange rate in a small country. This result is unambiguous, considering that small countries do not affect international prices, then only the import supply schedule moves upwards because it is measured in domestic currency[7]. In other words, international prices remain constant. The overall effect is that the country will

[7] In the case of a "big country", the devaluation is transmitted to international market and the increase in domestic prices is less than proportional.

consume fewer imports (**Q_3 – Q_4**) and produce more import-substitutes (**Q_1 – Q_3**). Producers of import substitutes will win and consumers will lose.

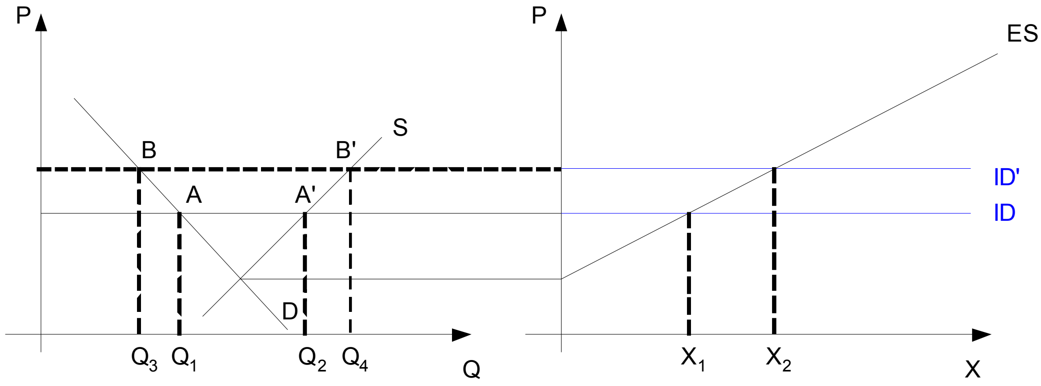

Figure 3.2 Effects of an exchange rate devaluation on the exports market in a small country

As in the imports market, the principal effect of exchange rate devaluations on the exportables market is the increase in the domestic price (Figure 3.2). Again, producers of exportable crops win, with production increasing from Q_2 to Q_4 and consumers lose, reducing the consumption from point A to B. Because the discussion is focusing in the small country scenario, international prices remain constant; therefore, real variables do not change.

In both markets (importables and exportables) producers are the winners. That means that the income redistribution effect of the exchange rate devaluation benefits mostly producers of tradables. By increasing production of tradables, the government achieves one of the principal goals of any administration, to increase (reduce) the trade surplus (deficit). More exports means more hard currency, badly needed by developing countries for service and international transactions.

Moreover, developing countries suffer constant macroeconomic instabilities that require structural adjustments, especially when public deficits or debts overcome the resource generation capacity of the country. These structural adjustments are usually carried as a "recipe" by international institutions like the World Bank and International Monetary Fund that includes tax reform, exchange rate devaluations, public expenditure reduction and trade liberalization. All these macroeconomic tools are aimed to increase the government revenue, though more exports (devaluation and trade liberalization) and internal means (taxes and expenditure reductions).

If the story would stop there, exchange rate devaluations would be a good suggestion for governments in trouble. However, as explained by Dornbusch (1975), the existence of non-tradables in an economy jeopardizes the success of any exchange rate devaluation scheme. Using a two country, two-good, two-monies model Dornbusch (1975) demonstrated that the final result depends largely on the response of non-tradables to the devaluation. Figure 3.3 helps to understand the process.

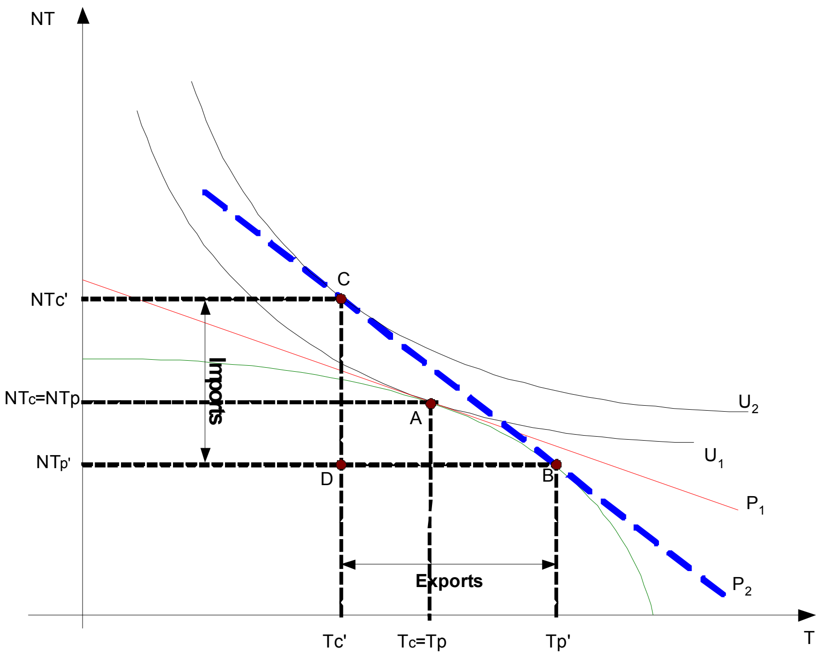

Figure 3.3 Effects of an exchange rate devaluation in a model with two goods

In Figure 3.1, let us suppose that the economy is in equilibrium at point A, where the production curve (green) along with the price relation (P_1) and the indifference curve

(U_1) determine the quantities of tradables (T) and non-tradables (NT) for consumption and production. Initially the country does not have excess supply; therefore, there is no trade. Tradables are of course measured in foreign currency, say, dollars, then when there is a devaluation the price of tradables measured by the domestic currency is more expensive. This moves the price relation to P_2 which is tangent to the new indifference curve U_2 setting the new production point at B. The new set of rules (prices, preferences and production possibilities) indicate that the country will produce more of tradables, and it will import non-tradables, which have become "importables". The first result is that the devaluation has created a trade surplus. However, the more profitable sector (tradables) will attract resources from the other sector, which in the short run are fixed, creating a pressure in that market for a price increase. If the price of non-tradables increases, P_2 returns to P_1 and we are again at point A. this means that the success of the devaluation policy depends on the response of non-tradables to the exchange rate.

Dornbusch (1975) indicated that if it is possible to keep the price of non-tradables fixed at point D in Figure 3.3, then we could still enjoy the trade surplus without any pressure from the non-tradables market. This is an alternative if the government intervene the market to keep the nominal price of NT fixed. However, Bruce and Purvis (1985) note that an alternative and more satisfactory approach than the assumption of fiscal policy is to make demands for traded and non-traded goods depend on total expenditure, which can differ form national income due to real-balance of wealth effects. The introduction of expenditure allows reaching equilibrium, which involves expenditure switching and expenditure reducing. The increase in income comes principally from the trade surplus and the equilibrium assumes that non-tradables have a zero or negative income elasticity.

3.4. Definition of food supply

The previous discussion was focused on exportables, importables and non-tradables. Based on these variables, we can discuss the effects of exchange rate devaluations on the food supply by using the following definition,

$$FS = Q_T + Q_M + Q_{ST} - Q_X \qquad \textbf{Eq. 3.1}$$

Where $\boldsymbol{Q_T}$ is total domestic production, $\boldsymbol{Q_M}$ is total imports, $\boldsymbol{Q_{ST}}$ is variation in stocks and $\boldsymbol{Q_X}$ is total exports. We can extend $\boldsymbol{Q_T}$ to differentiate the production of non-tradables and tradables (importables plus exportables), then we have:

$$Q_T = Q_{NT} + Q_{MS} + Q_{XP} \qquad \textbf{Eq. 3.2}$$

Combining equations (3.1) and (3.2) and rearranging terms yields:

$$FS = (Q_{NT} + Q_{ST}) + (Q_{XP} - Q_X) + (Q_{MS} + Q_M) \qquad \textbf{Eq. 3.3}$$

Equation 3.3 indicates that the FS is also de sum of the production of non-tradables plus the variation in stocks, the net result of subtracting total exports from the domestic production of those crops and the sum of production of import substitutes and total imports. In this sense, the FS is a function of non-tradable's domestic price and international prices adjusted by the exchange rate. The overall result of devaluations, *ceteris paribus*, will depend on the adjustment path on the non-tradables market. Production of import substitutes will increase, exports will increase but if non-tradables decrease, the net effect could be negative for the food supply. Moreover, if exports increase more than the production of exportable crops, the negative effect of devaluations is stronger.

3.5. The real exchange rate

Because we are concerned with real variables, it is not possible to include nominal exchange rates into the econometrical model. Therefore, to estimate the effects of exchange rate devaluations we will use the Real Exchange Rate (RXR). Definitions of the RXR are mixed in the literature (Devarajan, Lewis and Robinson, 1993; Edwards, 1989), but there is a general consensus about the traditional definition:

$$RXR = \frac{P_T \cdot e}{P_{NT}} \qquad \textbf{Eq. 3.4}$$

where $\boldsymbol{P_T}$ is the price of tradables, $\boldsymbol{P_{NT}}$ is the price of non-tradables and $\boldsymbol{e}$ is the nominal exchange rate (domestic currency per foreign currency). Finding a good proxy for both prices in Eq. (3.4) is not an easy task, especially if we work with groups of products. Therefore, indexes are commonly used, such as the consumer price index (CPI) or the gross domestic product (GDP) deflator.

Following Jaeger (1992) and the IMF we define the Real Exchange rate (***RXR***) as,

$$RXR = \frac{CPI_{DOM}}{CPI_{USA} X} \qquad \textbf{Eq. 3.5}$$

In (3.5) we are using the $\boldsymbol{CPI_{DOM}}$ as a proxy for non-tradable's prices and $\boldsymbol{CPI_{USA}}$ as a proxy for tradable crops prices. ***X*** is the official exchange rate (average for the period). It is easy to observe that (3.5) is the inverse of (3.4). When the ***X*** depreciates, the RXR decreases. By symmetry, when the ***X*** appreciates the RXR increases. In other words, when the RXR rises, exports should fall (negative sign), due to the fact that the ***X*** has appreciated, everything else constant. Alternative definitions of RXR are used in the literature[8]; however, high inflations in South America during the 80's make difficult the use of local currencies, which at the same time affect local prices.

The RXR can also be used as a proxy for the relative competitiveness of a country, as explained by Edwards (1989) and Lamb (2000). However, because we are assuming that the exchange rate is used as a policy tool, we will not investigate the sources of changes on the determinants of the RXR.

3.6. A theoretical model

In order to present a theoretical basis for the econometrical model, we develop a theoretical model, which draws on Dornbusch (1973). The model uses a two-country; two sectors, two goods; two-monies scheme to highlight the effects of exchange rate devaluations on the prices of non-tradables. Details of the mathematical procedure can be found in Annex 1.

The economy is divided in tradables and non-tradables, and each sector has an agricultural and non-agricultural sub sector. The total output of the economy is defined as,

$$Y = P_1^A X_1^A + P_1^N X_1^N + P_2^A X_2^A + P_2^N X_2^N \qquad \textbf{Eq. 3.6}$$

[8] Devarajan, Lewis and Robinson (1993) argue that when a "real" model is under analysis, real variables should be used, like relative prices. However, Bruce and Purvis (1985) indicate that a "pure model" does not take into account income and expenditure effects. Therefore the model is incomplete and could lead to erroneous conclusions and that the model has to be adjusted for nominal variables.

The price indexes for the tradables (P_1^i) and non-tradable sector (P_2^i) follow a Cobb – Douglas specification. The superscripts denote the agricultural (A) and non-agricultural sector (N) respectively. The non-tradable markets clear by definition, therefore, the excess supply in the tradable sector is equal to the trade balance. The equilibrium conditions for those markets are,

$$E_2^A = X_2^A(q, q_2, q_3) - C_2^A(q, q_2, q_3, \tilde{Z})$$
$$E_2^N = X_2^N(q, q_2, q_3) - C_2^N(q, q_2, q_3, \tilde{Z}) \qquad \textbf{Eq. 3.7}$$

In (3.7) we take into account that $\tilde{M}^* \equiv M^*/P_1^*$; $q^* \equiv P_2^*/P_1^*$; $P_1^* e = P_1$. The two equations in (3.7) establish the equilibrium in the domestic market, both for the agricultural and non-agricultural markets. In the same fashion we define the equilibrium in the foreign country denoted by an apostrophe. The equilibrium in the international market will be,

$$\tilde{H}(q, q_2, q_3, \tilde{M}) + \tilde{H}'(q', q_2', q_3', \tilde{M}') = 0 \qquad \textbf{Eq. 3.8}$$

Differentiating the first equation in (3.7) we obtain,

$$\hat{q}_2 = \frac{-m_2^A}{q_2 C_2^A(\epsilon_2^A + \eta_2^A)} d\tilde{H} \qquad \textbf{Eq. 3.9}$$

Equation (3.9) shows that an increase in real hoarding lowers the relative price of agricultural non-tradable goods. The terms m_2^A , ϵ_2^A and η_2^A denote respectively, the marginal propensity to spend on home goods, the compensated elasticity of demand for agricultural non-tradable goods, and the elasticity of supply. So far hoarding has been treated as an exogenous variable; however, we wish to develop an expression that relates the rate of hoarding, given the nominal quantity of money, to price changes. By total differentiating the hoarding function $\tilde{H}=\tilde{H}\left(q, q_{2,} q_{3,} \tilde{M}\right)$ we obtain,

$$d\,\tilde{H}=\omega_1 \hat{q}+\omega_2 \hat{q}_2+\omega_3 \hat{q}_3+\omega_4 \hat{P}_1 \qquad \textbf{Eq. 3.10}$$

Replacing (3.10) in (3.9) and after some modifications we have,

$$d\,\tilde{H}=\left[\gamma_1 \hat{P}_1^A+\gamma_2 \hat{P}_1^N\right]\gamma_3 \qquad \textbf{Eq. 3.11}$$

Where the terms γ_1, γ_2 and γ_3 are linear combinations of the parameters of the model. Recalling that (3.11) allows explicitly for market clearing in the home-goods market, that expression is identically equal to the excess supply of traded goods. Accordingly, we may use (3.11) and its counterpart for the foreign country to determine the effects of an exchange rate devaluation on the domestic price of traded goods.

$$\gamma_3 \gamma_1 \hat{P}_1^A+\gamma_2 \gamma_3 \hat{P}_1^N+\gamma_3' \gamma_1' \hat{P}_1^A{}'+\gamma'_2 \gamma'_3 \hat{P}_1^N{}'=0 \qquad \textbf{Eq. 3.12}$$

Solving for the relative change in the domestic currency price of traded goods we obtain (3.13),

$$d\,\tilde{H}=\left[\frac{\gamma_3 \theta_3}{\theta_1}\hat{e}-\hat{P}_1^N\left(\frac{\gamma_1 \theta_2}{\theta_1}-\gamma_2\right)\right]\gamma_3 \qquad \textbf{Eq. 3.13}$$

Substituting (3.11) in (3.13) it is proved that the devaluing country's balance of payments unambiguously improves. These results are similar to the model with one commodity; the departure arises from the fact that changes in absorption in the two countries change the equilibrium relative price of home goods. Substituting (3.13) in (3.9) it is possible to find that devaluations lower the relative price of non-tradable goods in the home country and raise it abroad, but this result depends on the relative reaction of non-agricultural prices in the tradable sector (Eq. 3.14). If non-agricultural tradables react negatively to exchange rate depreciations or less than proportionately, domestic prices of agricultural non-tradables will fall.

$$\hat{q}_2 = \phi_1 \hat{P}_1^N - \phi_2 \hat{e} \quad \text{and} \quad \hat{q}_3 = \phi_3 \hat{P}_1^N - \phi_4 \hat{e} \qquad \textbf{Eq. 3.14}$$

Dornbusch (1973) concludes that given imperfect substitutability between home goods and traded goods on the production side it is the adjustment in the relative price of home goods that translates changes in absorption into an excess supply of traded goods at home and an excess demand for traded goods abroad.

This theoretical analysis shows how macroeconomic policies affect farm profits in several but critical ways. Nominal exchange rates set an upper bound on the price paid to farmers for exported commodities. In the same way, exchange rates (together with import taxes and other restrictions) set prices of inputs and agricultural imports, which compete with domestic production (Jaeger, 1992). Moreover, if we take into account that overvaluation of the exchange rate is the principal non-tax distortion on the agricultural sector (accounting for 27% in average in developing countries, as reported by Krueger, Schiff and Valdés, 1988), the direct and indirect effects of exchange rate management could be fundamental for the agricultural sector.

3.7. Empirical analysis

3.7.1. Econometric model

In order to investigate the effects of exchange rate devaluations on agricultural prices (tradables and non-tradables) based on the previous theoretical exercise the following model is proposed:

$$
\begin{aligned}
&E_{it} = f\left(RXR_{it-1}, E_{it-1}, GDP_{it-1}, W_{it-1}, AIP_{it-1}, P^{Sg}_{it-1}, P^{Sy}_{it-1}, \varepsilon_{iE}\right)\\
&M_{it} = f\left(RXR_{it-1}, M_{it-1}, GDP_{it-1}, W_{it-1}, P^{Wh}_{it-1}, Dn_{it-1}, \varepsilon_{Mi}\right)\\
&NT_{it} = f\left(RXR_{it-1}, NT_{it-1}, GDP_{it-1}, AIP_{it-1}, P^{NT}_{it-1}, T_{it-1}, \varepsilon_{NTi}\right)\\
&TP_{it} = f\left(RXR_{it-1}, TP_{it-1}, GDP_{it-1}, W_{it-1}, AIP_{it-1}, P^{NT}_{it-1}, \varepsilon_{iTP}\right)\\
&FS_{it} = f\left(RXR_{it-1}, FS_{it-1}, GDP_{it-1}, \varepsilon_{iFS}\right)\\
&MS_{it} = f\left(RXR_{it-1}, MS_{it-1}, GDP_{it-1}, W_{it-1}, P^{Wh}_{it-1}, \varepsilon_{iMS}\right)\\
&RXR_{it} = f\left(AV_{it}, IR_{it}, L_{it}, PI_{it}, WR_{it}, \varepsilon_{iE}\right)\\
&GDP_{it} = f\left(I_{it}, TT_{it}, INF_{it-1}, HK_{it-1}, TB_{it-1}, GC_{it-1}, \varepsilon_{iGDP}\right)
\end{aligned}
\qquad \textbf{Eq. 3.15}
$$

Where $\boldsymbol{E_t}$ represents agricultural exports (1,000 metric tons); ***RXR*** is the exchange rate; $\boldsymbol{E_{t-1}}$ is the lagged value of $\boldsymbol{E_t}$; ***GDP*** is the (per capita) Gross Domestic Product ($us); ***W*** is the weighted GDP of commercial partners ($us); ***AIP*** is the average price of international commodities (agricultural); $\boldsymbol{P^{Sg}}$ is the domestic producer price of sugar and $\boldsymbol{P^{Sy}}$ is the domestic producer price of Soybeans. We also have the international price of Wheat $\boldsymbol{P^{Wh}}$, food donations ***Dn***, ***NT*** represents non-tradables, $\boldsymbol{P^{NT}}$ is the domestic producer's price of non-tradables and ***T*** is time. ***TP*** is total production of agricultural crops (1,000 metric tons), ***FS*** is food supply with the components defined in Annex 3 (and described in section 3.7.3) and ***MS*** is import substitutes (1,000 tons). The subscript "***i***" represents our developing countries: Argentina, Bolivia, Brazil and Venezuela.

We estimated the system for each country independently, however, some variables that appear in one set do not appear necessarily in the others. The complete set of equations can be found in Annex 4 and the description of the variables for each country in Annex 3.

For the RXR and GDP equations we have that ***AV*** is ***AIP*** plus non-agricultural commodities; ***IR*** is the domestic interest rate; ***L*** is the Libor interest rate (3 month period); ***PI*** is public investment; ***WR*** is weighted average of commercial partners real exchange rate; ***I*** is public investment as a percentage of the GDP; ***TT*** is total trade as a percentage of the GDP; ***INF*** is inflation measured by the CPI; ***HK*** is human capital as defined in Annex 3; ***TB*** is trade balance and ***GC*** is government consumption[9].

The terms ε_i are the error terms associated with each equation, which have the following mean and covariance properties (Srivastava and Giles, 1987):

$E\{\varepsilon_{it}\} = 0$	Zero mean
$E\{\varepsilon_{it}^2\} = \sigma_i$	Constant variance
$E\{\varepsilon_{it}\varepsilon_{js}\} = 0$	No serial correlation
$E\{\varepsilon_{it}\varepsilon_{jt}\} = \sigma_{ij}$	Contemporaneous correlation

The assumption that expected variables follow the adaptive expectations model developed by Nerlov (1958) ensure that the error terms are not autocorrelated, therefore, estimated coefficients are efficient and unbiased.

9 The equation for the RXR was structured based on Edwards (1989) and Bergwal (2002). The equation for the GDP was structured based on Bleaney and Nishiyama (2000).

All prices and financial variables are deflated with the CPI, base year 1995 = 100 and run from the year 1980 to 2000. Finally, variables are introduced in their logarithmic form, therefore, coefficients represent elasticities.

3.7.2. The definition of tradables and non-tradables

In order to apply the theoretical analysis to empirical experimentation we need to divide agricultural products into tradables and non-tradables[10]. This task is carried on based on the FAO's (Food and Agriculture Organization of the U.N.) Food Balance Sheets (FBS) which provide information in an annual basis of production, exports, imports, domestic and industrial consumption for more than 70 agricultural and livestock products. The theoretical support is provided by Dornbusch (1973), Strauss (1999), Douglas and Purvis (1985), Derevajan, Lewis and Robinson (1993) and Krueger, Schiff and Valdés (1988). Barret (1999) indicates that important subsectors in virtually all economies are non-tradable due to nonzero market intermediation costs. In many countries these costs often constitute an especially large part of the border parity price, rendering a large portion of agriculture internationally non-tradable. Moreover, market intermediation costs are themselves a function of the exchange rate since they invariable incorporate a substantial tradable component.

For the present study, the FBS were organized by product group (importable, exportable or non-tradable), allowing us to obtain an average of the quantities imported, exported and domestically produced in each year. Later, this average was compared with the production, exports and imports in each year and classifying the agricultural products into tradables and non-tradables according to the following

[10] The definition of Food Supply of this section is used also in the subsequent Chapters.

rule:

- If the average of imports is equal or bigger than domestic production, the product is classified as importable, otherwise, non-tradable
- If the average of exports is equal or bigger than 10% of the domestic production, the product is classified as exportable, otherwise, non-tradable

According to this rule, for the Bolivian case, 13 products were classified as exportables, 23 as non-tradables and 13 as importable of a total of 73 products. Table 3.2 shows the distribution for the other countries. It is important to notice that in some cases, a product can be exported, imported and domestically produced, but following the rules described before a clear separation can be made avoiding confusions. Although the FBS include processed foodstuff (like oils or sugar), they were not included in the variables because they do not represent agricultural production. However, prices of this sub-products were included in the average price of agricultural commodities as they influence producers in the decision making process.

Table 3.2 Distribution of crops for selected countries into tradables and non-tradables

	Argentina	Bolivia	Brazil	Venezuela	Japan
Export crops	21	13	11	6	0
Import substitutes	12	13	9	24	34
Non-tradables	12	23	28	19	15
Total included	45	49	48	49	49
Total FBS	72	73	75	75	76

Because the main focus of this analysis is the agricultural sector and not the livestock production, only crops were included in the study. Therefore, the food supply variable becomes the "agricultural food supply", per capita basis. A detailed description of which products were included in each group for each country can be found in Annex 2.

3.7.3. Data

Most of the data for production was obtained from the Food and Agricultural Organization (FAO) "Food Balance Sheets", although some data for specific crops was cross-checked with the respective country statistical sources like the Instituto Nacional de Estadística (INE) – Agricultural Production Annual Report and the Cámara Agropecuaria del Oriente (CAO) "Números de nuestra tierra". FAO's data is available through their statistical database on the internet (http://apps.fao.org/default.htm) or by using the FAOSTAT CD-ROM. For the Argentinean set, we used the same sources and data from the Ministry of Agriculture (www.mecon.gob.ar) and the Commodities Futures Market (www.ggg.com.ar). For the Brazilian case, also the ministry of Agriculture (www.agriculture.gob.br) and the Foundation Getulio Vargas (www.fgv.org.br).

Data for the economic variables was obtained from several sources, like the World Bank (WB), International Monetary Fund (IMF), Central Banks from each country, Statistical Bureaus, and other minor sources, like the ECLAC, ALADI and BID databases.

Details about data manipulation, sources and others are described in Annex 3, for the complete series of variables in Eq. 3.15.

3.7.4. Results for individual countries

The data was introduced in logarithmic form, and the system was estimated using the SUR method. Following Srivastava and Giles (1987), we consider the system in (3.15) as a set of individual equations, each one explaining a part of the economic phenomenon. This set of regression equations is said to comprise a simultaneous equations model, if one or more of the regressors (explanatory variables) in one or more of the equations is itself the dependent (endogenous) variable associated with another equation in the full system. On the other hand, suppose that none of the variables in the system are simultaneously both explanatory and dependent in nature. There may still be interactions between the individual equations if the random disturbances associated with at least some of the different equations are correlated with each other. That is, the equations may be linked statistically, even though not structurally, through the jointness of the error terms' distribution and through the non-diagonality of the associated variance-covariance matrix[11].

Because a lag of the dependent variable is present in the right side of the equations in , each equation is a Nerlovian representation of short-run elasticities, which are presented in Table 3.4. Although the system is made up of eight equations and 6 to 14 variables, only the first four and prices are presented in Table 3.4 to Table 3.6. The complete sets of results from the SUR estimation are displayed in Annex 4.

3.7.4.1. Short-run coefficients for Argentina

Table 3.3 shows the results for the econometrical estimation for the Argentinean data. The "Other" column represents a time trend variable (for the Total production equation), an average price of imports (for the imports and import substitutes equations), and a relative price between beef and petroleum for the exports equation. Details of those variables are offered in Annex 2 and 3. Overall, coefficients for

[11] Zellner (1962) studied these properties of simultaneous equations. He concluded that the jointness of the equations that comprise the structure of the system, and the form of the associated disturbances' variance-covariance matrix, introduce additional information over and above that available when the individual equations are considered separately. This suggests that treating the model as a collection of separate relationships will be suboptimal when drawing inferences about the models' parameters.

Argentina show high statistical significance. More than 60% of the coefficients are significant at the 10% level and 43% at the 1% level. Also, the fit of the specification indicates high correlation between the model and the data, all R^2 are above 0.7.

Signs of the coefficients are correct. As a result of an exchange rate devaluation, tradables (exports, imports and import substitutes) increase and non-tradables decrease with a net negative effect on the food supply. This empirical result supports the theoretical analysis and it is common for all countries in this study. Moreover, the negative reaction of non-tradables and the food supply is contrary to the results presented by Jaeger (1992) for the Sub-Saharan African data. Income elasticities are positive except for imports which are a small group for Argentina, comprised of unimportant crops and some tropical fruits. As expected, the average price of international commodities is positive for exports and import substitutes, but negative for non-tradables, suggesting that both groups are competitive on the production. To support this view, the signs of coefficients for export taxes are negative for exports and import substitutes, but positive for non-tradables. This means, that when an export tax is levied on the tradable sector, producers of non-tradables increase their production.

Production of exportable crops increase by 4.9% after a 10% devaluation, imports fall by 0.7% and import substitutes crops increase by 6.9%. However, production of non-tradables falls by 0.2% and the overall result is a fall in the food supply of 0.13%. These coefficients indicate that most of the reallocation process occurs among the tradable sector which is highly susceptible to changes on macroeconomic variables. On the other hand, the less integrated non-tradable sector is less affected but because the crops that form this groups are basic food stuff, the food supply falls, although marginally. If resources involved in the production of non-tradables are not demanded for the tradable sector (at least in the short run), especially land, then this sector will have a slower reaction to changes on the macroeconomic environment. The opposite is true for the tradable sector, which is highly integrated with the rest of the economic apparatus.

Then, resources move faster between the exports and the import substitutes sectors than between the tradable and non-tradable sector. However, in the middle and long-run, if the relative advantage of tradables production continues, resources will move towards the more profitable sector. Then, production of food stuff will decrease, and consumers will have to change their consumptions habits (changing to cheaper tradable products).

Table 3.3 Short-run coefficients for agricultural variables in Argentina

	Const.	RXR	LAG	GDP	W	AIP	TAX	Other	R^2
Exports	-1.68	-0.49**	0.36*	0.72**	0.22**	0.42	-0.16**	-0.35*	0.70
	(40.79)	(2.07)	(0.54)	(8.38)	(6.85)	(17.59)	(9.12)	(0.02)	
Imports	47.09*	0.70*	0.86*	-4.37*	-0.30			-1.48*	0.94
	(0.00)	(0.11)	(0.00)	(0.00)	(16.23)			(0.09)	
Non-tradables	1.17	0.02	0.32*	0.43*	0.16*	-0.07	0.07*		0.75
	(29.45)	(29.63)	(0.94)	(0.25)	(0.32)	(12.74)	(0.79)		
Total Production	4.82	-0.38	0.35**	0.61*	0.06		-0.10*	0.02*	0.82
	(12.54)	(16.74)	(2.96)	(0.96)	(16.74)		(0.74)	(0.63)	
Food Supply	1.60**	0.01	0.25**	0.33*	0.00*				0.86
	(1.87)	(25.86)	(5.09)	(0.05)	(0.00)				
Imports Substitutes	7.11**	-0.68*	0.48*			-0.29**	-0.17**	-0.39	0.86
	(4.71)	(0.01)	(0.00)			(2.93)	(2.47)	(14.07)	
	Const.	**AV**	**DIR**	**L**	**PIP**	**WR**	**R^2**		
RER	-3.77**	0.47**	-0.14*	-0.21**	-0.30	1.55*	0.84		
	(8.91)	6.22	(0.00)	(4.52)	(22.69)	(0.04)			
	Const.	**TIN**	**GCP**	**INF**	**TTP**	**TB**	**R^2**		
GDPPC	4.05*	1.18*	0.08*	-0.01*	0.26*	0.01*	0.99		
	(0.00)	(0.00)	(0.09)	(0.02)	(0.00)	(0.05)			

[1)] Numbers in parenthesis represent probability values, one tale test at 1% (*) and 10% (**)

3.7.4.2. Short-run coefficients for Bolivia

Table 3.4 Short-run coefficients for agricultural variables in Bolivia[1)]

	C	RXR	LAG	GDP	W	AIP	Other	R^2
Exports	-4.64	-3.76*	0.37*	1.50	0.73		0.42*	0.89
	(39.85)	(0.43)	(0.15)	(23.88)	(12.44)		(0.06)	
Imports	-0.16*	0.64**	0.94*	-2.20		-0.41*		0.68
	(0.07)	(3.52)	(0.00)	(33.35)		0.021		
Non-tradables	18.71*	0.63*	0.32*	-1.15*		-0.52*	0.07*	0.95
	(0.00)	(0.00)	(0.00)	(0.02)		(0.00)	(0.19)	
Total Production	-10.74**	-1.34*	0.12	2.74*	-1.34*	0.44*	0.49*	0.93
	(2.40)	(0.00)	(11.79)	(0.00)	(0.00)	(0.01)	(0.00)	
Food Supply	5.82*	0.10*	0.22*	-0.22**				0.83
	(0.00)	(0.66)	(0.00)	(7.36)				
Imports Substitutes	-15.99	-2.00*	0.51	4.64*	-0.61**			0.74
	(18.12)	(0.10)	(10.13)	(0.33)	(6.62)			
	C	**AV**	**IR**	**L**	**PI**	**WR**		**R^2**
RXR	2.86**	0.40*	0.08	0.23*	0.18**	-0.39**		0.84
	(4.64)	(0.28)	(18.20)	(0.37)	(8.64)	(3.78)		
	C	**I**	**HK**	**GC**	**INF**	**TT**	**TB**	**R^2**
GDP	5.72*	0.03	0.22*	0.03**	-0.01*	0.13*	0.02**	0.94
	(0.00)	(12.20)	(0.00)	(1.82)	(0.00)	(0.00)	(1.76)	

[1)] Numbers in parenthesis represent probability values, one tale test at 1% (*) and 10% (**)

In Table 3.4, **Other** represents producer prices, which changes for each equation. For example in the case of Exports, **Other** represents sugar and soybean producer's price and for NT is the NT's producer price. Also, in the case of NT and imports (M), Donations is not showed on Table 3.3, for better exposition. The same applies for the time trend variable for NT. For M and MS (import substitutes), the **Other** variable is the wheat's producer price, as explained in Annex 4.

All coefficients in Table 3.4 have the right sign. Exports, imports, import substitutes and total production react positively to an increase in the exchange rate (devaluation) and imports and NT have a negative reaction. This result confirms (indirectly) the theoretical model of Section 3.6. NT decrease, because either resources are mobilized to the new more profitable sectors or NT's price falls relatively to other prices. In the case of a small country, we should not expect changes in other countries' exchange rate that is why WR is exogenous in our model. In addition, it is implicitly assumed that even though agricultural prices have some effect on the economy, the non-agricultural sector is not affected, that is why RXR and GDP are endogenous variables.

The statistical significance of the coefficients is high, 81% of all coefficients are significant at the 10% level and more than 55% at the 1% level, one tale test. Most importantly, all coefficients for the real exchange rate (RXR) are significant at the 1% level, except for the imports equation where the RXR's coefficient is significant at the 5% level. In addition, the R^2 is high for all equation. The NT's equation and the one for per capita income (GDP) have R^2 of 0.98 and 0.95 respectively. The lowest R^2 is found in the Imports equation, where we have R^2=0.68. This relatively high fit of the data to the econometrical specification indicates that the RXR is important in the determination of production, especially in a model of partial adjustment expectations (Nerlov model).

Results in Table 3.4 indicate that after a 10% devaluation, exports increase by 37.6%, import substitutes increase by 20% but NT production decreases by 6.3%. For the same devaluation, TP increases by 13.4% and imports fall by 6.4%, with everything else constant. The response of tradables (imports, exports and import substitutes) to exchange rate movements is much higher than the response of the other variables. These results are in line with the discussion of the food supply determinants in section 3.4 and explain the negative reaction of the FS to devaluations. After a 10% devaluation the FS decreases by 1.1%, everything else constant.

Contrary to the finds of Jaeger (1992), our results indicate that devaluations decrease the production of NT. Also, TP increases, not only because of a better exchange rate but also reacts positively to prices of export (0.442) and NT crops

(0.493). In a way, this also confirms that agricultural producers react positively both in the large-scale sector (tradable) and in the small-scale sector (non-tradables) to price movements. This finding is supported by the analyses of Binswanger (1990), Schiff and Montenegro (1995) and Islam and Subramanian (1989), for the case of developing countries. The displacement of NT production by tradable crops is confirmed directly by the coefficients of the average of international prices for agricultural commodities (AVI) and the NT's price in the NT equation. NT reacts negatively to increases in the price of tradable crops and positively to its own price and the negative effect of tradables is bigger than the own-price elasticity. When prices of export crops increase by 10%, NT production decreases by 5.25%, everything else constant.

The food supply is affected by the exchange rate through direct and indirect channels. It is directly affected through changes in domestic prices of tradables and non-tradables and indirectly through changes in the input markets, including the financial market. Once the devaluation is carried out (and producers consider the shock as permanent), producers of tradables will increase their production as domestic prices rise and the relative competitiveness has increased compared with foreign countries. This increase in activity in the tradables sector attracts resources from other sectors of the economy, especially from the non-tradable sector. If we take into account that land and labor are fixed in the short-run, the obvious result is that production in the non-tradables sector will suffer from lack of financial resources (as financial institutions will prefer to lend to the more profitable sector) and reduced size of productive land.

This result could be another reason why agriculture has become more intensive in the use of available resources. And also, producers of NT crops will be forced by lower prices to produce in less suitable portions of their land, with the inevitable negative effect on the environment. FAO (1997), The World Bank (1996) and Thompson (2001) have discussed the pressure of small farmers on fragile ecosystems, among others.

The export and import substitute's crops have the highest coefficients in Table 3.4, indicating that the response is high in these sectors. Tradable crops in Bolivia are produced in the lowlands (tropical area), using large-scale production units and high inputs of machinery, chemicals and financial resources. Therefore, this sector is highly connect with the rest of the economy, accelerating the transmission of information and thus, accelerating the response of the sector. The opposite is true for the non-tradables sector.

The previous discussion indicates that in the event of a macroeconomic adjustment that includes devaluations of the exchange rate, as the one observed in Bolivia in the middle of the 80s, is it highly likely that producers of NT crops will bear most of the burden of the adjustment[12]. The instinctive reaction of policy makers to this kind of phenomena (which usually emerges in the form of social unrest) is usually to design Rural Development Projects (RDP) to "compensate" for the negative effects of macroeconomic policies. However, with a constant devaluation of the currency, NT prices will remain (nominally) constant, or fall (see Footnote 7). Then, any increase in NT production, as a result of the implementation of RDP will only add pressure on NT's prices, and continue falling.

To explain this fall in prices, Dornbush (1975) suggested the use of some policy tool, like price ceilings, or price controls. However, as indicated in Section 3.6, income

[12] The exchange rate devaluation carried on in Bolivia to control the hyperinflation reached more than 13,000% in an annualized basis. From 1987, the average devaluation has been 8.7 percent annually (domestic currency per U.S. dollar). Details of the economic environment during the crisis and the agriculture are discussed in The World Bank (1984).

effects can play the same role, if NT are inferior goods. Results of Table 3.4 indicate that imports (essentially wheat) and NT have a negative reaction to increases in per capita income. Both coefficients are comparatively high, and indicate that the income gains that come from the trade surplus will help to keep nominal prices of NT crops constant or in a decreasing trend (-2.20 and –1.15 for imports and NT respectively).

Coupled with the competition from the tradables sector and the negative income elasticity, non-tradables have a gloomy outlook.

The problems of the NT sector would be less stringent if producers could change (relatively) freely to another activity. However, NT producers are usually small farmers, who cannot find other sources of income than agriculture. Moreover, small farmers represent the biggest part of the poorest section of the population[13], therefore, more susceptible to income changes. On the other hand, producers of tradable crops are usually large farmers, who do not face the same income restrictions as NT producers, then, negative shocks are reflected in less production, not necessarily in less per capita income (FAO, 2000; IFAD 1999).

Thus, income redistribution of exchange rate devaluations clearly benefits producers of tradables and reduces (or maintains nominally) income in the NT sector. If we analyze the role of RDP with this new information, it is interesting to note that the RDP focus on increasing the production of NT (because they are both staple food and main source of income) would only reduce the income of producers. A more proactive policy would try to help small farmers (net losers of the adjustment) to: a) Move to another activity, so they can improve their chances of getting better income

[13] According to the last national census in Bolivia, 52% of the population is living in the rural areas. Of this 52%, 75% are below the poverty line as classified by the World Bank (INE, 2002; UDAPE, 2003).

and, b) Facilitate the move to the production of tradable crops, for those farmers who want to stay in the agricultural business.

Under this line of analysis, Schuh (2000) mentioned that an important feature of economic growth and development is that large amounts of labor will inevitably have to leave agriculture and that most of that labor will come from the currently small farmers. Public resources might better be invested in education and training programs that would facilitate this shift.

3.7.4.3. Short-run coefficients for Brazil

Table 3.5 shows results for the econometric estimation for the Brazilian data. The first six columns represent the same variables as in the previous cases. The "Other" column represents producer prices for specific crops and a time series as detailed in Annex 3. The exports' and total production equations have a time trend; the imports' equation included the producer's price of wheat and non-tradables the producers' price of maize. The food supply includes those three variables and the import substitutes' equation includes the producer's price of wheat and maize. Statistical significance is high, more than 78% of the coefficients in Table 3.5 are significant at the 10% level, and 47% are significant at the 1% level. All signs are correct, and as expected from the theoretical analysis. The fit of the model is high; the lowest R^2 is 0.69 for the import substitutes' equation.

Brazilian imports and import-substitutes have the highest coefficients for the RXR. In both groups wheat is the most important product by far (60% and 85%, respectively). Therefore, movements in the FS come mostly from the adjustment in the importables' market rather than from the rise in export which increase only by 1.93% for a 10% devaluation of the exchange rate with everything else constant. In the case of Brazil, the FS falls marginally by 0.44%. The small coefficient of the RXR for the NT might be indicating that, as pointed by Dornbusch (1973), if non-tradable crops are not affected by exchange rate devaluations, then trade surpluses are sustainable in the long run.

The relatively more sensitive imports sector might be related with the protection that Brazilian governments have benefited producers of maize and wheat. When there is a devaluation, importers of wheat (usually brokers located in the principal cities) adjust immediately their expectations and their business, thus, a relatively large fall in this sector comes as no surprise. Producers perceive those changes with a time gap and because of the nature of the agricultural business; they cannot adjust the scale of the business until the next planting season. Small farmers that are net buyers of grains (especially wheat) will suffer the worst of the adjustment process. They will face higher prices for their consumptions goods and lower prices for non-tradable products, the main source of their income.

Table 3.5 Short-run coefficients for agricultural variables in Brazil

	Const.	RXR	LAG	Income	W	AIP	Other	R^2
Exports	6.92*	-0.19**	0.40*	-0.17	-0.15**	0.40**	0.08*	0.95
	(0.02)	(2.26)	(0.13)	(34.15)	(9.99)	(1.37)	(0.00)	
Imports	-2.14	1.04*	0.58*	1.36	-1.19**		-0.66**	0.71
	(42.33)	(0.07)	(0.00)	(16.66)	(2.50)		(1.78)	
Non-tradables	8.56*	0.04	0.15**	-0.42**	0.27*		0.07	0.80
	(0.00)	(21.20)	(7.02)	(3.11)	(0.00)		(17.26)	
Total Production	7.85*	-0.09**	0.27**	0.40**	-0.09**	0.02	0.02*	0.94
	(0.09)	(2.94)	(4.84)	(5.78)	(2.94)	(19.20)	(0.00)	
Food Supply	-5.34*	0.04*	0.91*	0.74*			-0.18*	0.85
	(0.00)	(0.51)	(0.00)	(0.00)			(0.00)	
Imports Substitutes	-9.34	0.12*	0.27**	2.68**			0.83**	0.69
	(17.19)	(0.51)	(3.77)	(1.77)			(7.70)	
	Const.	**AV**	**DIR**	**L**	**PIP**	**WR**		**R^2**
RER	-1.68**	-0.85*	0.05*	0.54*	-0.06	2.27*		0.78
	(9.51)	(0.00)	(0.24)	(0.01)	(41.93)	(0.00)		
	Const.	**TIN**	**ED2**	**GCP**	**INF**	**TTP**	**TB**	**R^2**
GDPPC	6.87*	0.18*	0.32*	-0.06**	-0.01**	-0.15*	0.03**	0.77
	(0.00)	(0.31)	(0.01)	(1.08)	(9.40)	(0.11)	(1.04)	

[1)] Numbers in parenthesis represent probability values, one tale test at 1% (*) and 10% (**)

3.7.4.4. Short-run coefficients for Venezuela

Coefficients for Venezuela are shown in Table 1.6. Significance is high for the whole system where 90% of the coefficients are significant at the 10% level and more than 63% at the 1% level. The sample regression fits very well the data, values for the coefficient of determination R^2 are very high, with a range from 0.596 to 0.93.

All coefficients have the right signs, exports increase (-0.629), imports decrease (0.360) and non-tradables fall (0.100) after an exchange rate devaluation. However, the FS increases because the fall in the production of non-tradables and imports is smaller than the increase in the production of export crops and import substitutes. The high dependence of Venezuela on petroleum exports (more than 75% of total exports) diminish the importance of agricultural exports for the balance of the economy, but at the same time it creates enough financial resources for the support of domestic production (fixed prices and tariffs) which distort the relative profitability of each group. Although the elasticity of the RXR for import substitutes is almost as big as imports, the fall in the FS comes from the rise in exports.

All income elasticities are positive except for the import substitutes' equation. This result is not a surprise if we remember that the crops in this group are dominated by grains (wheat, barley, oats and maize) and oil-crops (soybeans, sunflower and cottonseed). Elasticities for tradables and non-tradables indicate that these two groups are competing for the same resources on the production, at least on the short-run.

Table 3.6 Short-run coefficients for agricultural variables in Venezuela

	Const.	RXR	LAG	Income	W	Others	R²	
Exports	-49.50**	-0.62**	0.70*	3.47**	1.25**	0.18	0.85	
	(1.54)	(8.17)	(0.00)	(1.51)	(6.86)	(25.52)		
Imports	0.40*	0.36*	0.39**	0.08		0.05	0.65	
	(0.87)	(0.31)	(9.15)	(44.61)		(36.43)		
Non-tradables	-0.41*	0.10*	0.65*	0.10**	0.20**	-0.04**	0.93	
	(0.09)	(0.55)	(0.01)	(1.58)	(8.69)	(5.48)		
Total Production	6.76*	-0.17*	0.60*	0.12*		0.01**	0.92	
	(0.03)	(0.07)	(0.00)	(0.97)		(1.73)		
Food Supply	3.12*	-0.16**	0.58*	0.08*		0.16*	0.84	
	(0.10)	(5.65)	(0.00)	(0.00)		(0.00)		
Imports Substitutes	24.14*	-0.51*	0.38*	-0.95*	-0.67**	0.42*	0.90	
	(0.04)	(0.25)	(0.22)	(0.91)	(3.43)	(0.03)		
	Const.	**AV**	**DIR**	**L**	**PIP**	**WR**		**R²**
RER	12.92*	-0.36	-0.01	0.44*	0.58*	-1.81**		0.59
	(0.17)	(10.12)	(41.00)	(0.40)	(0.19)	(2.48)		
	Const.	**TIN**	**ED2**	**GCP**	**INF**	**TTP**	**TB**	**R²**
GDPPC	6.47*	0.25*	0.15*	-0.01	-0.03**	0.19*	0.04*	0.70
	(0.00)	(0.00)	(0.21)	(39.68)	(3.25)	(0.03)	(0.00)	

1) Numbers in parenthesis represent probability values, one tale test at 1% (*) and 10% (**)

3.7.5. Country comparison

Countries with a more diversified and technical (capital intensive) agriculture like Argentina and Brazil have smaller coefficients of RXR for the food supply and non-tradables than the other two countries where agriculture is less developed and labor intensive, mostly oriented for the domestic market. The export oriented agriculture of Brazil and Argentina creates a great surplus of agricultural products, but because the non-tradable sector is less developed and managed basically by small farmers, resources are reallocated first on the tradable sector. Bolivia is a good example of how the RXR affects labor intensive agricultural sectors. Bolivian agricultural exports are less diversified than Brazil and Argentina (consisting mainly in soybeans and its sub-products) which makes this sector highly susceptible to changes on macroeconomic variables. But because exchange rate devaluations stimulate exports, they will absorb resources from the non-tradable sector, even in the short-run.

Production of NT has bigger coefficients for Bolivia and Venezuela where these crops represent more than 85% of total production and is smaller for Argentina and Brazil where production is more oriented to international markets. This result also shows the potential resources available for the production of tradables in the short run (where more land can not be developed). The NT sector holds labor and capital which can be used for the production of tradables. However, the speed of conversion from non-tradables to tradables will depend on climate restrictions, topographical characteristics of the land used in the production of NT and financial systems available to NT producers in these countries. Finally, countries with a weak (small) tradable sector have bigger RXR coefficients for the FS, showing that the development of the tradables sector is fundamental to achieve the desired level of food production. It is also important to note that exports and imports are concentrated on grains and oil crops and that they are directly (food) and indirectly (feed) more important for food supply than non-tradable products.

The real exchange rate coefficients are indicating us the degree of impact of this particular tool on the agricultural sector. If we consider the average devaluations that were implemented in our four developing countries when their macroeconomic adjustments were taking place, it is easy to image the degree of impact that the agricultural sector had to endure. The tradable sector was clearly favored (along with other measures to open the country to international trade), and the non-tradable sector was left totally in disadvantage with the correspondent negative effect on the food supply. The Rural Development Programs (RDP) that were established to help small farmers did no help, basically because to increase their income, more production of non-tradables was not the solution. This situation can be thought as standard for our four countries, and in some degree, for all developing countries.

3.8. Conclusions

The theoretical analysis showed that exchange rate devaluations improve the trade balance but depress NT prices in the short run. This is necessary to keep the trade surplus, which is the principal objective of exchange rate devaluations. To test these theoretical findings, an econometrical model was constructed and Bolivian data was used during the estimations. The SUR method was used with 8 equations for each country, 6 of them agricultural variables and 2 equations to create a link between the agricultural sector and the overall economy. Short-run coefficients are highly statistically significant and they have the right signs. Imports decrease, exports increase and production of NT decreases in order to maintain the trade surplus. If producers the NT are small farmers, and producers of tradables (export and import substitutes' crops) are large farmers, the income distribution effect of the devaluation scheme clearly benefits the latter group.

Production of non-tradables decreases due to its negative income elasticity. Elasticities for tradables show a consistent pattern of trade off between these two sectors. As a result of exchange rate devaluations, tradables (exports and import substitutes) increase their production and the production of non-tradables decreases. This result suggests a negative crowding-out for the non-tradable sector.

The massive devaluations of the 80's and 90's had an enormous impact on both sectors: tradables and non-tradables. Tradables benefited not only from their relative higher prices and competitiveness, but also from another macroeconomic measures to open the country. Non-tradables faced a negative environment, which was worsened by the increase in the production of crops with negative income elasticity.

A proactive policy is required to reduce the burden imposed on producers of NT. This policy has to be a combination of training and support for farmers that wish to change their main activity and training and support for farmers to wish to continue in the agricultural business. It would be wise to encourage producers of NT to change gradually towards tradable crops to enlarge their chances to increase their income.

Chapter 4

4. The money supply and the food supply

4.1. Introduction

The second step in the analysis of the macroeconomic influences in the agricultural sector is to study the effects of monetary policy on agricultural and non-agricultural prices. As it was indicated in Chapter 2, monetary policy is one of the principal tools to adjust the economy, and negative shocks are common during the adjustment process. The importance of monetary shocks is not only related to price movements, but also to "assumptions" abut the neutrality of the process. The analysis starts with a discussion of the overshooting model and the implications of introducing non-tradables into the discussion. Then, an empirical test of money neutrality and relative price flexibility will be performed using time series methods and cointegration theory. This allows us to find different coefficients for the short- and long-run processes and to trace the monetary shock on agricultural prices. For this Chapter we will use quarterly data from Bolivia (developing) and Japan (developed) to find out differences between these two kinds of countries.

The present analysis stresses a positive monetary shock through the theoretical and econometrical discussion, however, both shocks (positive and negative) are important from the policy making point of view. Positive shocks occur when governments increase money printing and negative shocks are an important feature of macroeconomic adjustment. Traditionally, the profession has assumed that the classical dichotomy between the real and the monetary sectors holds and carried out its research "in real terms" without explicitly specifying any monetary link. With the growing volatility of monetary and capital movements within and among countries, these links should no longer be ignored (Barnett, Bessler and Thompson, 1983).

The analysis of monetary shocks on the agricultural sector is highly related with the discussion on the previous Chapter. We will see that monetary shocks overshoot the exchange rate, creating a two-way channel that affects the agriculture directly and indirectly.

The first objective of this chapter is to extend the theoretical models of Stamoulis and Rausser (1988) and Saghaian, Reed and Marchant (2002) to include non-tradables in the agricultural and non-agricultural sector. This approach is novel in the economic literature. This subdivision will highlight the importance of non-tradables in the adjustment process as consequence of a monetary shock, especially in the agricultural sector. The second objective is to investigate the direct effects of monetary policy on agricultural prices and the indirect effects on the food supply using contemporary non-stationary time series econometric methods with the aid of the Vector Error Correction (VEC) model. Previous studies employed ad-hoc models relating prices to money variables or used VAR (vector autoregressive) techniques. Only Saghaian, Reed and Marchant (2002) and Robertson and Orden (1990) applied VEC and cointegration to analyze the short-/long-run characteristics of monetary shocks. Bessler (1984) used a VAR model and Han, Jansen and Penson (1990) used a GARCH model.

The third objective is to test the money neutrality assumption and overshooting hypothesis for the Bolivian data. If money is neutral, then monetary policy does not affect relative prices and only has a transitory effect on the economy, which, in theory, returns to equilibrium without any change in real terms. 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 represent the flexible sector of agriculture and that they are produced mainly by small farmers for domestic consumption) 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. This part of the thesis attempts to offer a more consistent test, differentiating also the relative flexibility between tradables and non-tradables in both agricultural and non-agricultural sectors.

4.2. The relation between money supply policy and the agricultural sector

As Stamoulis and Rausser (1988) indicated, the overshooting model provides the necessary conditions for monetary policy to have short-run effects on relative prices of different sectors in the economy with dissimilar degrees of price flexibility. The speed of adjustment of prices was shown (in their research) to be a function of several parameters characterizing the economic system even in the most simplistic version of the model. Thus, some evidence is needed that would justify the assumption of price stickiness and/or differential price responses (across sectors) to changes in money. To be more specific, for the case of agriculture, some evidence is needed to justify characterizing the agricultural sector as the flexible price sector when compared to manufacturing and services sectors (pp. 173). Newly developed econometrical methods (like time series and cointegration and their application to vector error correction – VEC – models) are very useful indeed to test for flexibility without having to impose too many restrictions on the model. While testing for flexibility in a traditional model the researcher has to "assume" something, often restricting the coefficients to work as flexible in one sector and sluggish on the other (like in Bordo, 1980). With VEC models, it is possible to obtain results for the complete set of variables, and tests for relative flexibility can be performed rather than assuming their existence. The other approach is to conduct a two-step procedure. First the flexibility of prices is tested and then the money neutrality is examined, however, we would be again assuming that flexibility either holds or not and that flexibility does not have any effect on the final result on the money neutrality.

The analysis of money supply, overshooting and its effects on the agricultural sector complement the analysis of the previous chapter. Especially if we recognize that the importance to agricultural economists is not the overshooting per se but the possibility that relative prices of farm products can be affected (negatively) by monetary policy (Stamoulis and Rausser, 1988). Therefore, two factors are of importance in the analysis of this Chapter:

- If relative prices are affected, then monetary contraction reduces agricultural prices, and these prices take more time to return to the long-run trend.
- If relative prices are affected, non-tradables have a stronger reaction, but they need more time to return to the long-run trend compared with agricultural tradables.

4.3. Literature review

Supporting the view that agricultural research was heavily oriented toward micro economics and not sufficiently concerned with U.S. economic policies, Brake (1974) presented a wide review of the agricultural economics literature up to 1973. On the same line, Francis (1974) analyzed the U.S. agricultural sector assuming that the trend rate of monetary growth was largely responsible for average price movements in the economy and that variations from the trend have a major influence on the cyclical movements of total output. However, Francis analysis only discussed trends and not presented any econometrical or theoretical discussion.

The overshooting model developed by Dornbusch (1976) theoretically analyzes the effects of a monetary shock. Frankel (1986) applied Dornbusch model to the agricultural sector, which was extended by Stamoulis, and Rausser (1988) 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 analyses. 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 flexible prices, which is consistent with rational expectations (Dornbusch, 1976; Frankel, 1986). 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 kind of approach has not been addressed in the literature before.

Bordo (1980) used the components of the U.S. wholesale price index and a broad definition of the money supply to test for flexibility on agricultural and non-agricultural prices. His results indicate that agricultural prices are more flexible than non-agricultural prices. Following Bordo, Musa (1981) analyzed the reaction of prices to monetary changes based in the assumption that there are costs associated with changes on the price of an individual commodity. Given this cost, it is optimal to adjust individual prices only at discrete intervals and by infinite amounts, and to permit disequilibrium during the intervals between price changes. Musa's theoretical analysis solidified the view introduced by Dornbush, that when prices have different reaction paths, money is not neutral in the short-run[14]. On a similar approach, Rotemberg (1982) analyzed the difference in flexibility between agricultural and non-agricultural prices. He developed a specific model of sticky (sluggish) prices which are sticky in the sense that they are closer to those prices which prevailed the period before than they would be if no agent's decisions at the present (***t***) depended on past prices (***t-1***). Chambers and Just (1982) followed with a paper that analyzes the effects of monetary factors on the agricultural sector. His model is a wide econometric effort to calculate the effects of changes on the level of domestic credit on the agricultural trade, inventory accumulation, and domestic disappearance. The principal finding is that tight monetary policy lowers prices and increases demand for domestic agriculture. He acknowledge the presence of exchange rate pressures that diminish the negative effects of monetary policy.

Empirical analyses of the overshooting hypothesis have been tested for the U.S. case, with a good review in Belongia (1991). For the New Zealand case, Robertson and Orden (1990) provided coefficients for the short-/long-run scenarios. Finally Saghaian, Reed and Marchant (2002) for the U.S. data and Saghaian, Hasan and Reed (2002) 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

[14] In Musa's (1981) model, individual prices are held constant over a finite interval and then adjusted by discrete amounts to their expected (average) equilibrium levels for the subsequent interval. In contrast, the general price level moves continuously and adjust gradually towards its equilibrium level. This behavior of the general price level reflects the fact that it is an average of the prices of individual commodities which are adjusted at different points of time.

countries, except in Bessler (1984) for Brazil. Interestingly, Bessler (1984) identifies two aspects of the adjustment process characteristic of developing countries. The firs is the effect on the level of real activity, whereby an increase in money leads to an increase in labor and output with no immediate increase in prices. This effect of money in the economy has its modern-day description as the stable Phillips curve. The second aspect of the dynamic process associated with money is the response of relative prices to a change in money supply. Finally, Obstfeld (1986) indicates that with short-run price rigidities, monetary policies will be neutral only in the long-run, and in the short-run these policies will have important real effects on all sectors of the economy, including the agriculture. Moreover, he argues that the effects of fiscal policies will generally be non-neutral even in the long-run.

Table 4.1 Previous studies of money supply shocks on the agricultural sector

Authors (year)	Variables	Sample period	Data frequency	Long-run neutrality
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)[1)]	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)[2)]	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)

Authors (year)	**Variables**	**Sample period**	**Data frequency**	**Long-run neutrality**
Saghaian, Reed and Marchant (2002)	Agricultural PPI, Industrial PPI. M1	1975-1999	Monthly	Non-neutral
Saghaian, Hasan, Reed (2002)[3)]	Agricultural PI, industrial PI. M1.	1985-1997	Monthly	Non-neutral

[1)] Canadian

[2)] New Zealand

[3)] Korea, Philippines, Thailand and Indonesian

Dorfman and Lastrapes (1996) introduced a new approach. First, they used U.S. data to calculate the response of agricultural prices to monetary shocks by imposing long-run money neutrality. And, second, they divide the agricultural sector into crops and livestock, without considering the non-agricultural sector. In general, their results show that in the short-run agriculture benefits from expansionary monetary policy. Livestock prices exhibit a strong positive response to money-supply shocks on impact, while crop prices have a very small initial positive response. However, crop prices gradually rise and take longer to fully adjust than livestock prices. The relative dynamics of the two agricultural prices are consistent with crops being an important input to livestock production.

A related research effort, connected with monetary policy is the study of inflation and agricultural prices. Starleaf, Meyers and Womack (1985) using U.S. data tested the hypothesis suggested by economic theory that farmers are benefited by an acceleration in the rate of general price inflation and, conversely, are harmed by a deceleration in the inflation rate. They found substantial amount of empirical evidence to support the hypothesis that farmers have been net beneficiaries of increased inflation rates and have suffered losses in terms of trade when inflation rates have declined. Furlong and Ingenito (1996), Shei and Thompson (1988) and Gardner (1981) offer a good review of the issue.

Although the previous research efforts indicated the importance of monetary shocks on the agricultural sector, none of them investigated further the redistributive effects inside the sector. Saghaian, Reed and Marchant (2002) include a tradable sector, but continue with the traditional agricultural/non-agricultural division of the economy. This lack of detail reduces the capacity of the analysis to find answers to the questions raised in Chapter 1 and 2. This study aims to fill that gap in the economic literature.

4.4. Theoretical model

Dornbush (1976) presented the original overshooting model as an application to exchange rate movements, and several studies applied his model to the agricultural sector. Frankel (1986) used Dornbusch's overshooting model, but instead of exchange rates, he used agricultural prices as the flexible sector and non-agricultural prices as the sluggish sector in a closed economy model. Stamoulis and Rausser (1988) extended his work for an open economy. In order to present a theoretical framework for the empirical analysis in this paper, the models by Stamoulis and Rausser (1988) and Saghaian, Reed and Marchant (2002) are extended to include two more sectors: agricultural sluggish (non-tradables) and non-agricultural flexible (manufactures).

The intuition behind the theory is better understood with the help of Figure 4.1, modified from Belongia (1991). Suppose that the economy is originally in equilibrium at point A, where the schedule EE represents all possible equilibrium points for both prices, flexible (P^F) and non-flexible (P^{NF}). A negative money shock reduces the demand of both products, moving the possible equilibrium points to the left (line E'E'). However, in the short run, only flexible prices show a decrease in their price, moving the equilibrium point to B. After a while, non-flexible prices start to adjust, and the economy finally moves to point C.

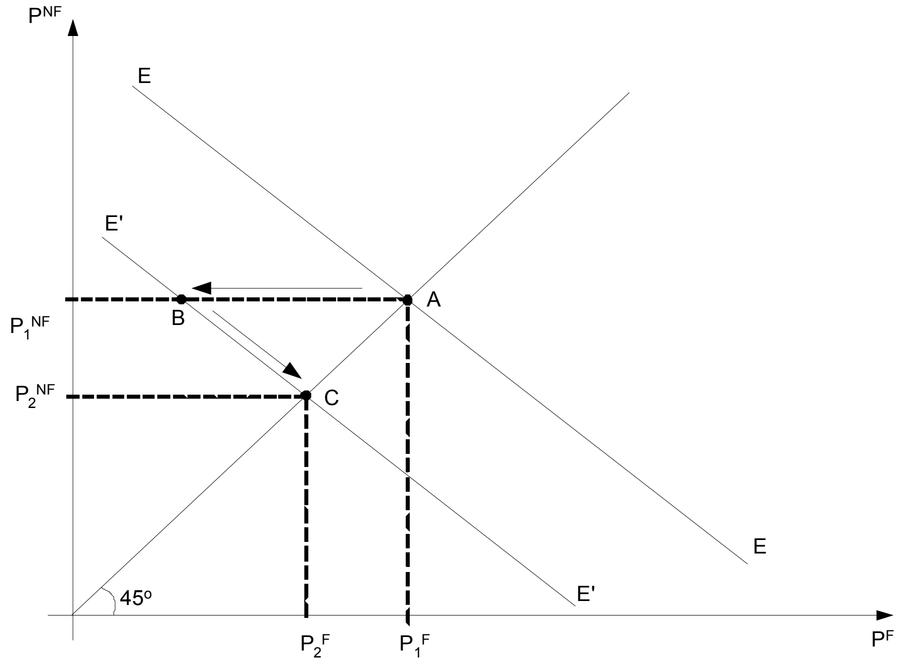

Figure 4.1 Response of flexible and sluggish prices to monetary shocks

The existence of sluggish and flexible prices has been addressed in the literature (Bordo, 1980), with the most common opinion being that sluggish prices are the result of rigid contracts. Structural constrains (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. The theoretical analysis assumes that there are differences between prices in their flexibility (return to the long-run trend) in their response to monetary shocks. This assumption will be discussed later in Section 4.6.

Equations (4.1a) through (4.1i') 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. We also have that ***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. Prices are divided as p_{AF} and p_{AS} (prices of flexible and sluggish agricultural products, respectively) and p_{NAF} and p_{NAS} (prices of flexible and sluggish non-agricultural products, respectively). ***p'*** is the foreign price level, exogenous; α is the share of flexible (agricultural = 1, non-agricultural = 2) and sluggish (agricultural = 3, non-agricultural = 4) prices on the general index and $\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 1$; χ and λ 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).

$r = r' + x$	Uncovered interest parity assumption representation (perfect capital mobility),	**Eq. (4.1a)**
$x = \dot{e}$	Perfect foresight,	**Eq. (4.1b)**
$m - p = \chi y - \lambda r$	Money market equilibrium of the LM curve,	**Eq. (4.1c)**
$p = \alpha_1 p_{AF} + \alpha_2 p_{NAF} + \alpha_3 p_{AS} + \alpha_4 p_{NAS}$	General price index,	**Eq. (4.1d)**
$y^d_{AF} = y^s_{AF} = f\left(\frac{e \cdot p'}{p_{AF}}, \frac{p_{AS}}{p_{AF}}, \frac{p_{NAS}}{p_{AF}}, \frac{r}{\dot{p}}, y\right)$	Equilibrium in the agricultural flexible, sector, instantaneous adjustment,	**Eq. (4.1e)**
$y^d_{NAF} = y^s_{NAF} = f\left(\frac{e \cdot p'}{p_{NAF}}, \frac{p_{AS}}{p_{NAF}}, \frac{p_{NAS}}{p_{NAF}}, \frac{r}{\dot{p}}, y\right)$	Equilibrium in the non-agricultural flexible sector, instantaneous adjustment,	**Eq. (4.1f)**

$$y^s_{AS} = f\left(\frac{e\cdot p'}{p_{AS}}, \frac{p_{AF}}{p_{AS}}, \frac{p_{NAS}}{p_{AS}}, \frac{r}{\dot{p}}, y\right)$$ Supply in the sluggish agricultural sector, **Eq. (4.1g)**

$$y^s_{NAS} = f\left(\frac{e\cdot p'}{p_{NAS}}, \frac{p_{AF}}{p_{NAS}}, \frac{p_{AS}}{p_{NAS}}, \frac{r}{\dot{p}}, y\right)$$ Supply in the sluggish non-agricultural sector, **Eq. (4.1g')**

$$\dot{p}_{AS} = f\left(\frac{y^s_{AS}}{y^d_{AS}}, u\right)$$ Equilibrium in the sluggish agricultural sector, **Eq. (4.1h)**

$$\dot{p}_{NAS} = f\left(\frac{y^s_{NAS}}{y^d_{NAS}}, u\right)$$ Equilibrium in the sluggish non-agricultural sector, **Eq. (4.1h')**

In Eq. (4.1h) and (4.1h') a point over a variable (·) 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. The final coefficients to be estimated are:

$\frac{dp_i}{dm}$, $\frac{de}{dm}$ and $\frac{dp_i}{de}$ where i = AF, NAF.

Based on these results, it is possible to indirectly explain the effects of monetary shocks on the food supply. Recalling from Chapter 3, equation 3.3,

FS* = *TP* + *M* – *E,

where we subtituted ***TP*** = Q_{NT} + Q_{ST}, ***M*** = Q_{MS} + Q_M and ***E*** = Q_{XP} – Q_X. Assuming that TP represents the non-tradable production, we have:

FS* = *NTP* + *M* - *E

FS* = *NTP* + *T **Eq. 4.2**

The identities in (4.2) are to state that the food supply (**FS**) is equal to total production (**TP**) plus imports (**M**) minus exports (**E**). These identities can be rearranged to show that the FS can also be calculated as the production of non-tradables (**NTP**) plus net tradables availability (**T**)[15]. Under the small country assumption, producers of tradables face a fixed demand, but domestic producer prices have to be equal or less than the international prices, leaving the NT sector as the buffer-adjusting sector; adjustments in this sector move the economy to the new equilibrium after a shock. If NT and tradables have normal supply price elasticities (positive), then monetary shocks can affect the FS in the short- and long-run. Based on the model in (14), presented above, it is possible to show that a monetary shock will depress flexible prices in the short-run, to do so, NT in both sectors are assumed to be the flexible group and tradables the sluggish one[16].

After some manipulation of equations (14) and taking the long-run-values, we get:

$$\begin{bmatrix} \dot{e}(t) \\ \dot{p}_{AF}(t) \\ \dot{p}_{AS}(t) \\ \dot{p}_{NAF}(t) \\ \dot{p}_{NAS}(t) \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} & z_{13} & z_{14} & z_{15} \\ z_{21} & z_{22} & z_{23} & z_{24} & z_{25} \\ z_{31} & z_{32} & z_{33} & z_{34} & z_{35} \\ z_{41} & z_{42} & z_{43} & z_{44} & z_{45} \\ z_{51} & z_{52} & z_{53} & z_{54} & z_{55} \end{bmatrix} \cdot \begin{bmatrix} (e-\bar{e}) \\ (p_{AF}-\bar{p}_{AF}) \\ (p_{AS}-\bar{p}_{AS}) \\ (p_{NAF}-\bar{p}_{NAF}) \\ (p_{NAS}-\bar{p}_{NAS}) \end{bmatrix} + \begin{bmatrix} 0 \\ h_2 \\ h_3 \\ h_4 \\ h_5 \end{bmatrix} \cdot \qquad \textbf{Eq. 4.3}$$

where in (4.3), coefficients $\boldsymbol{z_{ij}}$ are linear and nonlinear relations of coefficients in (14); $\boldsymbol{h_i}$ 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 (4.3) can be expressed in a rate of change form, allowing us to estimate the overshooting coefficient. To do so, we obtain the solutions of (4.3) and then differentiate each equation (throwing away the positive solutions for stability). In this way we obtain,

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15 Where ETP is domestic production of export crops and MSP represents the production of import substitutes. See Chapter 3, section 3.4 for more details.

16 Details of the mathematical calculations can be found in Annex 5.

$$\frac{de}{dm} = 1 - \frac{1}{\beta\lambda}\left[\alpha_1 \frac{dp_{AF}}{dm} + \alpha_2 \frac{dp_{NAF}}{dm} - 1\right]$$

$$\frac{dp_{AF}}{dm} = \frac{1}{\alpha_1}\left[1 + \beta\lambda\left(1 - \frac{de}{dm}\right) - \alpha_2 \frac{dp_{NAF}}{dm}\right] \qquad \textbf{Eq. 4.4}$$

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

The coefficients β are the solutions to the system in Equation 4.3. Equations in (4.4) 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. Moreover, 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 may 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.

4.5. Data

To test the hypothesis that money shocks do not have effects on relative prices, we used quarterly Bolivian and Japanese data 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 flexible prices; agricultural tradables (P_{AT}) are the producer prices of soybeans and sugar[17], the principal agricultural export products (Cámara Agropecuaria del Oriente - CAO, 2002), proxy for sluggish prices; services (P_{SE}) and industrial prices (P_{IN}) are the correspondent component of the Bolivian CPI[18] (Instituto Nacional de Estadística - INE), proxies for flexible and sluggish prices respectively. For the Japanese data[19], agricultural non-tradables is the domestic producer index price and tradables is the index of the rest of the agricultural products except livestock, dairy and fish. For both countries, the exchange rate (***er***) is the official exchange rate (national currency per U.S. dollar, average of the period – line rf in the International Monetary Fund Financial Statistics Yearbook (IMF FSY, 2002) 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 database (IMF, 2002 and http://ifs.apdi.net/imf/).

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.

Almost all of previous studies used the M1 as a proxy for money supply, although a broader definition is also possible. The use of M1 is preferred because it implies a faster reaction to monetary policy. Belongia (1991) provides a good review for studies before 1991 (see Table 4.1). 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 (1991), Robertson and

[17] In this Chapter we are using the same definition of tradables and non-tradables used in Chapter 3.

[18] A December 2002 the Consume Price Index (CPI) in Bolivia was composed of: Food and Beverages, Footwear and clothing, Housing, Furnishing and home related expenses, Health, Transport and communications, Education, Entertainment and culture, and other goods and services.

[19] The data for Japan was extracted from the Monthly Bulletin of Agricultural and Fishing Statistics of the Ministry of Agriculture and Fishing. The non-tradables groups is comprised basically by rice (different forms of commercialization) and non-tradables by the rest.

Orden (1990), Devadoss and Myers (1987) and Saghaian, Reed and Marchant (2002)).

4.6. Results

4.6.1. The ADF test

The Vector Error Correction (VEC) model requires non-stationary series (contains at least one unit root) and at least one cointegrating equation, otherwise the system can be estimated with traditional VAR procedures. Table 4.2 shows the results of the Augmented Dickey-Fuller[20] (ADF) test, which is standard in the literature to identify unit roots in time series. Following Cuddington and Liang (2000) and Enders (1995), 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 4.2 shows results for test on the levels of the variables (no first difference). Probabilities for the Mackinnon values (**M**) and for the respective lag (**lag**) are presented in two different columns. 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 4.2[21]. 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).

[20] Dickey, David and Wayne Fuller (1979)

[21] The statistical software used for the estimation (QMS's EViews) reports Mackinnon (1991) critical values and not those tabulated by Dickey and Fuller.

Table 4.2 ADF test results

Description	Japan				Bolivia			
	Lag	Value	Probability (%)		Lag	Value	Probability (%)	
			M**	Lag			M**	Lag
Levels								
P_{ANT}	5	-3.711	5.0		1	-0.863		
P_{AT}	5	-2.933			3	-0.640		
P_{IN}	2	-5.914			5	-2.211		
P_{SE}	2	-1.262			5	-0.027		
er	2	-3.174	10.0		3	-2.599		
M1	2	0.678			3	-0.977		
First difference								
P_{ANT}	5	-4.396	1.0	1.1	1	-8.340	1	0.01
P_{AT}	5	-5.391	1.0	1.2	3	-4.204	1	11.54
P_{IN}	2	-5.914	1.0	14.4	5	-5.044	1	2.17
P_{SE}	2	-4.431	1.0	3.1	5	-5.470	1	0.21
er	2	-3.644	5.0	1.7	3	-13.275	1	1.26
M1	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 (1991).

Alternative tests were conducted to confirm the results from the ADF analysis. The Phillips-Perron (1988) test had the same results as the ADF test (not reported here). Moreover, as Table 4.2 shows, lags of the ADF test were analyzed as Cuddington and Liang (2000) suggest, and most of the estimated coefficients were significant either at the 1% or 5% level. Only Agricultural prices of non-tradables (P_{AT}) for Bolivia and industrial prices (P_{IN}) for Japan were not significant at the 10% level.

4.6.2. Johansen's cointegration test

If each series is an I(1) process, the possibility of an equilibrium is examined using Johansen's (1986) 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 k. Formally, the model is expressed as follows:

$$\Delta x_i = \sum_{i=1}^{j} A_i \Delta x_{t-i} + \sum_{k=1}^{s} \omega_k \varepsilon_{t-1} + e_i$$ **Eq. 4.5**

were, $\boldsymbol{x}$ is a (nx1) matrix of endogenous variables, Δ represents first-difference, $\boldsymbol{A}$ is (nxn) matrix of coefficients, ω_k is a vector of coefficients, ε_{t-1} is the cointegrating relation and $\boldsymbol{e_i}$ is the error term. If $\boldsymbol{x}$ has a unit root, and $\boldsymbol{e}$ is stationary, ε_{t-1} has to be stationary as well. The ω coefficients represent the relationship between the long-run and short-run effects of the shock on the system. The Johansen's test analyzes the rank of matrix $\boldsymbol{A}$, which is equal to the number of cointegrating equations (**s**).

Table 4.3 Johansen's cointegrating test results

	Coint. Rank	Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value
Bolivia[a)]	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[b)]	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

[a)] Test assumes quadratic deterministic trend in data. Intercept and trend in CE, linear trend in VAR. Results with four lags.
[b)] Test assumes no deterministic trend in data. Intercept (no trend) in CE, no intercept in VAR. Results with four lags.

The eigenvalues are presented in the third column of Table 4.3, while the fourth column (likelihood ratio) gives the LR test statistic:

$$Q_T = -T \sum_{i=r+1}^{k} \log(1-\lambda)$$ **Eq. 4.6**

for τ = 0, 1, … k-1 where $\boldsymbol{i}$ is the $\boldsymbol{i\text{-}th}$ largest eigenvalue. $\boldsymbol{Q_t}$ is termed the *trace* *statistic* and used to test $H_1(\tau)$ against $H_1(k)$. To determine the number of cointegrating relations r, subject to the assumptions made about the trends in the series, we can proceed sequentially from r=0 to r=k-1 until we fail to reject. The first row in Table 4.3 tests the hypothesis of no cointegration, the second row tests the hypothesis of one cointegrating relation, the thirds row tests the hypothesis of two cointegrating relations, and so on, all against the alternative hypothesis of full rank, ***i.e***. all series in the VAR are stationary (Johnston and DiNardo, 1997; Enders, 1995).

The lag lengths were determined with the help of the ADF test, Akaike Info-Criterion and Schwarz Criterion. Four lags were used for the estimation. The test indicates that there are at most five cointegrating equations (CE) at the 1% level of confidence for Bolivia and four for Japan. This implies that in the case of Bolivia, prices and exchange rate are cointegrated with money supply and in the case of Japan, prices are cointegrated with the exchange rate and the money supply.

4.6.3. The Vector Error Correction (VEC) model

Of the previous studies, only Saghaian, Reed and Marchant (2002) used a VEC model. Before that, Bessler (1984) used a VAR system and Han, Jansen and Penson (1990) used an ARCH – GARCH model with an error correction component[22]. However, Han, Jansen and Penson did not use the stronger Johansen's test to control for the number of cointegrating terms and just iterated until they found suitable results. The system in (4.1) has the form of a VAR augmented by an error correction factor (the ω_k components of equation 4.1). The dependent variables respond to the lagged values of the endogenous variables (A_i) and the deviation from the long-run trend (ω_k). The existence of 5 CE for Bolivia, indicates that prices and

[22] Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models were developed by Engle (1982) and Bollerslev (1986) respectively.

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:

$$P_{(it-1)} = \pi_i + \gamma_{it} + \tau_i m_{(t-1)} \qquad \textbf{Eq. 4.7}$$

Following the same idea, the long-run error correction term for Japan is,

$$P_{(it-1)} = \pi_i + \tau_{(1i)} er + \tau_{(2i)} m_{(t-1)} \qquad \textbf{Eq. 4.8}$$

where $\boldsymbol{P_i}$ represents agricultural and non-agricultural prices; ***m*** is money supply and ***er*** is the exchange rate. The neutrality of money is tested through coefficient τ. If τ = 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 ***er*** with the money supply[23]. It is important to understand that τ represents the effect of money supply on prices, a positive number indicates that money supply increases prices (inflationary). However, the sign of τ is not a sufficient condition for the existence of overshooting or undershooting in the short-run. The sign and magnitude of the coefficients of ε, ω_k, indicates whether prices over- or under-shoot, and this tells us the direction of the adjustment in the long-run.

Using the same assumptions as in the Johansen's cointegration test, coefficients for Eq. (4.5) and (4.6) were obtained by estimation of the VEC system and they are

[23] In the long-run, ε in (5) equals zero, then 4.5 and 4.6 is introduced in 4.1 in the form $\varepsilon_{it-1} = P_{it-1} - \pi_i - \gamma_i t - \tau_i m_{t-1}$ for Bolivia and $\varepsilon_{it-1} = P_{it-1} - \pi_i - \tau_{1i} - \tau_{2i} m_{t-1}$

showed partially in Table 4.4. Some other coefficients are shown in Table 4.5 for better exposition. The VEC system is estimated simultaneously for the whole set of equations in (4.1), as showed in Annex 6 and 7. The figures in Table 4.4 are the estimated coefficients π, γ and τ from (4.5) and (4.6).

Table 4.4 Long-run cointegration between money, exchange rate and prices*

	Bolivia					Japan			
	ε_{1t-1}	ε_{2t-1}	ε_{3t-1}	ε_{4t-1}	ε_{5t-1}	ε_{1t-1}	ε_{2t-1}	ε_{3t-1}	ε_{4t-1}
P_{ANT}	1	0	0	0	0	1	0	0	0
P_{AT}	0	1	0	0	0	0	1	0	0
P_{IN}	0	0	1	0	0	0	0	1	0
P_{SE}	0	0	0	1	0	0	0	0	1
Er (τ_{1i})	0	0	0	0	1	-0.12 (-0.849)	0.86** (1.763)	0.34** (3.520)	0.46** (3.867)
Money (τ_i-τ_{2i})	-0.23* (-2.18)	-0.76** (-4.27)	-0.09 (-1.35)	-0.12** (-3.16)	-0.16** (-3.09)	0.64** (3.73)	-1.07** (-1.90)	-0.31** (-2.87)	-0.67** (-4.05)
TREND (γ_i)	-0.02	0.02	-0.02	-0.02	-0.01				
Constant (π)	-2.40	0.55	-3.01	-2.90	0.33	-7.41** (-10.88)	-2.37 (-1.07)	-4.36** (-8.53)	-3.70** (-6.24)

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

4.7. Discussion of the results

4.7.1. Long-run money cointegration for Bolivia

All coefficients estimated with the VEC model that represent the parameters in 4.5 were significant at the 1% or 5% level, except for P_{IN} (Table 4.4). All the coefficients are less than unity, indicating that they are affected by changes in the money supply but less than proportionately. As expected, all signs are positive (see footnote 70), 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 4.4, 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 (2002) for the U.S. case and confirms the hypothesis of Dornbusch (1976). After a monetary shock, people move away from the assets in domestic currency, anticipating a future appreciation, over-shooting the spot exchange rate.

Prices increase after the money supply in the neoclassical model, fundamentally 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 also assumes that this adjustment is instantaneous because all prices are flexible; mostly because it assumes perfect information.

Estimated coefficients in Table 4.4 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[24]. $\boldsymbol{P_{AT}}$ react more to changes in the money supply basically because, first, they are composed of commodities (soybeans and sugar) which are cultivated extensively with high inputs of tradables. Second, 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. Third, the depreciation of the exchange rate increases prices of commodities, measured in domestic currency. Finally, tradables have close substitutes both in the domestic and

[24] The relative difference between coefficients, was tested with the Wald test. All possible combinations were analyzed, being significant at the 1% level. The Wald test uses a χ^2 distribution.

international markets. Producers of non-tradable do not have to face those problems in the short-run, if transportation costs and the taste/price relation are high enough to restrict the adoption of a substitute.

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 $\boldsymbol{P_{AT}}$ to changes in the money supply. Besides that, as Mattos, Ito and Usami (2003) noted, depreciations of the exchange rate push prices of non-tradables downwards reducing the effect of positive money supply shocks.

4.7.2. Long-run money cointegration for Japan

As it can be seen in Table 4.4, $\boldsymbol{P_{AT}}$ and non-agricultural prices have positive coefficients, indicating the inflationary character of money supply, with $\boldsymbol{P_{AT}}$ being slightly bigger than one. The price of agricultural non-tradables has a negative sign, meaning that $\boldsymbol{P_{ANT}}$ decreases when money supply increases. This is a special case and mostly related with the characteristics of this group in Japan. $\boldsymbol{P_{ANT}}$ 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[25]. 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%, $\boldsymbol{P_{AT}}$ increases 10.05% but $\boldsymbol{P_{IN}}$ increases only 3.71%,

[25] 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 Warren (1989) indicated, rice has become an inferior good in Japan, meaning that prices will depress as income increases, *ceteris paribus*.

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 4.4 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, τ = 1.057 which is significant at the 1% level. 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. As Barnett, Bessler and Thompson (1983) indicated, if all prices in an economy were perfectly flexible with the same adjustment speed in response to equal magnitudes of excess demand, the general price level would be unaffected even though relative price change. Increases in some prices would exactly offset by declines in other.

4.7.3. Overshooting and short-/long-run relationship

4.7.3.1. Bolivia

The various ω_k coefficients of (4.1) can be understood as "speeds of adjustment" (Enders, 1995; Hendry and Juselius, 2001). The magnitude of each coefficient indicates how fast the variable returns to its long-run equilibrium; also importantly, the direction of the deviation. The sign of ω_k determines the "overshooting" or "undershooting" of the dependent variable. 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 4.5 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 in 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 much 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[26]. 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

[26] Bessler (1984) using a VAR model finds that under a usual monetarist ordering of money and prices, Cairne's theory that agricultural prices adjust faster is rejected. However, under an ordering which places money last in a contemporary causal chain, evidence weakly supports Cairnes. The comparison between the results for Brazil (Bessler) and the U.S. (Barnett) indicate that developing countries that are growing faster have a more sensitive agricultural sector. Bessler hypothesizes that maybe, in Brazil, agents have learned to adjust quicker than in other countries where macroeconomic environments are more stable.

because they do not expect individuals to increase the purchase of industrial goods even when there is more money available.

Table 4.5 Overshooting coefficients for the VEC model for Bolivia

	ΔP_{ANT}	ΔP_{AT}	Δ_{PIN}	ΔP_{SE}	Δer	$\Delta M1$
ω_1	-0.45*	-0.69	0.22*	0.22	0.35**	-1.76
	(0.31)	(0.63)	(0.14)	(0.13)	(0.14)	(1.34)
	(-1.46)	(-1.09)	(1.58)	(1.70)	(2.48)	(-1.31)
ω_2	0.04	-0.14	-0.05*	0.01	-0.04	0.42
	(0.08)	(0.17)	(0.04)	(0.03)	(0.04)	(0.35)
	(0.44)	(-0.87)	(-1.37)	(0.27)	(-0.99)	(1.19)
ω_3	-0.69	1.74	-1.04**	0.07	-0.19	2.51
	(0.72)	(1.48)	(0.33)	(0.30)	(0.33)	(3.14)
	(-0.97)	(1.17)	(-3.16)	(0.24)	(-0.58)	(0.80)
ω_4	2.50**	-2.78	1.06*	-0.90*	-1.21**	-3.57
	(1.17)	(2.42)	(0.54)	(0.50)	(0.55)	(5.12)
	(2.13)	(-1.15)	(1.97)	(-1.81)	(-2.22)	(-0.70)
$\omega 5$	-0.65	1.21*	-0.11	0.17	0.30*	3.60**
	(0.39)	(0.81)	(0.18)	(0.17)	(0.18)	(1.72)
	(-1.65)	(1.49)	(-0.62)	(1.03)	(1.66)	(2.09)
R^2	0.83	0.83	0.91	0.89	0.93	0.72
F-statistic	3.36	3.19	6.74	5.62	9.06	1.74
Obs	51	51	51	51	51	51

[a)] Numbers in parenthesis are standard errors and t-statistics respectively. A ** indicates 5% confidence and * indicates 10% confidence.

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% of 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). In a related study, Mattos, Ito and Usami (2003) showed that agricultural prices in Japan return faster to their long-run equilibrium than Bolivian prices. Information requires less time and it is easly available to consumers and producers in Japan, due to its relative higher development.

4.7.3.2. Japan

The estimated coefficients for ω_i in Japan indicate that agricultural prices and the price of services ($\boldsymbol{P_{SE}}$) overshoot but P_{IN} undershoots its long-run trend, although with a very small coefficient (Table 4.1). $\boldsymbol{P_{IN}}$ 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 4.4); therefore, the short-run fall is more than compensated in the long-run, indicating that $\boldsymbol{P_{IN}}$ is below its long-run equilibrium level. In the case of $\boldsymbol{P_{ANT}}$, 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. $\boldsymbol{P_{ANT}}$ has to fall in the long-run as indicated in Table 3, but in short-run $\boldsymbol{P_{ANT}}$ will increase for a while as a momentary effect. $\boldsymbol{P_{AT}}$ has a stronger reaction in the long-run to monetary shocks but is slower to return to its long-run equilibrium level compared with $\boldsymbol{P_{ANT}}$.

Table 4.6 Overshooting coefficients for the VEC model for Japan

	ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δer	$\Delta M1$
ω_1	-0.86**	-0.16	-0.03	-0.02	-0.04	-0.16
	(0.27)	(0.37)	(0.03)	(0.02)	(0.29)	(0.15)
	(-3.17)	(-0.44)	(-1.13)	(-1.02)	(-0.15)	(-1.12)
ω_2	-0.28**	-0.27*	0.00	0.01	0.33**	0.01
	(0.12)	(0.17)	(0.01)	(0.01)	(0.13)	(0.07)
	(-2.30)	(-1.64)	(-0.05)	(0.97)	(2.59)	(0.09)
ω_3	0.34	1.93*	0.06	0.08	-1.66*	-1.94**
	(0.97)	(1.31)	(0.11)	(0.06)	(1.02)	(0.52)
	(0.35)	(1.47)	(0.59)	(1.25)	(-1.62)	(-3.76)
ω_4	-0.44	-0.99	-0.05	-0.08*	0.09	1.49**
	(0.76)	(1.03)	(0.08)	(0.05)	(0.80)	(0.40)

	ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δer	$\Delta M1$
	(-0.58)	(-0.96)	(-0.62)	(-1.57)	(0.12)	(3.69)
R^2	0.76	0.62	0.91	0.85	0.65	0.89
F-statistic	3.64	1.84	11.64	6.46	2.17	8.98
Obs	59	59	59	59	59	59

[a)] Numbers in parenthesis are standard errors and t-statistics respectively. A ** indicates 5% confidence and * indicates 10% confidence.

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.

4.7.4. Comparison between countries

The estimated coefficients for ω_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 (see Tables 4.2 and 4.1). 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 4.4); 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 4.4, 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.

4.8. Conclusions

Based on the previous discussion, we can conclude that it is possible to extend the application of the overshooting hypothesis on the agricultural sector in order to incorporate tradables (sluggish) and non-tradables (flexible) into the agricultural and non-agricultural sectors of the economy. The theoretical analysis indicates that prices in the flexible groups will overshoot their long-run trend, and that a result depends on the exchange rate reaction to money shocks. Time series theory allows us to analyze empirically the theoretical model with enough flexibility to test for money neutrality, overshooting and price flexibility. The ADF test shows that the series utilized in this paper are non-stationary and they are tested for cointegration with the Johansen's methodology, finding five and four cointegrating relationships. The existence of cointegrating terms allows us to use the Vector Error Correction (VEC) model, which is a VAR augmented by the error correction.

The money neutrality is rejected with the data analyzed in this paper. Bolivian and Japanese data indicate 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. Moreover, if we take into account the massive monetary contractions that accompanied macroeconomic shocks, it is not exaggerated to say that prices were severely affected.

The VEC model indicates that prices in Bolivia and Japan increase in the short-run (money is inflationary) and decrease towards their long-run equilibrium values. Although agricultural prices react faster in the short-run to monetary shocks, non-agricultural prices return faster to the long-run equilibrium. In all cases the data confirm the overshooting of agricultural and non-agricultural prices. In light of this, farm policy makers must recognize the inherent instability in agricultural prices caused by volatile monetary policy when formulating farm price and income programs. The impact that volatility of monetary policy has upon the relative volatility of agricultural prices is a feature of monetary policy transmission that has not been explicitly quantified, but it may well rival the importance of relationships between the conditional means of money growth and agricultural price changes. This fact was pointed first by Han, Jansen and Penson (1990).

The overshoot in the agricultural sector may force the food supply out of its long-run trend, reducing the quantity of food available to consumers in the short-run. The indirect effect of monetary shocks on the FS is ambiguous if the shock is positive. If this shock is negative, however, the FS will likely fall. This result is important for policy makers, especially in food importing developing countries. For developing countries that face future macroeconomic adjustments, which usually imply massive monetary contractions, accurate estimations of negative effects of those adjustments on the most unprotected sectors of the population are necessary for policy design.

Chapter 5

5. Evaluation of the impacts of macroeconomic policy on the food supply and non-tradable crops production

5.1. The food supply and macroeconomic policy

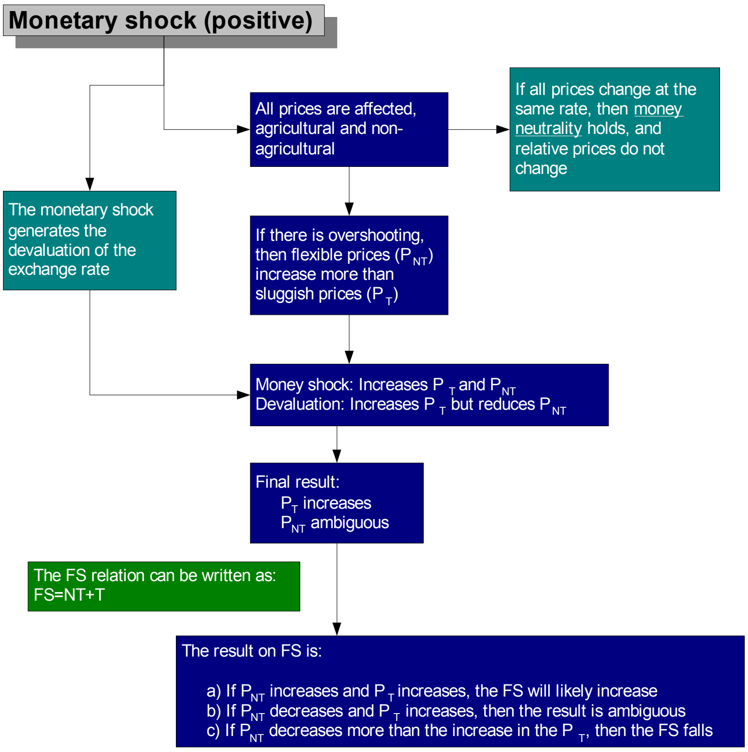

Figure 5.1 Indirect effects of monetary shocks on the food supply

The analysis of the effects of monetary policy and exchange rate devaluations on the food supply (FS) can be understood better with the help of Figure 5.1. First of all, if money is neutral, we would not expect any change on the FS. However, if real variables react to monetary shocks (either in the long-run or short-run) the food supply will be affected.

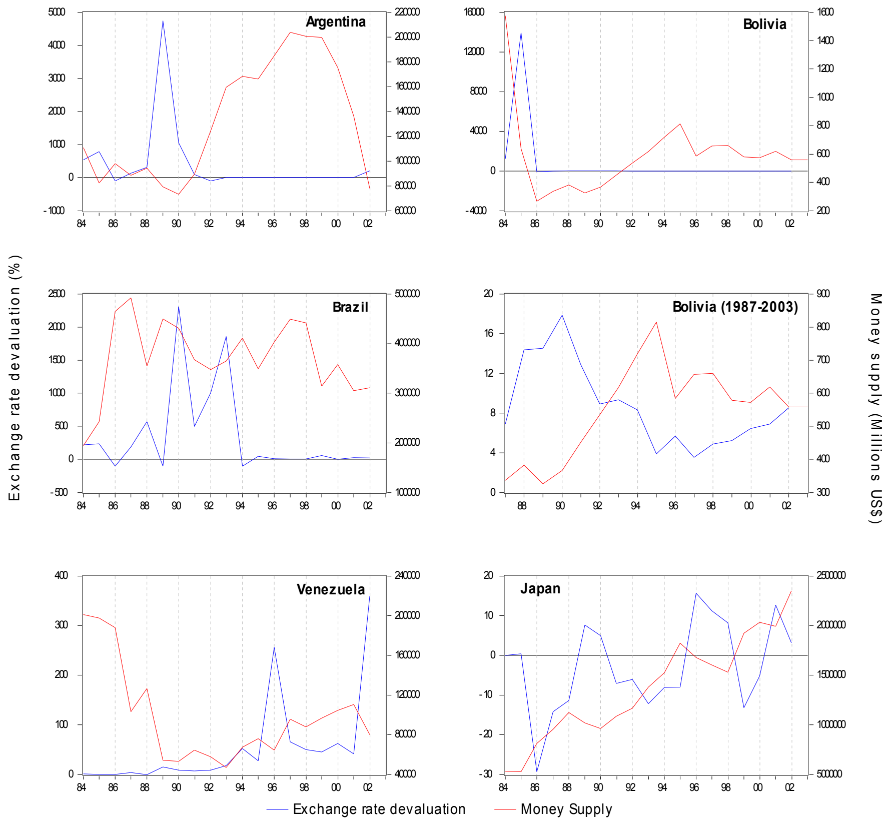

Figure 5.2 Relation between the FS and macroeconomic variables

In the previous Chapter it was assumed that the monetary shock was positive, *i.e.* an acceleration of money supply, which occurs when governments are in need to cover public deficits. The other possibility is that governments are facing unsustainable fiscal deficits and they have to cut expenses in order to reduce the deficit[27] (which is usually the situation of a developing country before starting a macroeconomic adjustment). This means that they need to reduce the amount of money in circulation, which leads to a negative monetary shock.

[27] As explained in Chapter 2, reductions of fiscal deficits are complemented with exchange rate devaluations, tax reform and liberalization in a standard macroeconomic adjustment package.

Figure 5.1 shows a flow diagram to trace the effects of a positive monetary shock on the food supply. With everything else held constant, the final effect on the FS depends on the reaction of $\boldsymbol{P_{AF}}$ (non-tradables) to the devaluation of the exchange rate. However, if the monetary shock is negative, the FS will fall inevitably because both agricultural prices $\boldsymbol{P_{ANT}}$ and $\boldsymbol{P_{AT}}$ will fall. In this process we recognize the implicit relationship between the exchange rate and the money supply.

As discussed before, exchange rate devaluations and money supply shocks are comparatively much stronger as a result of macroeconomic adjustments than in any other year. Therefore, it is illustrative to compare the effects of an average year with an "adjustment" year. The episodes of adjustment on the developing economies of the present study are concentrated in the second half of the 80's and the first half of the 90's. Of course, this phenomenon is not particular of this part of world. Macroeconomic adjustments were observed all around the world after the debt crisis of 1982, and more recently, the Asian crisis of 1998 and the Russian crisis of 1999 required similar procedures.

Figure 5.2 shows the data for the four South American countries analyzed in Chapter 3 and Japan. The graph for Bolivia has two parts, with a particular graph for the period 1987-2003 showed below the general one. As a rule of thumb, it is possible to identify the adjustment period by the peaks of the series. The case of Bolivia is dramatically clear, until 1985, both the exchange rate and the M1 growth increased very fast, but with the structural adjustment it plummeted to very low levels. The data for Argentina shows only one episode similar to the Bolivian case. However, a detailed analysis of the years from 1989 through 2003 shows at least another three situations where the government was forced to adopt a strict macroeconomic policy. Table 5.1 shows the magnitude of the adjustment for the variables of interest. The figures for Brazil are similar to the one for Argentina. The first adjustment for Brazil was the mildest of the series, happening at the beginning of 1988, the second and biggest started on 1990 and triggered the adjustment of 1993. At the end of the 90's Brazil experienced another macroeconomic crisis that started in 1996 and ended in 1999. Venezuela had a fairly stable macroeconomic environment until the beginning of 1993 when things started to deteriorate and a spiral of devaluations signaled the end of the stable years. An adjustment was implemented in 1996 that devaluated the currency by 255% and stabilized the economy. However, recently it has started to devaluate again, which suggest another adjustment package will have to be designed in the near future.

On the other hand, the situation of Japan shows an enviable macroeconomic stability through the series. Of course, the relatively "free" exchange rate is not as intervened as in developed countries. Exchange rate devaluations happen mostly because some fundamental variables of the economy have also changed or if the government intervenes the market through monetary policy. The Japanese series shows in average an appreciation process, with some devaluation outbreaks, for example in 1988-89 and in 1996-98, but in general the Yen has been appreciating. Compared with our four South American countries, Table 5.1 shows that the devaluations in Japan are much smaller than the ones experimented in South America.

Table 5.1 Exchange rate devaluations and money supply events for the period 83-2002

	Argentina	Bolivia	Brazil	Venezuela	Japan
ER devaluation maximum	789.6 (1985) 1,051.7 (1990)	13,931.4 (1985)	235.51 (1985) 568.21 (1988) 1,859.86 (1993)	359.82 (2002)	15.65 (1996)
ER devaluation average for the stable period	0.10	8.64	22.24	34.88	-2.75

	Argentina	Bolivia	Brazil	Venezuela	Japan
ER devaluation for the whole series	393.10	779.33	364.44	51.15	-2.75
Money supply at the top of the crisis	204,038.91	1,576.00	492,177.87	270,449.20	2,351,062.53
Money supply average for the stable period	177,321.26	548.99	366,462.17	108,827.73	1,328,051.12
Maximum jump M1 growth (years)	90-94	90-95	84-87	96-2001	90-95
Maximum jump M1 growth (%)	129.4436	149.82	102.8991	70.80	89.26
Maximum drop M1 growth (years)	97-2002	84-86	97-99	85-91	95-98
Maximum drop M1 growth	61.67	83.06	30.08	73.02	16.04
Average M1 growth	0.726	-0.357	2.460	-1.159	8.803

By observing Table 5.1 it is possible to have a better idea of the magnitude of the macroeconomic adjustment that was necessary to correct fundamental variables on our four developing countries. The maximum devaluation in Japan (for the series presented) was 15.65, but for Argentina, Bolivia and Brazil we have more than one thousand percent devaluation in one year, which indicates the severity of the macroeconomic imbalance. The same figure is present for the M1 and M1 growth. From one year to the next or short periods of time, money supply in our developing countries decreased (negative monetary shock) by more than 100% in comparison with Japan which has only a 16.04% drop for the years from 1995 through 1998.

As we showed in the preceding Chapters, these significative macroeconomic shocks had an enormous impact on the food supply and agricultural variables. In the following sections, we will offer some basic calculation where we will use the coefficients and information gathered previously.

5.2. Quantification and analysis of static effects

Now we turn to some simple calculations based on the results of Chapter 3 and 4. We will use the results from Table 5.2, especially the average shock for the period of analysis, the average for the stable years and the one percent shock. Both kinds of shocks, direct and indirect will be addressed.

5.2.1. Monetary shocks impacts for Japan and Bolivia

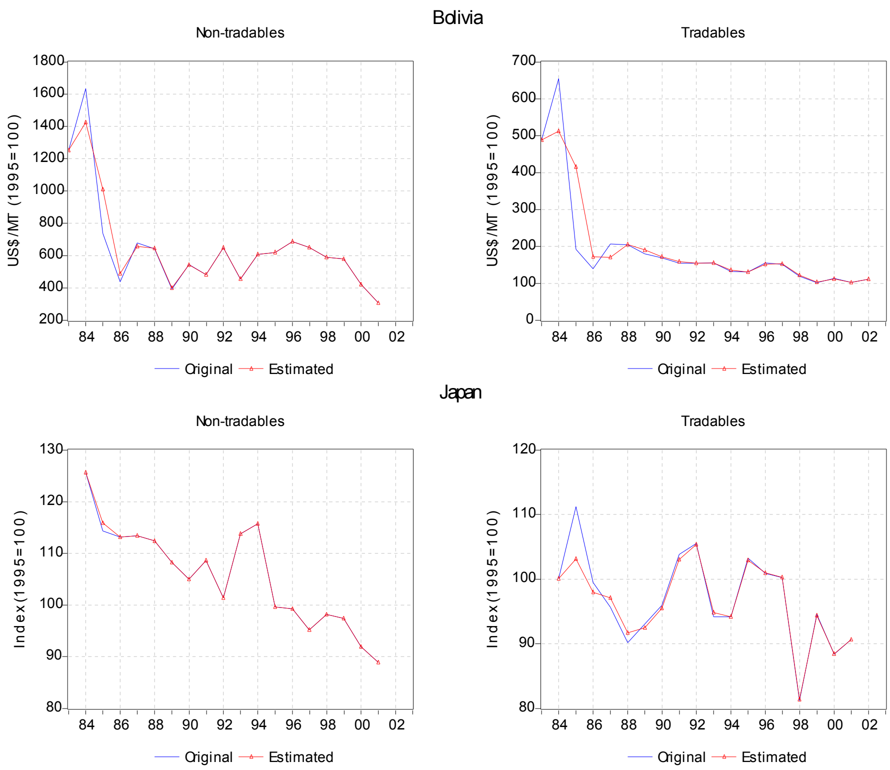

Figure 5.3 Overshooting effects on Bolivian and Japanese agricultural prices

First we describe monetary shocks (as percentage growth of the money supply) of

Table 5.3 on agricultural prices, everything else held constant. The exercise is pretty similar to the "impulse-response" analysis described in the literature (Enders, 1995). We use the original series for agricultural price (tradables and non-tradables) and then we apply the overshooting parameter calculated on Chapter 4. In this way, we are assuming that the shock occurs in the first year, and then it diminishes over time. The speed of the adjustment is then determined by the overshooting parameter. As explained before, a negative sign of the overshooting parameter indicates that prices increase in the short run, which means that they have to fall in the future.

Table 5.2 Estimations of changes on agricultural prices as a result of a monetary shock

	Bolivia				Japan			
	Agr. NT		Agr. Tradables		Agr. NT		Agr. Tradables	
	Original	Estimated	Original	Estimated	Original	Estimated	Original	Estimated
Average for the series	560.39	552.54	551.47	553.41	105.59	105.45	97.08	96.67
Average for the first 4 Quarters	633.04	604.89	692.84	700.43	115.39	115.6	106.31	104.86
%	12.96%	9.47%	25.63%	26.57%	9.28%	9.63%	9.50%	8.48%
Max difference (positive)	13.75		58.5		1.64		1.4	
Max difference (negative)	-72.29		-49.2		-0.52		-3.22	

In the short run, prices will be affected by monetary shocks if they are flexible. Results from Chapter 4 indicate that for the agricultural sector, non-tradables are more flexible than tradables. By using the overshooting coefficients of Chapter 4, the paths of overshooting and misalignment in the short-run are showed in Figure 5.3. It is possible to observe that agricultural non-tradable prices return faster to their long-run equilibrium, everything else held constant. This result is true both for Japan and Bolivia. As Table 5.2 shows, the overshooting of prices in the short-run increased non-tradable's prices by 12.96% in the first years for Bolivia, and 9.28% for Japan. The figure is similar for tradables which increased 25.63% for Bolivia and 9.5% for

Japan. The difference between the estimated prices and the observed series is small but highlights the importance of taking into account the base year for the analysis. In contrast the difference in the averages for the whole series for the original data and the estimated series are comparatively smaller[28]. We can indicate that the differences between the averages represent the level of long-run misalignment. In this way, tradables for Bolivia and non-tradables for Japan seem to have departed further from the long-run equilibrium compared with the other two variables, everything else held constant.

On the other hand, long-run departures from the equilibrium level are described by the cointegrating equation. Table 5.3 shows the set of equations for the cointegrating terms for agricultural prices.

Table 5.3 Long-run cointegrating equations for agricultural prices

	Agricultural non-tradables	Agricultural tradables
Bolivia	PANTt-1 = 2.402 +0.018t +0.229mt-1	PATt-1 = -0.550 -0.021t +0.762mt-1
Japan	PANTt-1 = 7.412 +0.120ert-1 -0.642mt-1	PATt-1 = 2.372 -0.806ert-1+1.057mt-1

Relations in Table 5.3 are telling us that for Bolivia and Japan, an increase in the money supply will be reflected immediately in the price level. These coefficients will be used later when we calculate the effects of price changes on quantities of agricultural products.

5.2.2. Exchange rate effects on agricultural production

For this section we will mainly use the coefficients from Chapter 3 and we will further illustrate the relationship between the exchange rate, money supply and

[28] It is important to note that prices in the case of Bolivia are simple averages of the items of each group but Japanese prices are indexes calculated by the Ministry of Agriculture Forestry and Fisheries.

agricultural variables for the Bolivian case. We will analyze the changes in the quantities of agricultural tradables and non-tradables when there is a currency devaluation (revaluation). Table 5.4 shows the results based on the coefficients of Chapter 3.

Table 5.4 Exchange rate effects on agricultural variables in South America

	Argentina	Bolivia	Brazil	Venezuela
Non-transables				
Exchange rate coefficient	-0.02	-0.63	-0.04	0.25
Average NT production	29,018.17	3,055.95	81,216.79	10,403.77
1% devaluation	-596.09	-1,936.69	-3,522.86	2,613.68
Average for the whole series	-2,343.23	2,710.81	-12,838.71	1,336.90
Average for the stable period	-0.60	-167.33	-783.48	911.65
Food supply				
Exchange rate coefficient	-0.01	-0.11	-0.04	0.05
Average FS	421.38	404.76	404.46	355.27
1% devaluation	-5.61	-44.29	-17.78	16.28
Average for the whole series	-22.05	342.77	-64.80	8.33
Average for the stable period	-0.01	-3.83	-3.95	5.68
Exports				
Exchange rate coefficient	0.49	3.77	0.19	0.63
Average Exports production	22,316.09	244.83	21,847.93	262.47
1% devaluation	10,941.56	921.92	4,213.42	165.20
Average for the whole series	43,011.26	1,290.42	15,355.38	84.50
Average for the stable period	10.94	79.65	937.06	57.62

From Table 5.4 it is possible to see that although small coefficients indicate low response from endogenous variables to exchange rate devaluations, actual quantities are important, especially for the food supply. In Table 5.4, the row "Average for the period" is the exchange rate devaluation from 1983 through 2002 and the row "Average for the stable period" is the average of the exchange rate after the macroeconomic adjustments of the 80s[29].

As showed before, the Bolivian hyperinflation of the 80s was the highest of our four

[29] Second and third line of Table 5.1 respectively.

South American countries. Therefore, the highest values for tradables, food supply and exportables are for Bolivia. However, the other countries also show important values, especially for the food supply. In any other year, a devaluation as small as 1% per year will decrease the food supply in Argentina by 5.61 Kg/person, in Venezuela and Brazil the figure is around 16 Kg/person/year. These values highlight the importance of taking into account the effects of exchange rate devaluations, maybe not for the urban settlements but for rural areas where 16 Kg. less of food can make the difference. In this point it is interesting to note that (as mentioned in other research efforts) the poorest section of the the population spends more on food than the richest group, therefore they will perceive a stronger shock than other sections of the population.

Table 1.4 also shows that exports can grow from one year to the next by 100% if we use the average for the stable period and much more if we use the average for the whole series. This fact has a recent example in the case of Argentina who saw its currency depreciate from a pegged one to one to the US dollar to more than 3.2 per dollar in just four months. In no more than two months exports, and particularly agricultural exports, started to grow faster than the rest of the economy (which was in recession) becoming the engine that has rescued Argentina from its worst economic crisis.

Finally we want to show the relationship between monetary policy, exchange rate depreciation and agricultural variables. As illustrated in Figure 5.4 there are several mechanisms from where macroeconomic shocks affect agricultural variables. The diagram in Figure 5.4 complements the idea that monetary shocks have two ways of affecting agricultural production. The first one is through the exchange rate, which in turn determines the relative competitiveness of each group. The second channel is through the direct effect that money shocks have on relative prices if money neutrality does not hold in the short-run (or even in the long-run).

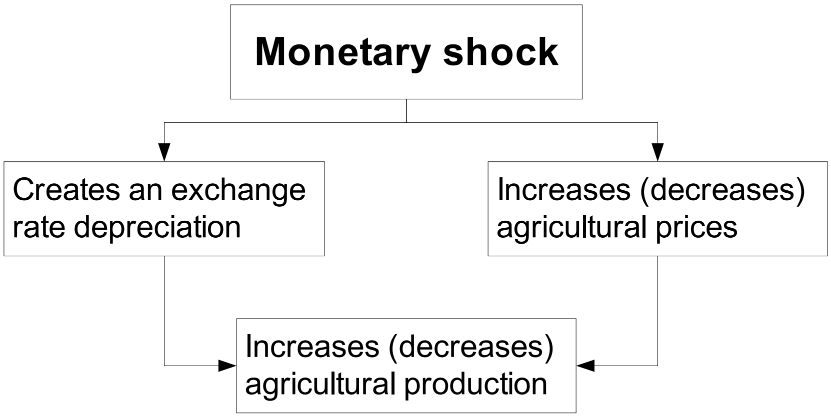

Figure 5.4 Direct and indirect effects of monetary shocks on agricultural production

Of course it is difficult to know which effect happens first and which one is stronger. In most of the cases the individual perception of the shock will play a major role in the production decision process of each farmer. As an exercise we use the Bolivian coefficients for both money shocks and exchange rate effects. From Chapter 4 we know that a one percent devaluation of the exchange rate will depreciate the currency by 0.160 percent. But the the maximum increase in money growth for the period of analysis is 149.82% which might have appreciated the exchange rate by 39.97% which in turn might have influenced the food supply to fall by 15,31%, which represents 61.99 Kg./person/year. The production of non-tradables may decrease by 294,200 MT, 88.71%. At the same time, this depreciation might have increased exports by more than 500%.

On the other hand the direct effect of monetary shocks is reflected in the long-run cointegrating coefficient of Table 5.3. Using the same assumptions as in the previous cases, we utilize the average increase in the money supply as the primary shock. If the money supply increases by 149.82% prices in the agricultural sector will increase in 57.21% and 190.36% in the non-tradable and tradable sectors respectively. This increase in prices is translated into production decisions, exportables might increase by 171.89% (to 665.68 thousand MT from the average 224.83 thousand MT) and non-tradables might increase by 11.05%. Although the decrease in the production of non-tradables seems to be marginal, it is comparable to the increase in the production of exportables if we compare quantities instead of marginal changes.

The static comparison indicates that the production of non-tradables might increase lightly if we take into account the exchange rate and monetary effects for a positive monetary shock. In the case of a negative monetary shock, the result is unambiguously negative. However, these results rely heavily on the assumptions of the econometric estimations and the *ceteribus paribus* approach.

5.3. Partial Conclusions

The food supply will decrease as a result of a monetary shock unambiguously if P_{ANT} decreases, because monetary shocks also originate an exchange rate devaluation. The overshooting analysis is an application of the "impulse-response" methodology which illustrates the relative flexibility of agricultural non-tradable prices both for Japan and Bolivia.

The quantitative estimation of these effects indicates that the food supply will fall, but marginally (in average), less than 2% for the series of this study when we use the average money supply growth for the period. The quantitative assessment indicates that exportables increase by more than 170% through the direct effect of monetary shocks and by more than 500% if we consider the exchange rate effect. As it was shown in Chapter 3, producers of these crops are more likely to lose with this kind of macroeconomic policy.

Chapter 6

6. Policy implications

Until now, we have analyzed in detail the effects of exchange rate and monetary shocks on the agriculture for several countries. Those results, although empirical, have to be useful for a working project or policy. This chapter illustrates the usefulness of our previous results, and highlights the importance of having reliable data for key variables that are used daily for policy design. To simplify the discussion, we have chosen Bolivia for this case study.

The main findings of the previous Chapters are:

- The food supply will fall in the event of an exchange rate devaluation. This is the result of the reaction of agricultural non-tradable crops to exchange rate devaluations.
- Prices of agricultural non-tradables overshoot their long-run trend after a monetary shock. Therefore, if producers of non-tradable crops perceive that increase as a permanent increase, they will face harsh decreases soon after.
- In both cases, exchange rate devaluations and monetary shocks, distributive effects benefit producers of tradable crops and work against producers of non-tradable crops.

The basic assumptions behind the recommendations for agricultural policy are that:

- Exchange rate devaluations will continue at the average rate.
- Fiscal deficits and exogenous variables will force developing countries to adjust their macro economy, like a cycle.
- Producers of non-tradable crops are small farmers of the highlands (on average) and producers of tradable crops are industries, corporations and big farmers of the lowlands (on average).

Based on the previous assumptions, it is obvious that the continuing devaluations will depress non-tradables and boost the competitiveness of the tradable sector. Under this scenario, it is important to analyze the role of rural development programs (RDPs) and the orientation that they should have in a modern world of open economies and macroeconomic instability.

6.1. A pro-trade rural development program (RDP)

During the years of "inward industrialization" (1960-1985), RDPs were basically small projects, funded by international donors and concentrated on research and extension. The majority of the research was focused on "potential products" with little or no feedback from producers, especially small farmers. For example, many resources were invested on studies of the agronomic characteristics of quinoa production. Quinoa is not an extensive crop, neither a "cash" crop nor a potential exportable product. Besides that, only a small percentage of that research reached the actual producers and most of the knowledge was lost. The same happened with other products, both in the lowlands and in the highlands of Bolivia. After the macroeconomic adjustments of 1985, the strategy was different. The government left all research efforts to the private sector and concentrated on "rural development programs" or "integral rural development". This consisted in bringing to the rural areas not only agricultural knowledge but also education, health programs, credit, productive infrastructure and institutional support. The idea was to "keep farmers in the agricultural production" and in this way increase agricultural output and reduce the rural-urban migration (The World Bank, 1998a).

As pointed out in Chapters 3 and 4, macroeconomic stability requires a competitive exchange rate, an open trade policy and a tight fiscal policy. Under this scenario, the production of non-tradables faces a gloomy future. Encouraging the production of non-tradables would only lead to oversupply and therefore, declining prices.

A more favorable RDP would focus on facilitating a market solution and helping small farmers to move out of the agricultural sector or to continue there but focus on the production of tradable crops. Schuh (2000) indicated that policy makers should take into account the fact that small farmers (the less competitive ones) will have to leave the agricultural sector anyway, that this is a historical fact, and fighting that reality is just delaying a normal process in the development of a country.

Figure 1.1 shows schematically the proposed RDP for the highlands. Most of the farmers in this area are small farmers, producers of non-tradables (UDAPE, 2002). The strategy is based on our previous findings. Because non-tradables crops are not a promising sector, it seems logical to try to move towards tradable crops. Putting aside, for the moment, agro-ecological considerations, it is possible to say that the market will regulate prices and quantities of non-tradables, and that in an unregulated market, supply and demand forces will determine prices and quantities. If production of non-tradables is reduced by enticing producers of non-tradable crops to change to tradable crops, then prices in the non-tradable sector will likely increase. This will influence the trade balance and the RXR in the short-run, of course, but it will also improve the income of the "still" producers of non-tradables.

With more production of tradables, the food supply (FS) will increase more than proportionately, as demonstrated before.

In the long-run the exchange rate will continue to depreciate (helped by monetary expansion). In that case there will be plenty of room for producers of non-tradables to move to the production of tradable crops. Also, in the long-run arable land is not a restriction anymore and expansion in the lowlands is possible.

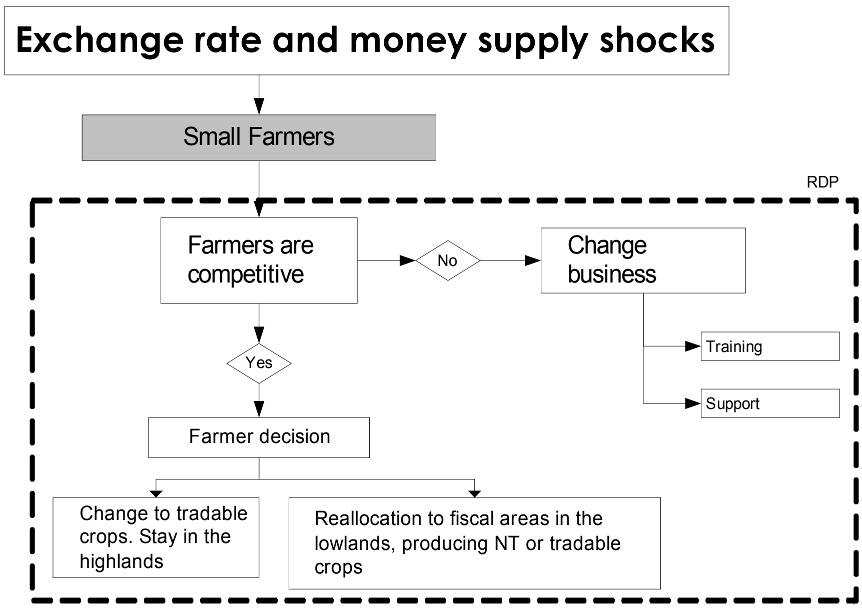

Figure 6.1 Strategy for a pro-trade rural development program for small farmers

6.2. Components of the pro-trade rural development program (RDP)

The two principal components of the pro-trade RDP are a new policy for agricultural land and a re-organization of the support system for small and large farmers. Although these two principal components can be characterized as "projects for new legislation", the scope of this study is just to outline the principal items of those components. Later, in other studies, details of each component can be structured in order to make them operational. For example, it is necessary to investigate the geographical areas to be intervened, the price levels that will equal the marginal value of the land, operational costs, sources of financial resources and contents of the support programs.

6.2.1. Land tenure system

Considering that the agricultural land in the highlands is highly fractioned, one of the principal objectives of a land tenure system for this region would be the concentration of land into "economically manageable units". It would be necessary to determine the minimum size (in average) so that a farm can be competitive in the market (tradables or non-tradables). The scheme would work after the following logic:

- The government creates the "Land Bank" (LB). The LB will buy agricultural land in sensible areas, including those that are classified as ecologically fragile. Because one of the aims of the program is to increase the size of the productive unit in the highlands, the LB would devote most of its energies to the highlands. The LB will work closely with the Agricultural Superintendence, which regulates the private property, rights and taxation of agricultural land.
- The sellers are offered two options. They can "exchange" their land in the highlands for land of equivalent size and value in the lowlands, or just get money. If they choose to sell, they will be also offered a complete support package that includes agricultural training, health and education facilities and access to commercial credit.
- Buyers of land in the highlands are offered only land in areas that are not classified as ecological fragile and only the productive unit of the pre-determined "minimum economical size". They are offered support to engage in the production of tradable crops and access to commercial credit lines.

- Producers that move to the lowlands can produce tradables or non-tradables according to their choice and they are offered support and credit lines.

Because the highlands are in disadvantage with the lowlands, there will be fewer buyers than sellers, leaving the LB with a surplus of land that can be converted into protected areas or national parks. The main result is less agriculture in the highlands, less farmers and less pressure on the ecosystem. The farmers that remain are those that feel that they can still make money in the agricultural business. There are various identifiable benefits for the society besides those already mentioned.

First, the private property over the land will be clarified, helping the process initiated in 1994 with the new Land Law in Bolivia and reducing the current pressure over the Agricultural Superintendence. Second, a pseudo-retirement program for farmers would be working. Those farmers that feel that the agricultural business is too much for them or feel like they just want to move on, will have an opportunity even if there is no private buyer for their land. Third, the migration to the lowlands would be more controlled than it is at the present.

6.2.2. Support system for the agricultural sector

The main objective of this program would be facilitating the change towards the production of tradable crops, both in the lowlands and in the highlands. In fact, most of the proposed components of this support system are presently working, albeit in different agencies and without a central coordinating body. The principal issues that the system will have to solve are:

- Coordinate the research efforts among the institutions that are, at present, in charge of agricultural and livestock research, and with other related institutions, like universities and non-governmental institutions.

- Coordinate and standardize procedures with the financial institutions and commercial banks that provide resources to farmers. This is especially important with farmers that produce tradable crops for foreign markets.
- Develop or help to develop specific productive infrastructure projects for specific regions that cannot fund the design and bureaucratic process of these kinds of projects. This issue is more related to the lack of coordination between the different public institutions that provide loans to local governments and the direct beneficiaries.
- Facilitate the creation of a mechanism of interaction between small farmers and private companies that offer extension, training and investigation.

6.3. Measurable indicators

The pro-trade RDP should have several measurable indicators that are directly and indirectly linked with the principal objective of "increasing the net income of the rural productive unit". Besides the direct benefits, we can identify indirect benefits that are harder to measure but still important when considering the global impact of this new approach.

- Number of families that have moved to the lowlands. This also indicates, indirectly, the number of families (productive units) still living in the highlands.
- Average area under production in the highlands. This indicator will show whether the average area has grown as expected, compared with the baseline.
- Average income of the rural production unit. This indicator should include the production units that continue their agricultural activities in the highlands, those that have moved to the lowlands, and those that have decided to change

business.

- Volume and value of exports from the highlands and new production units in the lowlands compared with the baseline.
- Level of the food supply and share of non-tradables in total production.

Chapter 7

7. Final conclusions

The present study analyzed the influence of macroeconomic adjustments on the agricultural sector by using the exchange rate and money supply in four South American countries and Japan. Two chapters discussed each macroeconomic policy tool and another chapter discussed a Rural Development Program (RDP) that includes the empirical findings. The evidence that RDPs were not tuned with the accompanying trade liberalization was overwhelming. Our results also highlight the differences between previous studies that have not included non-tradables in their analyzes.

Chapter 3 dealt with the exchange rate and its effect on agricultural production and the food supply. We developed a theoretical model that extended previous studies in various ways. First, we included non-tradables for the agricultural and non-agricultural sectors. The theoretical results indicate that an exchange rate devaluation would depress the price of non-tradables in the devaluating country and increase it in the foreign country. To test these results we constructed an econometrical model based in the Seemingly Unrelated Regression (SUR) procedure for Argentina, Bolivia, Brazil and Venezuela. The econometrical model assumed that the agricultural sector was small, compared with the rest of the economy, but its behavior affected the general macroeconomic equilibrium. The coefficients for the econometric system supported our theoretical results; that is, exchange rate devaluations depress non-tradables production and boost tradables production if non-tradables are inferior goods. This result has a direct effect on the food supply. The food supply falls in the short-run for three of four countries (Argentina, Bolivia and Venezuela), with the sharpest fall in Bolivia (0.11% per each 1% devaluation). The exchange rate coefficients for the food supply for Bolivia and Venezuela are bigger than for Argentina and Brazil. This indicates that as the tradable sector increases in importance, in the agricultural sector the food supply is less affected by exchange rate shocks.

Cross-elasticities between non-agricultural production and international prices indicate that there was a significant crowding-out between these two sectors. If international prices of commodities increase by 10%, production of non-tradables in Argentina, Bolivia and Venezuela will decrease by 0.2%, 6.3% and 1% respectively. These results indicate to us the high mobility of resources between these two sectors. If everything is held constant, the immediate effect of an increase in international prices could be a net fall on the food supply.

Complementarily, Chapter 4 presented a model with non-tradables that analyzed the effects of monetary shocks on agricultural prices by using Bolivian and Japanese data. Monetary shocks are not only important for their direct impact on the agricultural sector, but also because they create the necessary conditions for exchange rate devaluation. Thus, monetary shocks have direct and indirect effects on agricultural prices which, in turn, create an indirect effect on agricultural output and income. Results of the theoretical model indicate that monetary shocks create an overshooting of agricultural prices. Agricultural prices for both tradables and non-tradables over-react in the short run, increasing more than expected (under the assumption that tradable prices are fixed and non-tradable crops' prices are flexible). The basic assumptions are that prices have differences in their speed of reaction to shocks and that money is neutral in the long-run. The overshooting of agricultural prices in the theoretical model depends on the reaction of the exchange rate to monetary shocks. If the exchange rate overshoots, agricultural prices overshoot the most, but they still overshoot if exchange rates and non-agricultural prices undershoot.

To test these theoretical findings we developed an econometrical model based on time-series theory and co-integration. This approach has not been fully applied to the agricultural sector, although the coefficients that the model offers to the researcher are highly important. Traditional models impose restrictions on the coefficients, which can mislead the interpretation of the results. Our empirical results confirm the assumptions made in the theoretical analysis; non-tradables are more flexible than tradables (non-tradables prices are our proxy for flexible prices and tradable prices are our proxy for sticky prices). This result is consistent for Bolivia and Japan. However, agricultural prices in Bolivia need more time to return to their long-run equilibrium than non-agricultural prices, a phenomenon which runs contrary to the standard assumption in the economic literature. If farmers do not fully interpret the monetary shock as temporal, producers of non-tradables will bear most of the costs of the adjustment process. The relative development of the country also affects the results. As tradables increase their share on total production/consumption, goods tend to become homogeneous, reducing the overshooting effect of monetary shocks. The results for Japan confirm that their tradable sector (both agricultural and non-agricultural) is more important than the non-tradable sector.

Both exchange rate devaluations and monetary shocks have negative effects for non-tradables and clearly benefit producers of tradable crops. A simulated monetary shock using our previous results shows that Bolivian agricultural non-tradables prices will increase by 12.96% in the first four quarters and Japanese agricultural non-tradables prices will increase by 9.28%, on average. Although the general effect of both policies could be good for the overall economy (tradable prices also increase as a result of a monetary shock), it hides redistribution processes inside the agricultural sector. Total production and, more importantly, food production show that the general effect of macroeconomic adjustments were beneficial for the agricultural sector. Again, using our results from Chapter 3 and adjusting the indirect effect of monetary policy on the exchange rate for Bolivia we calculated the quantitative effects of exchange rate devaluations for our four South American countries. The simulation results indicate that a one percent exchange rate devaluation will reduce the food supply by 5.6 Kgs/person/year in Argentina but by 44.2% and 17.7% in Bolivia and Brazil respectively. These results show the importance of our empirical findings for policy makers. In short, policy makers should take into account that producers of non-tradables are the net losers of the processes. Even worse, non-tradable producers are usually small farmers that do not have other sources of income and rely heavily on their agricultural output.

Policy makers, funding institutions and researchers, acknowledge this negative impact on small farmers. To compensate small farmers (producers of non-tradables), they have proposed and executed several Rural Development Programs (RDPs). However, the heavy focus of these projects on the production of non-tradables only depresses non-tradables prices and deteriorates even more the livelihood of small farmers. The basic reasons for this were discussed in Chapters 3 and 4. The macroeconomic outlook for developing countries, Bolivia in particular, indicates that exchange rate devaluations and tight monetary policies will continue in the foreseeable future. Therefore, it is advisable to “move with the current” as proposed by Schuh (2000), Díaz-Bonilla and Reca (2000) and Abbot (1999).

Our proposal for a pro-trade RDP is aimed at concentrating the scarce resources on the production of tradables and helping small farmers to move out of the agricultural business or to move to other areas where they can be competitive. A new and aggressive land tenure system has to be introduced with the adequate support from official and private sectors.

Developing countries have many resources that have not been exploited so far. Tradition, lack of planning, and information had concentrated agricultural production units in specific areas. Our econometrical and theoretical analyzes offer solid results that indicate that the chances of competing in this new "open world" for small farmers are gloomy. Only moving towards tradable crops will help to improve the living conditions of this region, and at the same time to ensure an adequate level of domestic production of food supply.

Nevertheless, results of this study indicate that macroeconomic policies, especially exchange rate and monetary policies are very important for the agricultural sector and for the food supply. Even though 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 monetary shocks and exchange rate devaluations. 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.

8. References

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Annex 1

9. Annex 1: Effects of exchange rate devaluations in a traditional model

9.1. One commodity model

The following theoretical model is based on Dornbusch (1973), Douglas and Purvis (1985) and Derevajan, Lewis and Robinson (1993). The principal outcome of the model is that exchange rate devaluations depress non-tradables prices and that is a pre-requisite for the creation of a trade surplus. The first part of the model describes the devaluation effect when there is only one good and the second part introduces non-tradables.

We start with the definition of the demand for nominal balances,

$$L = kP\bar{y} \text{ and } L^* = k^* P^* \bar{y}^* \qquad \textbf{Eq. 9.1}$$

where ***k***, ***k**** are the desired proportions of money to income, $\bar{y}, \bar{y}^*$ are the real outputs and ***P***,***P**** is the price level. Asterisks denote the foreign country. If the country's exchange rate is ***e***, then we can define the domestic price in terms of the foreign price,

$$P = P^* \cdot e$$ **Eq. 9.2**

The money supply is defined as in (9.3) where we are assuming that initially the money supply is fixed and the government only changes it to keep the exchange rate fixed. Therefore, the money supply is a function of the trade balance surplus,

$$\dot{M} = B = -e \cdot \dot{M}^*$$ **Eq. 9.3**

Where a dot over the variable indicates change in time. The desired nominal expenditure in each country Z, Z^* is defined as the money income minus the flow of money H, H^*, which is the quantity of money that individuals want to keep in their pockets. ***H (H*)*** is assumed to be proportional to the stock excess demand.

$$Z = P\bar{y} - H \text{ , } Z^* = P^*\bar{y}^* - H^*$$ **Eq. 9.4**

$$H = \pi(L - M) = H(P, M)$$
$$H^* = \pi^*(L^* - M^*) = H^*(P^*, M^*)$$ **Eq. 9.5**

Where in (9.4) and (9.14) π and π* represent the rates of adjustment in the domestic and foreign country respectively. Also, the expenditure functions in (9.4) indicate that in the short-run the marginal propensity to spend out of income is smaller than unity, while in the long run it equals unity, after we reach monetary equilibrium.

The short run effects of a exchange rate devaluation on the domestic country start with the equilibrium between the price levels. Differentiating Eq. 9.2 we have,

$$dP = e \cdot dP^* + P^* \cdot de$$

$$\frac{dP}{P} = \frac{e \cdot dP^*}{P} + \frac{P^* \cdot de}{P}$$

$$\frac{dP}{P} = \frac{e \cdot dP^*}{P^* \cdot e} + \frac{P^* \cdot de}{P^* \cdot e}$$

$$\hat{P} = \hat{P}^* + \hat{e} \qquad \textbf{Eq. 9.6}$$

Because hoarding in the domestic and foreign country are linked, the devaluation has to affect both price levels in an amount big enough to encourage hoarding in the domestic country and dis-hoarding in the foreign country. Formally, the equilibrium condition in the goods market is:

$$\pi\left(kP\bar{y} - M\right) + e \cdot \pi^* \left(k^* \frac{P^* \bar{y}^*}{e} - M^*\right) \qquad \textbf{Eq. 9.7}$$

where we have used the equilibrium in the market ***H=-H*e*** and Eq. 9.2. In the equilibrium ***L*** (the money supply) equals ***M*** (the money demand). Totally differentiating (9.7) we have,

$$\pi kP\bar{y} - \pi M + \pi^* k^* P\bar{y}^* - e\pi^* M^*$$

$$\pi kP\bar{y} + \pi^* k^* P\bar{y}^* = e\pi^* M^* + \pi M$$

$$P(\pi k\bar{y} + \pi^* k^* \bar{y}^*) = e\pi^* M^* + \pi M$$

$$P = \frac{e\pi^* M^* + \pi M}{\pi k\bar{y} + \pi^* k^* \bar{y}^*}$$

$$dP = \frac{\pi^* M^*}{\pi k\bar{y} + \pi^* k^* \bar{y}^*} de$$

$$\hat{P} = \frac{\pi^* M^* e}{P\pi k\bar{y} + P\pi^* k^* \bar{y}^*} \hat{e}$$

$$\hat{P} = \frac{\pi^* M^* e}{\pi M + \pi^* M^* e} \hat{e} \qquad \textbf{Eq. 9.8}$$

where we have used equations (9.27) and (9.2). Now we define the world supply of money ($\overline{M}$) in terms of the domestic currency as:

$$\overline{M} = M + eM^* \qquad \textbf{Eq. 9.9}$$

If we define the domestic share on the world money supply as σ and the foreign share as σ* we can rewrite (9.8) as[30],

$$\hat{P} = \frac{\frac{\pi^* M^* e}{\overline{M}}}{\frac{\pi M}{\overline{M}} + \frac{\pi^* M^* e}{\overline{M}}}\hat{e}$$

$$\hat{P} = \frac{\pi^* \sigma^*}{\pi\sigma + \pi^* \sigma^*}\hat{e} \qquad \textbf{Eq. 9.10}$$

Replacing (9.9) in () we have the same result for the foreign price level:

$$\frac{\pi^* \sigma^*}{\pi\sigma + \pi^* \sigma^*}\hat{e} = \hat{P}^* + \hat{e}$$

$$\hat{P}^* = \frac{\pi^* \sigma^*}{\pi\sigma + \pi^* \sigma^*}\hat{e} - \hat{e}$$

$$\hat{P}^* = \frac{\pi^* \sigma^* \hat{e} - \hat{e}\left(\pi\sigma + \pi^* \sigma^*\right)}{\pi\sigma + \pi^* \sigma^*}$$

$$\hat{P}^* = \frac{-\pi\sigma}{\pi\sigma + \pi^* \sigma^*}\hat{e} \qquad \textbf{Eq. 9.11}$$

Equations (9.10) and (9.11) are indicating us the direction of movement of the price level after a exchange rate devaluation. The direction is negative for the foreign country and positive for the domestic country. The magnitude of the effect depends

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[30] That means $\sigma = \frac{M}{\overline{M}}$ and $\sigma^* = \frac{M^* e}{\overline{M}}$

on the relative weight of each country. It is important no note that in the case of a small country, the domestic country price level raises the same amount of the devaluation, formally from (9.10) we have,

$$\hat{P} = \frac{\pi^*\sigma^*}{\pi\sigma + \pi^*\sigma^*}\hat{e} \cdot \frac{\pi^*\sigma^*}{\pi^*\sigma^*}$$

$$\hat{P} = \frac{\frac{\pi^*\sigma^*}{\pi^*\sigma^*}}{\frac{\pi\sigma}{\pi^*\sigma^*} + \frac{\pi^*\sigma^*}{\pi^*\sigma^*}}\hat{e}$$

$$\hat{P} = \frac{1}{0+1}\hat{e}$$

$$\hat{P} = \hat{e} \qquad \textbf{Eq. 9.12}$$

where we have used the fact that the share of a small country on the world supply of money is zero in the limit ($\pi\sigma / \pi^*\sigma^* = 0$). In other words, in a small country, the devaluation of the exchange rate is fully transmitted to the price level in the short-run.

The trade balance surplus can be obtained from (9.5); differentiating the flow demand function of money with respect to the price level and replacing () we have,

$$dB = dH = k\pi P\bar{y} \cdot \hat{P}$$

$$dB = dH = k\pi\left(P\bar{y}\right)\left(\frac{\pi^* M^* e^*}{\pi M + \pi^* M^* e}\hat{e}\right)$$

$$dB = dH = \pi M\left[\frac{\pi^* M^* e^*}{\pi M + \pi^* M^* e}\right] \cdot \hat{e} \qquad \textbf{Eq. 9.13}$$

From Eq. 9.13 we can conclude that the balance of payments improves as a result of a exchange rate devaluation, and the result is unambiguous.

9.2. A model of exchange rate devaluation with non-tradables

In the following discussion the focus in on the price relation between non-tradables and tradables and not on the terms of trade (the relation between domestic and foreign prices). As it will be seen later, the changes in the price relation between tradables and non-tradables affect also the equilibrium rate of hoarding. In this part we extend Dornbusch model to include a second sector in the economy which also has a non-tradable and tradable component. Therefore, we need to define the price indexes that will be used to divide the economy.

$$P_2 = (P_2^A)^{\alpha} (P_2^N)^{(1-\alpha)}$$
$$P_1 = (P_1^A)^{\beta} (P_1^N)^{(1-\beta)} \qquad \textbf{Eq. 9.14}$$

Where in Eq. 9.14 subscripts denote tradables and non tradables (1 and 2 respectively) and superscripts denote agricultural (A) and non-agricultural (N) sectors respectively. The Greek letters alpha (α) and beta (β) represent the shares of each group in each sector. Then we define the real value of output as,

$$Y = P_1^A X_1^A + P_1^N X_1^N + P_2^A X_2^A + P_2^N X_2^N \qquad \textbf{Eq. 9.15}$$

We would like to use relative prices, therefore we divide by P_1 to have,

$$\tilde{Y} = q^{(1-\beta)} X_1^A + \frac{1}{q^{\beta}} X_1^N + q_2 X_2^A + q_3 X_2^N \qquad \textbf{Eq. 9.16}$$

where in Eq. 9.16 we have used the price indexes of Eq. 9.14 and replaced,

$$q=\frac{P_1^A}{P_1^N} \qquad \frac{P_1^N}{P_1}=\left(\frac{1}{q}\right)^{\beta}$$

$$q_2=\frac{P_2^A}{P_1} \qquad q_3=\frac{P_2^N}{P_1}$$

In this way the supply functions for our four groups will be,

$$\begin{aligned}
X_1^A &= f_1^A(q, q_{2,} q_3) \\
X_1^N &= f_1^N(q, q_{2,} q_3) \\
X_2^A &= f_2^A(q, q_{2,} q_3) \\
X_2^N &= f_2^N(q, q_{2,} q_3)
\end{aligned} \qquad \textbf{Eq. 9.17}$$

where the two first equations describe the supply in the tradable sector and the second two the supply in the non-tradable sector, and that supplies depend on relative prices. In the same way de define demand for the four groups as,

$$\begin{aligned}
C_1^A &= g_1^A(q, q_{2,} q_{3,} \tilde{Z}) \\
C_1^N &= g_1^N(q, q_{2,} q_{3,} \tilde{Z}) \\
C_2^A &= g_2^A(q, q_{2,} q_{3,} \tilde{Z}) \\
C_2^N &= g_2^N(q, q_{2,} q_{3,} \tilde{Z})
\end{aligned} \qquad \textbf{Eq. 9.18}$$

A tilde over a variable indicates a relative value with respect to the tradable index price P_1 and not a "real" value, but in the sense of this analysis they will be termed as real values. As in the case of the supply functions, demand functions depend on relative prices and real expenditure.

We define real expenditure ($\tilde{Z}$) as real income ($\tilde{Y}$) less real hoarding ($\tilde{H}$).

$$\tilde{Z} = \tilde{Y} - \tilde{H}$$ **Eq. 9.19**

The assumptions made on the previous section apply here too. Specifically, we continue to consider hoarding as a function of stock excess demand for money, in that order we can write the desired rate of real hoarding in terms of relative prices and real money,

$$\tilde{H} = \tilde{H}\left(q, q_{2,} q_{3,} \tilde{M}\right)$$ **Eq. 9.20**

where we are using the real value of the money demand $\tilde{M} = M / P_1$. According to the assumption, an increase in the domestic price level (in either country) raises the desired rate of real hoarding, therefore,

$$q \frac{\partial \tilde{H}}{\partial q} \equiv \omega_1 > 0 \quad ; \quad -\tilde{M} \frac{\partial \tilde{H}}{\partial q} \equiv \omega_2 > 0$$ **Eq. 9.21**

In equilibrium real expenditure will equal real income, then, we can write (9.16) in a more disaggregated form to show the parts of the model. Replacing (9.16) in (9.19) we have,

$$\tilde{Z} = \tilde{Y} - \tilde{H}$$
$$\tilde{H} = \tilde{Y} - \tilde{Z}$$
$$\tilde{Y} = q^{(1-\beta)} X_1^A + \frac{1}{q^\beta} X_1^N + q_2 X_2^A + q_3 X_2^N - \left(q^{(1-\beta)} C_1^A + \frac{1}{q^\beta} C_1^N + q_2 C_2^A + q_3 C_2^N \right)$$
$$\tilde{Y} = q^{(1-\beta)}\left(X_1^A - C_1^A \right) + \frac{1}{q^\beta}\left(X_1^N - C_1^N \right) + q_2\left(X_2^A - C_2^A \right) + q_3\left(X_2^N - C_2^N \right)$$ **Eq. 9.22**

It is important to note that in Eq. 9.22, we have assumed that in equilibrium total consumption ($\tilde{Z}=\tilde{C}$) equals total expenditure. From Eq. 9.22 we can conclude that when the market of non-tradables clears ($X_2^A=C_2^A; X_2^N=C_2^N$), the trade surplus is equal to the planned rate of hoarding. Then, the equilibrium conditions ensure that the markets for non-tradables clear in each country and tradables clear in the international market. Formally,

$$\begin{aligned} E_2^A &= X_2^A(q, q_{2,} q_3) - C_2^A(q, q_{2,} q_{3,} \tilde{Z}) \\ E_2^N &= X_2^N(q, q_{2,} q_3) - C_2^N(q, q_{2,} q_{3,} \tilde{Z}) \end{aligned} \quad \textbf{Eq. 9.23}$$

Eq. 9.23 represents the equilibrium conditions in the domestic market for the tradable sector, for the foreign country we have similar relations,

$$\begin{aligned} E_2^{'A} &= X_2^{'A}(q^{'}, q_2^{'}, q_3^{'}) - C_2^{'} A(q^{'}, q_2^{'}, q_3^{'}, \tilde{Z}^{'}) \\ E_2^{'N} &= X_2^{'N}(q^{'}, q_2^{'}, q_3^{'}) - C_2^{'N}(q^{'}, q_2^{'}, q_3^{'}, \tilde{Z}^{'}) \end{aligned} \quad \textbf{Eq. 9.24}$$

where we are using the relations $\tilde{M}^{'}=M^{'}/P_1^{'}$ and $P_1^{'}e=P_1$. An apostrophe denotes the foreign country. The last clearing equation is defined for the international market as,

$$\tilde{H}(q, q_{2,} q_{3,} \tilde{M}) + \tilde{H}^{'}(q^{'}, q_2^{'}, q_3^{'}, \tilde{M}^{'}) = 0 \quad \textbf{Eq. 9.25}$$

To investigate the effects of devaluations in this extension of the model with non-tradables, we will first analyze the relationship between real hoarding and domestic prices. Differentiating the first market equilibrium in (9.23) we have,

$$\frac{\partial X_2^A}{\partial q_2} dq_2 - \left[\frac{\partial C_2^A}{\partial q_2} dq2 + \frac{\partial C_2^A}{\partial \tilde{Z}} d\,\tilde{Z} \right] = 0$$

Replacing $\tilde{Z}$ from (9.6) and rearranging to form elasticities:

$$\frac{\partial X_2^A}{\partial q_2} dq_2 - \left[\frac{\partial C_2^A}{\partial q_2} dq_2 + \frac{\partial C_2^A}{\partial \tilde{Z}} (d\,\tilde{Y} - d\,\tilde{H}) \right] = 0$$

$$\frac{\partial X_2^A}{\partial q_2} dq_2 \frac{q_2 X_2^A}{q_2 X_2^A} - \frac{\partial C_2^A}{\partial q_2} dq_2 \frac{q_2}{q_2} - \left[\frac{\partial C_2^A}{\partial \tilde{Z}} \left(dq_2 \frac{\partial \tilde{Y}}{\partial q_2} - d\,\tilde{H} \right) \right] = 0$$

making $\epsilon_2^A = \frac{\partial X_2^A}{\partial q_2} \frac{q_2}{X_2^A}$ (elasticity of supply) and further rearranging we have,

$$\epsilon_2^A \frac{dq_2}{q_2} X_2^A - \frac{\partial C_2^A}{\partial q_2} dq_2 \frac{q_2}{q_2} - \frac{\partial C_2^A}{\partial \tilde{Z}} dq_2 \frac{\partial \tilde{Y}}{\partial q_2} - d\,\tilde{H} \frac{\partial C_2^A}{\partial \tilde{Z}} = 0$$

Replacing $\frac{dq_2}{q_2} = \hat{q}_2$ and solving for $\hat{q}_2$,

$$\hat{q}_2 \left[\epsilon_2^A X_2^A - \frac{\partial C_2^A}{\partial q_2} q_2 - q_2 \frac{\partial C_2^A}{\partial \tilde{Z}} \frac{\partial \tilde{Y}}{\partial q_2} \right] = -d\,\tilde{H} \frac{\partial C_2^A}{\partial \tilde{Z}}$$

in equilibrium $X_2 = C_2$, then rearranging we have,

$$\hat{q}_2 = \frac{-q_2 \frac{\partial C_2^A}{\partial \tilde{Z}} d\tilde{H}}{q_2 \left[\epsilon_2^A C_2^A - \frac{\partial C_2^A}{\partial q_2} q_2 \frac{C_2^A}{C_2^A} - q_2 \frac{\partial C_2^A}{\partial \tilde{Z}} \frac{\partial \tilde{Y}}{\partial q_2} \frac{C_2^A}{C_2^A} \right]}$$

$$\hat{q}_2 = \frac{-m_2^A}{q_2 C_2^A \left(\epsilon_2^A + \eta_2^A \right)} d\tilde{H} \qquad \textbf{Eq. 9.26}$$

Where,

$$m_2^A = q_2 \frac{\partial C_2^A}{\partial \tilde{Z}} \qquad \eta_2^A = \frac{-q_2}{C_2^A} \left(\frac{\partial C_2^A}{\partial q_2} + \frac{\partial C_2^A}{\partial \tilde{Z}} \frac{\partial \tilde{Y}}{\partial q_2} \right)$$

The term m_2^A represents the marginal propensity to spend on non-tradables (home goods) and η_2^A represents the compensated elasticity of demand for non-tradables. In the same fashion we find the relation for the non-agricultural price relation,

$$\hat{q}_3 = \frac{-m_2^N}{q_2 C_2^N \left(\epsilon_2^N + \eta_2^N \right)} d\tilde{H} \qquad \textbf{Eq. 9.27}$$

To analyze the relationship between real hoarding and agricultural tradable price movements given the real quantity of money we need to differentiate the first equation in (9.23). Taking the total differential of Eq. 9.23 we have,

$$d\tilde{H} = \frac{\partial \tilde{H}}{\partial q} dq + \frac{\partial \tilde{H}}{\partial q_2} dq_2 + \frac{\partial \tilde{H}}{\partial q_3} dq_3 + \frac{+\partial \tilde{H}}{\partial \tilde{M}} d\tilde{M}$$

$$d\,\tilde{H}=\frac{\partial\,\tilde{H}}{\partial\,q}dq\frac{q}{q}+\frac{\partial\,\tilde{H}}{\partial\,q_2}dq_2\frac{q_2}{q_2}+\frac{\partial\,\tilde{H}}{\partial\,q_3}dq_3\frac{q_3}{q_3}+\frac{\partial\,\tilde{H}}{\partial\,\tilde{M}}d\,\tilde{M}\,\frac{\tilde{M}}{\tilde{M}}$$

Replacing $\hat{q}=\frac{dq}{q}$ we have

$$d\,\tilde{H}=\omega_1\,\hat{q}+\omega_2\,\hat{q}_2+\omega_3\,\hat{q}_3+\omega_4\,\hat{P}_1 \qquad \textbf{Eq. 9.28}$$

Where:

$$\omega_1=\frac{\partial\,\tilde{H}}{\partial\,q}q\,;\,\omega_2=\frac{\partial\,\tilde{H}}{\partial\,q_2}q_2\,;\,\omega_3=\frac{\partial\,\tilde{H}}{\partial\,q_3}q_3\,;\,\omega_4=\frac{\partial\,\tilde{H}}{\partial\,\tilde{M}}\tilde{M}$$

Where in Eq. 9.18 we have used the relations described in Eq. 9.21 and also the fact that in equilibrium ***M*** = ***L***, therefore from Eq. 9.1 $\hat{M}=-\hat{P}_1$. Replacing (9.15) and (9.17) in (9.18) we have,

$$d\,\tilde{H}=\omega_1\,\hat{q}+\omega_2\left[\frac{-m_2^A}{q_2C_2^A\left(\epsilon_2^A+\eta_2^A\right)}d\,\tilde{H}\right]+\omega_3\left[\frac{-m_2^N}{q_2C_2^N\left(\epsilon_2^N+\eta_2^N\right)}d\,\tilde{H}\right]+\omega_4\,\hat{P}_1$$

Replacing the terms in brackets and solving for $d\,\tilde{H}$ we have,

$$\delta_1=\frac{-m_2^A}{q_2C_2^A\left(\epsilon_2^A+\eta_2^A\right)} \quad \text{and} \quad \delta_2=\frac{-m_2^N}{q_2C_2^N\left(\epsilon_2^N+\eta_2^N\right)}$$

$$d\,\tilde{H}=\omega_1\,\hat{q}-\omega_2\,\delta_1\,d\,\tilde{H}-\omega_3\,\delta_2\,d\,\tilde{H}+\omega_4\,\hat{P}_1$$

Replacing de values of $\hat{q}$ and $\hat{P}_1$ yields,

$$d\,\tilde{H}\left(1+\omega_2\delta_1+\omega_3\delta_2\right)=\omega_1\left(\hat{P}_1^A-\hat{P}_1^A\right)+\omega_4\left(\beta\,\hat{P}_1^A+\left(1-\beta\right)\hat{P}_1^N\right)$$

$$d\,\tilde{H}\left(1+\omega_2\delta_1+\omega_3\delta_2\right)=\hat{P}_1^A\left(\omega_1+\omega_4\beta\right)+\hat{P}_1^N\left(\omega_4\left(1-\beta\right)-\omega_1\right)$$

Replacing the terms in parentheses and solving for $d\,\tilde{H}$ we have,

$$d\,\tilde{H}=\left[\gamma_1\hat{P}_1^A+\gamma_2\hat{P}_1^N\right]\gamma_3$$ **Eq. 9.29**

where in Eq. 9.20,

$$\gamma_1=\omega_1+\omega_4\beta \qquad \gamma_2=\omega_4\left(1-\beta\right)-\omega_1 \qquad \gamma_3=\frac{1}{1+\omega_2\delta_1+\omega_3\delta_2}$$

The relation in Eq. 9.20 represents the explicit clearing in the home-goods market, which is equal to the excess supply of traded goods. Therefore, we can use Eq. 9.20 and its counterpart in the foreign country to analyze the effects of a devaluation on domestic prices,

$$\tilde{H}+\tilde{H}^{'}=0$$

$d\,\tilde{H}+d\,\tilde{H}^{'}=0$ replacing Eq. 9.20 we have,

$$\gamma_3\gamma_1\hat{P}_1^A+\gamma_2\gamma_3\hat{P}_1^N+\gamma_3'\gamma_1'\hat{P}_1'^A+\gamma_2'\gamma_3'\hat{P}_1'^N=0$$, recalling from Eq. 9.12 that:

$$\hat{P}_1^N=\hat{P}_1'^N+\hat{e} \qquad \hat{P}_1^A=\hat{P}_1'^A+\hat{e}$$

$$\hat{P}_1^A=\frac{\theta_3\hat{e}}{\theta_1}-\frac{\theta_2\hat{P}_1^N}{\theta_1} \qquad \textbf{Eq. 9.30}$$

where,

$$\theta_1=\gamma_3\gamma_1+\gamma_3'\gamma_1' \qquad \theta_2=\gamma_2\gamma_3+\gamma_2'\gamma_3' \qquad \theta_3=\gamma_3'\gamma_1'+\gamma_2'\gamma_3'$$

Eq. 9.24 is showing that prices increase in the domestic country, but less than proportionately that the devaluation ($0<\theta_3/\theta_1<1$). If agricultural and non-agricultural prices have a positive reaction to exchange rate devaluations, the final result will depend on the relative strength of that reaction. If agricultural prices are more responsive the devaluation will increase agricultural prices but prices in the non-agricultural sector might decline. Replacing Eq. 9.20 in Eq. 9.24 shows that the devaluing country's balance of payments increases unambiguously,

$$d\tilde{H}=\left[\frac{\gamma_3\theta_3}{\theta_1}\hat{e}-\hat{P}_1^N\left(\frac{\gamma_1\theta_2}{\theta_1}-\gamma_2\right)\right]\gamma_3 \qquad \textbf{Eq. 9.31}$$

The trade balance will increase unambiguously if prices in the non-agricultural tradable sector increase but less than proportionately to the exchange rate devaluation. Finally, to find the effect of a devaluation on domestics prices, we replace Eq. 9.25 in Eq. 9.15 and Eq. 9.17 to have,

$$\hat{q}_2=-\delta_1 d\tilde{H}$$

$$\hat{q}_2=\frac{\delta_1(\gamma_1\theta_2-\gamma_2\theta_1)}{\theta_1}\hat{P}_1^N-\frac{\delta_1\gamma_1\theta_3}{\theta_1}\hat{e}$$

$$\hat{q}_2 = \phi_1 \hat{P}_1^N - \phi_2 \hat{e}$$ **Eq. 9.32**

Where,

$$\phi_1 = \frac{\delta_1 \left(\gamma_1 \theta_2 - \gamma_2 \theta_1 \right)}{\theta_1} \qquad \phi_2 = \frac{\delta_1 \gamma_1 \theta_3}{\theta_1}$$

Following the same procedure for the relative price of non-agricultural non-tradables we have,

$$\hat{q}_3 = \phi_3 \hat{P}_1^N - \phi_4 \hat{e}$$ **Eq. 9.33**

Where,

$$\phi_3 = \frac{\delta_2 \left(\gamma_1 \theta_2 - \gamma_2 \theta_1 \right)}{\theta_1} \qquad \phi_4 = \frac{\delta_2 \gamma_1 \theta_3}{\theta_1}$$

Equations (9.26) and (9.27) indicate us that the devaluation will depress domestic prices in the devaluing country and improve domestic prices in the foreign country. If there is only one group of tradables and non tradables (i.e. β = 1 and α = 1) we return to the original result of Dornbusch, $\hat{q} = -\phi_2 \hat{e}$. Our results highlight the importance of non-tradables in the final result of devaluations on particular sectors. If non-agricultural tradables are less responsive to exchange rate devaluations, then agricultural non-tradables will fall unambiguously.

Annex 2

10. Annex 2: Products included in the Food Balance Sheets

10.1. For Argentina:

Exports	Imports	Non-tradables	Not included
Wheat	Roots, Other	Rye	Wine
Rice (Milled Equivalent)	Coconuts - Incl Copra	Oats	Beer
Barley	Sesameseed	Potatoes	Beverages, Fermented
Maize	Palmkernels	Cassava	Beverages, Alcoholic
Millet	Citrus, Other	Sweet Potatoes	Alcohol, Non-Food
Sorghum	Bananas	Sugar Cane	Bovine Meat
Cereals, Other	Pineapples	Pulses, Other	Mutton & Goat Meat
Beans	Dates	Oilcrops, Other	Pigmeat
Peas	Coffee	Tomatoes	Poultry Meat
Soyabeans	Cocoa Beans	Vegetables, Other	Meat, Other
Groundnuts (Shelled Eq)	Pepper	Grapes	Fats, Animals, Raw
Rape and mustard seed	Cloves	Pimento	Butter, Ghee
Olives			Cream
Onions			Honey
Oranges, Mandarines			Freshwater Fish
Lemons, Limes			Demersal Fish
Grapefruit			Pelagic Fish
Apples			Marine Fish, Other
Fruits, Other			Crustaceans
Tea			Cephalopods
Spices, Other			Molluscs, Other
			Aquatic Animals, Others
			Aquatic Plants
			Fish, Body Oil
			Fish, Liver Oil
			Milk
			Eggs

10.2. For Bolivia

Exports	Imports	Non Traded	Not considered
Sugar Cane	Wheat	Rice	Wine
Sweeteners, Other	Barley	Maize	Beer
Soyabeans	Rye	Millet	Beverages, Fermented
Groundnuts (Shelled Eq.)	Oats	Sorghum	Beverages, Alcoholic
Sunflower seed	Peas	Cereals, Other	Alcohol, Non-Food
Cotton Seed	Pulses, Other	Potatoes	Bovine Meat
Oilcrops Other	Olives	Cassava	Mutton & Goat Meat
Oranges, Mandarines	Citrus, Other	Sweet Potatoes	Pig meat
Lemon, Limes	Dates	Roots, Other	Poultry Meat
Grapefruit	Pimento	Yams	Meat, Other
Coffee	Spices, Other	Beans	Fats, Animals, Raw
Cocoa Beans	Coconuts - Incl. Copra	Rape and Mustards seed	Butter, Ghee
Pepper	Sesames seed	Palmkernels	Cream
		Tomatoes	Honey
		Onions	Freshwater Fish
		Vegetables, Other	Demersal Fish
		Bananas	Pelagic Fish
		Apples	Marine Fish, Other
		Pineapples	Crustaceans
		Grapes	Cephalopods
		Fruits, Other	Molluscs, Other
		Tea	Aquatic Animals, Others
		Cloves	Fish, Body Oil
			Fish, Liver Oil

10.3. For Brazil:

Exports	Imports	Non Traded	Not considered
Sugar Cane	Wheat	Rice	Wine
Soyabeans	Barley	Maize	Beer
Groundnuts (Shelled Eq.)	Peas	Rye	Beverages, Fermented
Sunflower seed	Pulses, Other	Oats	Beverages, Alcoholic
Cotton Seed	Olives	Millet	Alcohol, Non-Food
Oilcrops Other	Citrus, Other	Sorghum	Bovine Meat
Oranges, Mandarines	Dates	Cereals, Other	Mutton & Goat Meat
Lemon, Limes	Pimento	Potatoes	Pigmeat
Grapefruit	Spices, Other	Cassava	Poultry Meat
Coffee		Sweet Potatoes	Meat, Other
Cocoa Beans		Roots, Other	Fats, Animals, Raw
Pepper		Yams	Butter, Ghee
		Beans	Cream
		Rape and Mustards seed	Honey
		Coconuts - Incl. Copra	Freshwater Fish
		Sesames seed	Demersal Fish
		Palmkernels	Pelagic Fish
		Tomatoes	Marine Fish, Other
		Onions	Crustaceans
		Vegetables, Other	Cephalopods
		Bananas	Molluscs, Other
		Apples	Aquatic Animals, Others
		Pineapples	Aquatic Plants
		Grapes	Fish, Body Oil
		Fruits, Other	Fish, Liver Oil
		Tea	Eggs
		Cloves	Milk - excluding butter

10.4. For Venezuela:

Exportables	Importables	Non-tradables	Not considered
Rice (milled equivalent	Wheat	Potatoes	Wine
Sugar Cane	Barley - excluding beer	Cassava	Barley, Beer
Sesameseed	Maize	Sweet Potatoes	Beverages, Fermented
Lemons, Limes	Rye	Roots, other	Beverages, Alcoholic
Fruit, other	Oats	Yams	Alcohol, Non-Food
Cocoa Beans	Millet	Beans	Beef and Veal
	Sorghum	Groundnuts (Shld Eq.)	Mutton & Goat Meat
	Cereals, other	Coconuts - incl. Copra	Pigmeat
	Peas	Palmkernels	Poultry Meat
	Pulses, other	Tomatoes	other Meat
	Soyabeans	Onions	Fats, Animals, Raw
	Sunflowerseed	Vegetables, other	Butter, Ghee
	Rape and Mustardseed	Oranges, Mandarines	Cream
	Cottonseed	Grapefruit	Honey
	Olives	Bananas	Freshwater Fish
	Oilcrops, other	Plantains	Demersal Fish
	Citrus, Other	Pineapples	Pelagic Fish
	Apples - excl. Cider	Grapes - excl. Wine	Marine Fish, other
	Dates	Coffee	Crustaceans
	Tea		Cephalopods
	Pepper		Molluscs, other
	Pimento		Aquatic Animals, Others
	Cloves		Fish, Body Oil
	Spices, other		Fish, Liver Oil
			Milk - excluding butter
			Eggs

10.5. For Japan:

Exportables	Importables	Non-tradables	Not considered
	Wheat	Rice (Milled Equivalent)	Wine
	Barley	Potatoes	Beer
	Maize	Sweet Potatoes	Beverages, Fermented
	Rye	Roots, Other	Beverages, Alcoholic
	Oats	Yams	Alcohol, Non-Food
	Millet	Sugar Cane	Bovine Meat
	Sorghum	Sugar Beet	Mutton & Goat Meat
	Cereals, Other	Tomatoes	Pigmeat
	Cassava	Onions	Poultry Meat
	Beans	Vegetables, Other	Meat, Other
	Peas	Oranges, Mandarines	Fats, Animals, Raw
	Pulses, Other	Citrus, Other	Butter, Ghee
	Soyabeans	Grapes	**Cream**
	Groundnuts (Shelled Eq)	Fruits, Other	Honey
	Sunflowerseed	Tea	Freshwater Fish
	Rape and Mustardseed		Demersal Fish
	Cottonseed		Pelagic Fish
	Coconuts - Incl Copra		Marine Fish, Other
	Sesameseed		Crustaceans
	Palmkernels		Cephalopods
	Olives		Molluscs, Other
	Oilcrops, Other		Aquatic Animals, Others
	Lemons, Limes		Aquatic Plants
	Grapefruit		Fish, Body Oil
	Bananas		Fish, Liver Oil
	Apples		Milk - Excluding Butter
	Pineapples		Eggs
	Dates		
	Coffee		
	Cocoa Beans		
	Pepper		
	Pimento		
	Cloves		
	Spices, Other		

Annex 3

11. Annex 3: Variables used in the econometrical specification of Chapter 3

11.1. Variables common to all systems

Variable	Source	Observations
Exports (E_{it})	Food Balance Sheets, FAO (1,000 tons)	1980-2000. The variable included the 13 products detailed in Annex 2.
Real Exchange Rate (RXR)	World Bank macroeconomic series (http://www.worldbank.org/research/growth/GDNdata.htm)	1960-1998. The years 1999 and 2000 were completed with national and IMF sources
GDP per capita	Ibid.	Ibid.

Variable	Source	Observations
Weighted average of commercial partners income (W)	GDP in millions of U.S. $ obtained from the World Bank, http://www.worldbank.org/research/growth/GDNdata.htm. Trade (in millions of U.S. $) with commercial partners obtained from www.worldbank.org/trade/	The average is a geometric average weighted by the share of each country on total trade. The commercial partners are the 10 South American countries, U.S., Europe 15 and Japan.
Average of agricultural international prices (AIP)	IMF commodities series and FAO's commodity prices report (http://apps2.fao.org/ciwpsystem/ciwp_q-e.htm)	Original sources as described in the IMF Financial Statistics Yearbook
Imports (Mit)	Food Balance Sheets, FAO (1,000 tons)	1980-2000. The variable included the 13 products detailed in Annex 2.
Non-tradables production (*NT*)	Food Balance Sheets, FAO (1,000 tons)	1980-2000. The variable included the 23 products detailed in Annex 2.
Time (*T*)		A linear time series, 1980=1

Variable	Source	Observations
Total production (*TP*)	Food Balance Sheets, FAO (1,000 tons)	1980-2000. The variable includes the 49 products detailed in Annex 2.
Food supply (*FS*)	Food Balance Sheets, FAO (1,000 tons)	1980-2000. The variable includes the 23 products detailed in Annex 2.
Import substitutes (*MS*)	Food Balance Sheets, FAO (1,000 tons)	1980-2000. The variable includes the 13 products detailed in Annex 2.
Average of international prices of commodities (*AV*)	IMF commodities series, FAO's commodity prices report and The London Metal Exchange (http://www.lme.co.uk/)	Original sources as described in the IMF Financial Statistics Yearbook
Interest rate (*IR*)	World Bank and the National Institute of Estatistics – Bolivia http://www.worldbank.org/research/growth/GDNdata.htm.	Nominal lending rate, average for the year.
Libor rate (*L*)	IMF Financial Statistics Yearbook	3 month Libor rate
Public investment (*PI*)	World Bank and the Bolivian Central Bank http://www.worldbank.org/research/growth/GDNdata.htm.	Public investment as a share of GDP, real terms

Variable	Source	Observations
Weighted average of the RXR of commercial partners (*WR*)	RXR obtained from the World Bank, http://www.worldbank.org/research/growth/GDNdata.htm. Trade (in millions of U.S. $) with commercial partners obtained from www.worldbank.org/trade/	The average is a geometric average weighted by the share of each country on total trade. The commercial partners are the 10 South American countries, U.S., Europe 15 and Japan.
Total investment (*I*)	World Bank and Central Banks http://www.worldbank.org/research/growth/GDNdata.htm , www.bcb.gov.bo , www.ibge.net, www.indec.mecon.gov.ar, www.ocei.gov.ve, www.stat.go.jp	Total investment (public plus private) as a share of GDP, real terms
Total trade (*TT*)	World Bank and the National Institutes of Statistics http://www.worldbank.org/research/growth/GDNdata.htm , www.ine.gov.bo, www.ibge.net, www.indec.mecon.gov.ar, www.ocei.gov.ve, www.stat.go.jp	Total trade as a share of GDP, real terms

Variable	Source	Observations
Inflation (*INF*)	World Bank and the National Institutes of Statistics http://www.worldbank.org/research/growth/GDNdata.htm , www.ine.gov.bo , www.ibge.net, www.indec.mecon.gov.ar, www.ocei.gov.ve, www.stat.go.jp	Measured as a the annual variation of the CPI
Human capital (*HK*)	World Bank, Ministries of Education and the National Institutes of Statistics http://www.worldbank.org/research/growth/GDNdata.htm; http://www.minedu.gov.bo/ , www.ine.gov.bo , www.ibge.net, www.indec.mecon.gov.ar, www.ocei.gov.ve, www.stat.go.jp	Rate of enrollment on highshools
Trade Balance (*TB*)	World Bank and the National Institutes of Statistics http://www.worldbank.org/research/growth/GDNdata.htm , www.ine.gov.bo , www.ibge.net, www.indec.mecon.gov.ar, www.ocei.gov.ve, www.stat.go.jp	Exports minus imports as a share of GDP, real terms.

Variable	Source	Observations
Government consumption (*GC*)	World Bank, IMF and the National Institutes of Statistics http://www.worldbank.org/research/growth/GDNdata.htm , www.ine.gov.bo , www.ibge.net, www.indec.mecon.gov.ar, www.ocei.gov.ve, www.stat.go.jp	As a share of GDP, real terms

11.2. Variables specific to the Argentinean data

Variable	Source	Observations
Relative price of Beef meat to petroleum (Beef/Petro)	Ministry of Agriculture of Argentina, Sociedad Rural Argentina (Rural Society of Argentina, http://www.ruralarg.org.ar/) and Bolsa de Cereales de Buenos Aires (Buenos Aires cereals exchange market)	Relative price of deflated values
Imports price	Ministry of Agriculture of Argentina and Sociedad Rural Argentina (Rural Society of Argentina, http://www.ruralarg.org.ar/)	Index of the price of tropical fruits including Banana, pineaple, citrus and mango

Variable	Source	Observations
Dummy variables	1980-1988 = 0 (hyperinflation – inflation period) 1989-2000 = 1 (stable period)	C Dum indicates a dummy variable for the constant term. Dum Lag indicates a dummy variable for the lagged value of the dependent variable. Dum RER indicates a dummy variable for the RER.

11.3. Variables specific to the Bolivian data

Variable	Source	Observations
Producer's price of sugar (P^{Sg})	Cámara Agropecuaria del Oriente (Eastern Agricultural Chamber)	Deflated by the CPI.
Producer's price of soybean (P^{Sy})	Cámara Agropecuaria del Oriente (Eastern Agricultural Chamber)	Deflated by the CPI.
Producer's price of wheat (P^{Wh})	Cámara Agropecuaria del Oriente (Eastern Agricultural Chamber)	Deflated by the CPI.
Donations (*Dn*)	FAOSTAT (1,000 tons) and World Food Programme	Donations of wheat, grains, oilcrops and derivates
Non-tradables producer price (P^{NT})	FAOSTAT and CAO	Deflated by the CPI. Index of 21 products detailed in Annex 2.

Variable	Source	Observations
Dummy variables	1980-1985 = 1 (Hyperinflation and inflation period) 1986-2000 = 0 (Stable period)	C Dum indicates a dummy variable for the constant term. Dum Lag indicates a dummy variable for the lagged value of the dependent variable.

11.4. Variables specific to the Brazilian data

Variable	Source	Observations
Producer's price of maize (P^{ma})	Fundación Getulio Vargas (Getulio Vargas Foundation) and Bolsa de Mercadorías y Futuros (Brazilian Mercantile & Futures Exchange)	Deflated, 1995=100
Producer's price of wheat (P^{wh})	Fundación Getulio Vargas (Getulio Vargas Foundation) and Bolsa de Mercadorías y Futuros (Brazilian Mercantile & Futures Exchange)	Deflated, 1995=100

Variable	Source	Observations
Dummy variables	1980-1991 = 0 (Hyperinflation and inflation period) 1992-2000 = Stable period	C Dum indicates a dummy variable for the constant term. Dum Lag indicates a dummy variable for the lagged value of the dependent variable. Dum RER indicates a dummy variable for the RER.

11.5. Variables specific to the Venezuelan data

Variable	Source	Observations
Petroleum	IMF Statistical Database, OPEC and The World Bank	Price at Venezuelan ports
Producer's price of wheat (P^{wh})	Oficina central de estadística e informatica (Central office of statistics and informatics)	Deflated, 1995=100
Producer's price of rice (P^{ri})	Oficina central de estadística e informatica (Central office of statistics and informatics)	Deflated, 1995=100
Producer's price of maize (P^{Ma})	Oficina central de estadística e informatica (Central office of statistics and informatics)	Deflated, 1995=100
Producer's price of Sugar (P^{sg})	Oficina central de estadística e informatica (Central office of statistics and informatics)	Deflated, 1995=100

Variable	Source	Observations
Dummy variables	1980 – 1982; 1989-200 = 1 (Inflation outbreaks) 1983-1988 = 0 (Stable period)	Deflated 1995 = 100

12. Annex 4: SUR estimation: Complete results for Chapter 3

12.1. Argentina

System: DOS_ARG
Estimation Method: Seemingly Unrelated Regression
Date: 08/20/02 Time: 15:11
Sample: 1981 1999
Included observations: 19
Total system (unbalanced) observations 139

	Coeff.	Std. Error	t-Statistic	Prob.
ARG(1)	-1.6824	7.2016	-0.2336	0.8158
ARG(2)	-0.4903	0.2368	-2.0705	0.0414
ARG(3)	0.7248	0.5208	1.3917	0.1676
ARG(4)	0.2289	0.1525	1.5012	0.1370
ARG(5)	0.3693	0.1418	2.6054	0.0108
ARG(6)	-0.1615	0.1201	-1.3444	0.1824
ARG(7)	-0.3552	0.0935	-3.8010	0.0003
ARG(8)	0.4250	0.4540	0.9362	0.3518
ARG(10)	47.0962	8.8703	5.3094	0.0000
ARG(11)	0.7029	0.2213	3.1762	0.0021

Equation: LOG(SA::ARTE)=ARG(1)+ARG(2)*LOG(SA::AR_REER(-1)) +ARG(3)*LOG(AR_GDPPC95(-1))+ARG(4)*LOG(SA::ARGWAY(-1))+ARG (5)*LOG(SA::ARTE(-1))+ARG(6)*LOG(SA::ARTAX) +ARG(7)*LOG (SA::BEEF_95/SA::PETRO_95)+ARG(8)*LOG(SA::AVERAGE(-1))

Observations: 19

R-squared	0.7	Mean dependent var	9.99267
Adjusted R-squared	0.52	S.D. dependent var	0.28704
S.E. of regression	0.2	Sum squared resid	0.44
Durbin-Watson stat	2.33		

Equation: LOG(SA::ARPCTIM)=ARG(10)+ARG(11)*LOG(SA::AR_REER (-1))+ARG(12)*LOG(AR_GDPPC95(-1))+ARG(13)*LOG(SA::ARGWY(-1)) +ARG(14)*LOG(SA::ARPCTIM(-1))+ARG(15)*LOG(SA::BANANA_95(-1))

Observations: 19

R-squared	0.95	Mean dependent var	2.64
Adjusted R-squared	0.92	S.D. dependent var	0.88236
S.E. of regression	0.24	Sum squared resid	0.76507
Durbin-Watson stat	2.58		

ARG(12)	-4.3794	0.9001	-4.8657	0.0000
ARG(13)	-0.3005	0.3033	-0.9909	0.3245
ARG(14)	0.8602	0.1763	4.8778	0.0000
ARG(15)	-1.4821	0.4587	-3.2310	0.0018
ARG(20)	1.1768	2.1690	0.5425	0.5889
ARG(22)	0.0205	0.0382	0.5371	0.5926
ARG(23)	0.4336	0.1503	2.8843	0.0050
ARG(24)	0.1613	0.0576	2.7999	0.0063
ARG(25)	0.3275	0.1366	2.3965	0.0187
ARG(26)	-0.0758	0.0661	-1.1466	0.2548
ARG(27)	0.0735	0.0298	2.4622	0.0158
ARG(30)	3.0892	2.6714	1.1564	0.2507
ARG(36)	1.7345	0.4207	4.1228	0.0001
ARG(31)	0.0690	0.0711	0.9702	0.3347
ARG(32)	-0.4524	0.1048	-4.3173	0.0000
ARG(33)	0.3583	0.1873	1.9131	0.0591
ARG(34)	-0.1051	0.0422	-2.4878	0.0148
ARG(35)	-0.1016	0.0778	-1.3062	0.1950
ARG(37)	0.6151	0.2577	2.3869	0.0192
ARG(38)	0.0252	0.0099	2.5481	0.0126
ARG(40)	1.6005	0.7567	2.1152	0.0373
ARG(41)	0.0133	0.0205	0.6505	0.5171
ARG(42)	0.3310	0.0964	3.4317	0.0009
ARG(43)	0.2572	0.1555	1.6546	0.1017
ARG(44)	-0.0011	0.0030	-0.3481	0.7287
ARG(50)	7.1187	4.2046	1.6931	0.0941
ARG(51)	-0.6880	0.1757	-3.9166	0.0002
ARG(52)	0.4891	0.0828	5.9074	0.0000

Equation: LOG(SA::ARNTPR)=ARG(20)+ARG(22)*LOG(SA::AR_REER)+ARG(23)*LOG(AR_GDPPC95(-1))+ARG(24)*LOG(SA::ARGWAY(-1))+ARG(25)*LOG(SA::ARNTPR(-1))+ARG(26)*LOG(SA::AVERAGE_95(-1))+ARG(27)*LOG(SA::ARTAX)

Observations: 19

R-squared	0.75	Mean dependent var	10.27182
Adjusted R-squared	0.63	S.D. dependent var	0.11019
S.E. of regression	0.07	Sum squared resid	0.05396
Durbin-Watson stat	1.54		

Equation: LOG(ARTPR1)=ARG(30)+ARG(36)*DUMAR5+ARG(31)*LOG(SA::AR_REER(-1))+ARG(32)*DUMAR5*LOG(SA::AR_REER(-1))+ARG(33)*LOG(ARTPR1(-1))+ARG(34)*LOG(SA::ARTAX)+ARG(35)*LOG(SA::ARGWAY)+ARG(37)*LOG(AR_GDPPC95)+ARG(38)*(TIME)

Observations: 19

R-squared	0.83	Mean dependent var	11.15577
Adjusted R-squared	0.69	S.D. dependent var	0.15531
S.E. of regression	0.09	Sum squared resid	0.07490
Durbin-Watson stat	1.59		

Equation: LOG(SA::ARPCAS)=ARG(40)+ARG(41)*LOG(SA::AR_REER(-1))+ARG(42)*LOG(AR_GDPPC95)+ARG(43)*LOG(SA::ARPCAS(-1))+ARG(44)*DUMAR4*LOG(SA::AR_REER(-1))

Observations: 19

R-squared	0.79	Mean dependent var	6.04184
Adjusted R-squared	0.73	S.D. dependent var	0.05006
S.E. of regression	0.03	Sum squared resid	0.00931

ARG(53)	-0.2963	0.1545	-1.9180	0.0585
ARG(54)	-0.1791	0.0898	-1.9941	0.0494
ARG(55)	-0.3938	0.3632	-1.0843	0.2813
ARG(56)	0.2714	0.3820	0.7105	0.4794
ARG(60)	-3.7736	2.7789	-1.3579	0.1781
ARG(61)	0.4780	0.3080	1.5518	0.1244
ARG(62)	-0.1472	0.0302	-4.8720	0.0000
ARG(63)	-0.2172	0.1269	-1.7125	0.0904
ARG(64)	-0.3038	0.4037	-0.7526	0.4538
ARG(65)	1.5507	0.4453	3.4823	0.0008
ARG(70)	4.0564	0.3338	12.1530	0.0000
ARG(71)	1.1881	0.1010	11.7580	0.0000
ARG(73)	0.0821	0.0254	3.2346	0.0017
ARG(74)	-0.0123	0.0033	-3.7711	0.0003
ARG(75)	0.27	0.03	9.67	0.0000
ARG(76)	0.02	0.01	3.46	0

Determinant residual covariance 8.13E-023

Durbin-Watson stat	2.14		

Equation: LOG(SA::ARIMS)=ARG(50)+ARG(51)*LOG(SA::AR_REER(-1)) +ARG(52)*LOG(SA::ARIMS(-1))+ARG(53)*LOG(SA::AVERAGE_95(-1)) +ARG(54)*LOG(SA::ARTAX)+ARG(55)*LOG(SA::ARGWR(-1))+ARG(56) *LOG(AR_GDPPC95(-1))

Observations: 19

R-squared	0.87	Mean dependent var	5.13478
Adjusted R-squared	0.8	S.D. dependent var	0.31258
S.E. of regression	0.14	Sum squared resid	0.23
Durbin-Watson stat	2.05		

Equation: LOG(SA::AR_REER)=ARG(60)+ARG(61)*LOG (SA::AVERAGE_95)+ARG(62)*LOG(SA::AR_DIR)+ARG(63)*LOG (SA::LIBOR90(-1))+ARG(64)*LOG(SA::ARTIN)+ARG(65)*LOG (SA::ARGWR)

Observations: 18

R-squared	0.84	Mean dependent var	4.16
Adjusted R-squared	0.78	S.D. dependent var	0.43
S.E. of regression	0.2	Sum squared resid	4.84E-01
Durbin-Watson stat	1.9		

Equation: LOG(AR_GDPPC95)=ARG(70)+ARG(71)*LOG(SA::ARTIN)+ARG (73)*LOG(SA::ARGCP)+ARG(74)*LOG(SA::ARG_INF2) +ARG(75)*LOG (SA::ARTTP)+ARG(76)*LOG(SA::AR_TB5000)

Observations: 7

R-squared	1	Mean dependent var	8.65
Adjusted R-squared	0.99	S.D. dependent var	0.05
S.E. of regression	0	Sum squared resid	2.41E-05
Durbin-Watson stat	3.24		

12.2. Bolivia

System: DOS_BOL_FIN14
Estimation Method: Seemingly Unrelated Regression
Date: 06/12/03 Time: 11:25
Sample: 1980 1999
Included observations: 20
Total system (unbalanced) observations 143

	Coefficient	Std. Error	t-Statistic	Prob.
BO(1)	-4.645	18.003	-0.258	0.797
BO(2)	-3.766	1.400	-2.690	0.009
BO(3)	0.373	0.122	3.055	0.003
BO(4)	1.508	2.114	0.713	0.478
BO(5)	0.731	0.630	1.162	0.249
BO(6)	0.592	0.833	0.711	0.479
BO(7)	0.421	0.272	1.547	0.126

Equation: LOG(SA::BOTE)=BO(1)+BO(2)*LOG(SA::BO_REER)+BO(3) *LOG(SA::BOTE(-1))+BO(4)*LOG(SA::BO_GDPPC95(-1))+BO(5) *LOG(SA::BOLWAY(-1))+BO(6)*LOG(SA::SOY_95)+BO(7) *LOG(SA::SUGAR_95(-2))

Observations: 18

R-squared	0.879	Mean dependent var	5.211
Adjusted R-squared	0.814	S.D. dependent var	1.004
S.E. of regression	0.433	Sum squared resid	2.066
Durbin-Watson stat	2.053		

	Coefficient	Std. Error	t-Statistic	Prob.
BO(10)	7.467	2.266	3.295	0.001
BO(11)	-7.631	1.303	-5.855	0.000
BO(12)	0.647	0.353	1.833	0.070
BO(13)	-2.208	5.113	-0.432	0.667
BO(15)	-0.987	0.144	-6.878	0.000
BO(16)	0.250	0.075	3.317	0.001

Equation: LOG(SA::BOPCTIM)=BO(10)+BO(11)*DUMBO4+BO(12) *LOG(SA::BO_REER(-1))+BO(13)*(LOG(SA::BO_GDPPC95)/(LOG (SA::BOLWAY)))+BO(15)*LOG(SA::BOPCTIM(-1))+BO(16)*LOG (SA::BOPCDON(-1))+BO(17)*DUMBO4*LOG(SA::BOPCTIM (-1))+BO(18)*LOG(SA::WHEAT_95(-1))

Observations: 19

BO(17)	1.935	0.343	5.639	0.000		R-squared	0.685	Mean dependent var	3.984
BO(18)	-0.418	0.203	-2.056	0.043		Adjusted R-squared	0.484	S.D. dependent var	0.240
						S.E. of regression	0.172	Sum squared resid	0.326
						Durbin-Watson stat	2.019		
BO(20)	21.480	1.483	14.480	0.000					
BO(28)	-2.766	0.980	-2.824	0.006					
BO(21)	0.634	0.152	4.183	0.000		Equation: LOG(SA::BONTPR)=BO(20)+BO(28)*DUMBO2+BO(21) *LOG(SA::BO_REER)+BO(22)*LOG(SA::BO_GDPPC95)+BO(23) *LOG(SA::BONTPR(-1))+BO(24)*LOG(SA::BOPPNTDD(-1)) +BO(25)*DUMBO2*LOG(SA::BONTPR(-1))+BO(26)*LOG (SA::AVERAGE_95(-1))+BO(27)*LOG(SA::BOPCDON)+BO(29) *TIME			
BO(22)	-1.153	0.316	-3.644	0.000					
BO(23)	-0.717	0.060	-12.026	0.000					
BO(24)	0.070	0.024	2.978	0.004					
BO(25)	0.421	0.124	3.386	0.001		Observations: 16			
BO(26)	-0.525	0.049	-10.623	0.000		R-squared	0.985	Mean dependent var	7.981
BO(27)	-0.025	0.010	-2.463	0.016		Adjusted R-squared	0.962	S.D. dependent var	0.164
BO(29)	0.018	0.006	2.846	0.006		S.E. of regression	0.032	Sum squared resid	0.006
						Durbin-Watson stat	2.525		
BO(30)	-6.994	3.483	-2.008	0.048					
BO(38)	-3.747	2.516	-1.489	0.140					
BO(31)	-1.347	0.226	-5.962	0.000		Equation: LOG(SA::BOTPR)=BO(30)+BO(38)*DUMBO5+BO(31) *LOG(SA::BO_REER(-1))+BO(32)*LOG(SA::BOTPR(-1))+BO(33) *LOG(SA::BO_GDPPC95(-1))+BO(34)*LOG(SA::BOLWAY(-1)) +BO(35)*LOG(SA::AVERAGE_95)+BO(36)*LOG(SA::BOPPNTD D(-1))+BO(37)*DUMBO5*LOG(SA::BOTPR(-1))			
BO(32)	-0.302	0.253	-1.194	0.236					
BO(33)	2.745	0.436	6.295	0.000					
BO(34)	0.345	0.065	5.301	0.000		Observations: 16			
BO(35)	0.442	0.113	-3.908	0.000		R-squared	0.930	Mean dependent var	8.818
BO(36)	0.493	0.083	5.905	0.000		Adjusted R-squared	0.849	S.D. dependent var	0.171
BO(37)	0.426	0.283	1.506	0.136		S.E. of regression	0.066	Sum squared resid	0.031
						Durbin-Watson stat	1.382		

BO(40)	11.348	1.213	9.353	0.000
BO(41)	-5.521	1.554	-3.551	0.001
BO(42)	0.109	0.043	2.534	0.013
BO(43)	-0.227	0.155	-1.464	0.147
BO(44)	-0.736	0.130	-5.642	0.000
BO(45)	0.960	0.259	3.706	0.000

Equation: LOG(SA::BOPCAS)=BO(40)+BO(41)*DUMBO2+BO(42)*LOG(SA::BO_REER(-1))+BO(43)*LOG(SA::BO_GDPPC95(-1))+BO(44)*LOG(SA::BOPCAS(-1))+BO(45)*LOG(SA::BOPCAS(-1))*DUMBO2

Observations: 19

R-squared	0.832	Mean dependent var	6.000
Adjusted R-squared	0.767	S.D. dependent var	0.069
S.E. of regression	0.033	Sum squared resid	0.014
Durbin-Watson stat	2.078		

BO(50)	-12.299	13.425	-0.916	0.362
BO(57)	-3.698	1.523	-2.427	0.017
BO(51)	-2.000	0.629	-3.179	0.002
BO(52)	-0.286	0.222	-1.284	0.203
BO(53)	4.648	1.669	2.785	0.007
BO(54)	-0.615	0.405	-1.519	0.132
BO(55)	0.285	0.547	0.520	0.604
BO(56)	0.797	0.336	2.370	0.020

Equation: LOG(SA::BOIMS)=BO(50)+BO(57)*DUMBO4+BO(51)*LOG(SA::BO_REER(-1))+BO(52)*LOG(SA::BOIMS(-1))+BO(53)*LOG(SA::BO_GDPPC95(-1))+BO(54)*LOG(SA::BOLWAY)+BO(55)*LOG(SA::WHEAT_95(-1))+BO(56)*DUMBO4*LOG(SA::BOIMS(-1))

Observations: 19

R-squared	0.740	Mean dependent var	4.463
Adjusted R-squared	0.574	S.D. dependent var	0.365
S.E. of regression	0.238	Sum squared resid	0.624
Durbin-Watson stat	1.885		

BO(60)	2.861	1.682	1.701	0.093
BO(61)	0.400	0.141	2.842	0.006
BO(62)	0.081	0.088	0.913	0.364
BO(63)	0.231	0.084	2.745	0.007
BO(64)	0.182	0.132	1.375	0.173
BO(65)	-0.390	0.216	-1.800	0.076

Equation: LOG(SA::BO_REER)=BO(60)+BO(61)*LOG(SA::AVERAGE_95)+BO(62)*LOG(SA::BO_LIR)+BO(63)*LOG(SA::LIBOR90)+BO(64)*LOG(SA::BOPUI)+BO(65)*LOG(SA::BOLWR)

Observations: 18

R-squared	0.849	Mean dependent var	4.796
Adjusted R-squared	0.786	S.D. dependent var	0.233
S.E. of regression	0.108	Sum squared resid	0.140

					Durbin-Watson stat 0.805
BO(70)	5.721	0.215	26.600	0.000	
BO(71)	0.039	0.033	1.173	0.244	Equation: LOG(SA::BO_GDPPC95)=BO(70)+BO(71)*LOG (SA::BOTIN)+BO(72)*LOG(SA::BOED2(-1))+BO(73)*LOG (SA::BOGCP(-2))+BO(74)*LOG(SA::BOL_INF(-1))+BO(75)*LOG (SA::BOTTP(-1))+BO(77)*LOG(SA::BO_TB1000(-1))
BO(72)	0.224	0.046	4.844	0.000	
BO(73)	0.035	0.017	2.128	0.036	
BO(74)	-0.013	0.003	-4.407	0.000	Observations: 18
BO(75)	0.134	0.030	4.466	0.000	R-squared 0.949 Mean dependent var 7.398
BO(77)	0.027	0.013	2.142	0.035	Adjusted R-squared 0.921 S.D. dependent var 0.052
					S.E. of regression 0.015 Sum squared resid 0.002
					Durbin-Watson stat 2.233
Determinant residual covariance			1.33E-021		

12.3. Brazil

System: DOS_BRA

Estimation Method: Seemingly Unrelated Regression

Date: 08/20/02 Time: 20:31

Sample: 1980 1999

Included observations: 20

Total system (unbalanced) observations 148

	Coefficient	Std. Error	t-Statistic	Prob.					
BR(1)	15.68261	4.29471	3.65161	0.00040		Equation: LOG(SA::BRTE)=BR(1)+BR(2)*DUMBR2+BR(3)*LOG (SA::BR_REER(-1))+BR(4)*LOG(SA::BRTE(-1))+BR(5)*TIME+BR (6)*LOG(SA::AVERAGE_95(-1))+BR(7)*DUMBR2*LOG (SA::BRTE(-1))+BR(8)*LOG(SA::BRAWAY(-1))+BR(9)*LOG (SA::BR_GDPPC95(-1))			
BR(2)	-8.76011	2.10871	-4.15426	0.00010					
BR(3)	-0.19285	0.09499	-2.03019	0.04530					
BR(4)	-0.48758	0.15741	-3.09748	0.00260		Observations: 19			
BR(5)	0.08036	0.01625	4.94643	0.00000		R-squared	0.95	Mean dependent var	9.96
BR(6)	0.40819	0.18210	2.24162	0.02750		Adjusted R-squared	0.92	S.D. dependent var	0.32
BR(7)	0.89168	0.20950	4.25621	0.00010		S.E. of regression	0.09	Sum squared resid	0.08
BR(8)	-0.15280	0.11832	-1.29143	0.19990		Durbin-Watson stat	2.2		
BR(9)	-0.17045	0.41617	-0.40957	0.68310					
BR(10)	-2.14853	11.07238	-0.19404	0.84660					
BR(11)	1.03981	0.31679	3.28235	0.00150		Equation: LOG(SA::BRPCTIM)=BR(10)+BR(11)*LOG (SA::BR_REER(-1)) +BR(12)*LOG(SA::BRPCTIM(-1))+BR(13) *LOG(SA::BRAWY(-1))+BR(14)*LOG(SA::BR_GDPPC)+BR(15) *LOG(SA::WHEAT_95(-1))			
BR(12)	0.58359	0.12650	4.61319	0.00000					
BR(13)	-1.19279	0.60054	-1.98619	0.05010					
BR(14)	1.36300	1.40091	0.97294	0.33320		Observations: 18			
BR(15)	-0.66605	0.31220	-2.13345	0.03560		R-squared	0.72	Mean dependent var	-3.02
						Adjusted R-squared	0.6	S.D. dependent var	0.45
						S.E. of regression	0.29	Sum squared resid	0.98
						Durbin-Watson stat	1.9		
BR(20)	15.53036	3.64047	4.26604	0.00000					
BR(21)	-6.96402	3.55471	-1.95909	0.05320		Equation: LOG(SA::BRNTPR)=BR(20)+BR(21)*DUMBR3+BR(22) *LOG(SA::BR_REER)+BR(23)*LOG(SA::BRNTPR(-1))+BR(24) *LOG(SA::BR_GDPPC95(-1))+BR(25)*LOG(SA::MAIZE_95(-1)) +BR(26)*DUMBR3*LOG(SA::BRNTPR(-1))+BR(27)*LOG (SA::BRAWAY(-1))			
BR(22)	0.04338	0.05402	0.80295	0.42410					
BR(23)	-0.45965	0.26548	-1.73143	0.08680					
BR(24)	-0.42169	0.22332	-1.88832	0.06220					
BR(25)	0.06991	0.07368	0.94879	0.34530		Observations: 19			
BR(26)	0.61103	0.31243	1.95571	0.05360		R-squared	0.81	Mean dependent var	11.31
BR(27)	0.27483	0.04587	5.99226	0.00000		Adjusted R-squared	0.69	S.D. dependent var	0.1

						S.E. of regression	0.06	Sum squared resid	0.04
						Durbin-Watson stat	1.82		
BR(30)	7.85780	2.44861	3.20908	0.00190		Equation: LOG(SA::BRTPR)=BR(30)+BR(31)*LOG(SA::BR_REER)+BR(32)*LOG(SA::BRTPR(-1))+BR(33)*TIME+BR(34)*LOG(SA::BRAWAY(-1))+BR(35)*LOG(SA::BR_GDPPC95)+BR(36)*LOG(SA::AVERAGE_95(-1)/SA::BRAVDD(-1))			
BR(31)	-0.09284	0.04849	-1.91446	0.05880					
BR(32)	0.27402	0.16326	1.67839	0.09680					
BR(33)	0.02737	0.00664	4.12136	0.00010					
BR(34)	-0.12202	0.06566	-1.85850	0.06640		Observations: 19			
BR(35)	0.40765	0.25653	1.58910	0.11560		R-squared	0.94	Mean dependent var	12.9
BR(36)	0.02376	0.02716	0.87468	0.38410		Adjusted R-squared	0.92	S.D. dependent var	0.17
						S.E. of regression	0.05	Sum squared resid	0.03
						Durbin-Watson stat	2.34		
BR(40)	5.98992	0.76710	7.80858	0.00000		Equation: LOG(SA::BRPCAS)=BR(40)+BR(41)*DUMBR+BR(42)*LOG(SA::BR_REER(-1))+BR(43)*LOG(SA::BRPCAS(-1))+BR(44)*LOG(TIME)+BR(45)*DUMBR*LOG(SA::BRPCAS(-1))+BR(46)*LOG(SA::BR_GDPPC95)+BR(47)*LOG(SA::WHEAT_95(-1))+BR(48)*DUMBR*LOG(SA::BR_REER(-1))+BR(49)*LOG(SA::MAIZE_95(-1))			
BR(41)	-11.33474	1.39033	-8.15255	0.00000					
BR(42)	0.04396	0.01675	2.62425	0.01020					
BR(43)	-0.91259	0.11396	-8.00792	0.00000					
BR(44)	-0.05154	0.01030	-5.00331	0.00000					
BR(45)	1.82874	0.22220	8.23028	0.00000					
BR(46)	0.74389	0.09032	8.23665	0.00000		Observations: 19			
BR(47)	-0.17957	0.03694	-4.86076	0.00000		R-squared	0.86	Mean dependent var	6
BR(48)	0.08297	0.02961	2.80215	0.00620		Adjusted R-squared	0.72	S.D. dependent var	0.03
BR(49)	0.04214	0.03470	1.21454	0.22780		S.E. of regression	0.02	Sum squared resid	0
						Durbin-Watson stat	2.16		
BR(50)	-9.34684	9.82214	-0.95161	0.34390		Equation: LOG(SA::BRIMS)=BR(50)+BR(51)*LOG(SA::BR_REER(-1))+BR(52)*LOG(SA::BRIMS(-1))+BR(53)*LOG(SA::BR_GDPPC(-1))+BR(54)*LOG(SA::WHEAT_95(-1))+BR(55)*LOG(SA::MAIZE_95(-1))			
BR(51)	-1.29540	0.28319	-4.57425	0.00000					
BR(52)	0.27308	0.15178	1.79919	0.07540					
BR(53)	2.68217	1.25520	2.13684	0.03540					
BR(54)	-1.07235	0.57767	-1.85634	0.06670		Observations: 19			
BR(55)	0.83546	0.58106	1.43782	0.15400		R-squared	0.69	Mean dependent var	8.05

Adjusted R-squared	0.58	S.D. dependent var	0.41
S.E. of regression	0.27	Sum squared resid	0.93
Durbin-Watson stat	2.52		

BR(60)	-1.68357	1.27532	-1.32012	0.19020
BR(61)	-0.85647	0.15333	-5.58590	0.00000
BR(62)	0.05384	0.01855	2.90332	0.00470
BR(63)	0.54337	0.12788	4.24902	0.00010
BR(64)	-0.06669	0.32616	-0.20447	0.83850
BR(65)	2.27294	0.30825	7.37370	0.00000

Equation: LOG(SA::BR_REER)=BR(60)+BR(61)*LOG (AVERAGE_95) + BR(62)*LOG(SA::BR_DIR)+BR(63)*LOG (SA::LIBOR90)+BR(64)*LOG(SA::BRTIN)+BR(65)*LOG (SA::BRAWR)

Observations: 19

R-squared	0.78	Mean dependent var	4.38
Adjusted R-squared	0.7	S.D. dependent var	0.23
S.E. of regression	0.13	Sum squared resid	0.21
Durbin-Watson stat	1.46		

BR(70)	6.87359	0.60378	11.38419	0.00000
BR(71)	0.18178	0.06481	2.80474	0.00620
BR(72)	0.32066	0.08348	3.84124	0.00020
BR(73)	-0.06655	0.02845	-2.33929	0.02160
BR(74)	-0.01164	0.00878	-1.32669	0.18800
BR(75)	-0.14972	0.04727	-3.16731	0.00210
BR(76)	0.04	0.02	2.35	0.02
Determinant residual covariance			4.39E-022	

Equation: LOG(SA::BR_GDPPC95)=BR(70)+BR(71)*LOG (SA::BRTIN)+BR(72)*LOG(SA::BRED2)+BR(73)*LOG (SA::BRGCP(-1))+BR(74)*LOG(SA::BRA_INF)+BR(75)*LOG (SA::BRTTP)+BR(76)*LOG(SA::BR_TB7000)

Observations: 16

R-squared	0.77	Mean dependent var	8.24
Adjusted R-squared	0.62	S.D. dependent var	0.05
S.E. of regression	0.03	Sum squared resid	0.01
Durbin-Watson stat	1.18		

12.4. Venezuela

System: DOS_VEN

Estimation Method: Seemingly Unrelated Regression

Date: 08/20/02 Time: 20:52

Sample: 1980 1999

Included observations: 20

Total system (unbalanced) observations 147

	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**	
VE(1)	-49.50136	22.56658	-2.19357	0.03080	Equation: LOG(SA::VETE)=VE(1)+VE(2)*LOG(SA::VE_REER(-1))+VE(3)*LOG(SA::VETE(-1))+VE(4)*LOG(SA::VENWAY)+VE(5)*LOG(SA::VE_GDPPC95(-1))+VE(6)*LOG(SA::RICE_95(-1)/SA::SUGAR_95(-1))+VE(7)*LOG(SA::MAIZE_95(-1))
VE(2)	-0.62941	0.44784	-1.40543	0.16330	Observations: 19
VE(3)	0.70475	0.12907	5.46045	0.00000	R-squared 0.85; Mean dependent var 5.31
VE(4)	1.25581	0.83713	1.50015	0.13710	Adjusted R-squared 0.78; S.D. dependent var 0.83
VE(5)	3.47194	1.57686	2.20182	0.03020	S.E. of regression 0.39; Sum squared resid 1.83
VE(6)	0.18222	0.27567	0.66100	0.51030	Durbin-Watson stat 2.27
VE(7)	0.93152	0.46388	2.00810	0.04760	
VE(10)	4.09001	5.89340	0.69400	0.48950	Equation: LOG(SA::VEPCTIM)=VE(10)+VE(17)*DUMVE5+VE(11)*LOG(SA::VE_REER)+VE(12)*LOG(SA::VEPCTIM(-1))+VE(13)*LOG(SA::VE_GDPPC95(-1))+VE(14)*LOG(SA::WHEAT_95(-1))+VE(15)*DUMVE5*LOG(SA::VEPCTIM(-1))
VE(17)	-3.68875	1.52190	-2.42378	0.01740	Observations: 19
VE(11)	0.36037	0.12849	2.80466	0.00620	R-squared 0.65; Mean dependent var 5.17
VE(12)	-0.33852	0.24279	-1.39431	0.16670	Adjusted R-squared 0.48; S.D. dependent var 0.22
VE(13)	0.08946	0.65823	0.13590	0.89220	S.E. of regression 0.16; Sum squared resid 0.31
VE(14)	0.05416	0.15558	0.34810	0.72860	Durbin-Watson stat 1.97
VE(15)	0.73349	0.29959	2.44830	0.01630	

VE(20)	1.20331	2.02869	0.59314	0.55460	
VE(21)	-1.62193	0.50213	-3.23014	0.00170	
VE(22)	-0.25122	0.09664	-2.59956	0.01090	Equation: LOG(SA::VENTPR)=VE(20)+VE(21)*DUMVE2+VE(22)*LOG(SA::VE_REER(-1))+VE(23)*LOG(SA::PETRO_95(-1))+VE(24)*LOG(SA::VENTPR(-1))+VE(25)*DUMVE2*LOG(SA::VE_REER(-1))+VE(26)*LOG(SA::VENWAY)+VE(27)*LOG(SA::SUGAR_95)
VE(23)	0.10227	0.04680	2.18515	0.03150	
VE(24)	0.65211	0.15648	4.16741	0.00010	
VE(25)	0.35095	0.11523	3.04567	0.00300	Observations: 19
VE(26)	0.20347	0.14838	1.37127	0.17370	R-squared 0.94 / Mean dependent var 9.25
VE(27)	-0.04324	0.02675	-1.61606	0.10960	Adjusted R-squared 0.9 / S.D. dependent var 0.16
					S.E. of regression 0.05 / Sum squared resid 0.03
					Durbin-Watson stat 2.49

VE(30)	6.75981	1.88162	3.59255	0.00050	
VE(31)	-0.17576	0.05346	-3.28767	0.00140	Equation: LOG(SA::VETPR)=VE(30)+VE(31)*LOG(SA::VE_REER(-1))+VE(32)*LOG(SA::VETPR(-1))+VE(33)*TIME+VE(34)*LOG(SA::PETRO_95(-1))+VE(35)*LOG(SA::AVERAGE(-1))
VE(32)	0.60793	0.12955	4.69277	0.00000	
VE(33)	0.00804	0.00375	2.14594	0.03460	Observations: 19
VE(34)	0.12351	0.05185	2.38226	0.01930	R-squared 0.92 / Mean dependent var 9.49
VE(35)	-0.44850	0.12675	-3.53853	0.00060	Adjusted R-squared 0.9 / S.D. dependent var 0.16
					S.E. of regression 0.05 / Sum squared resid 0.03
					Durbin-Watson stat 2.32

VE(40)	2.70078	0.61066	4.42273	0.00000	
VE(48)	0.42394	0.13258	3.19766	0.00190	Equation: LOG(VEPCAS)=VE(40)+VE(48)*DUMVE3+VE(41)*LOG(SA::VE_REER(-1))+VE(42)*LOG(VEPCAS(-1))+VE(43)*LOG(SA::PETRO_95(-1))+VE(44)*DUMVE3*LOG(SA::VE_REER(-1))+VE(45)*LOG(SA::WHEAT_95(-1))+VE(46)*LOG(SA::SUGAR_95(-1))+VE(47)*TIME
VE(41)	-0.04584	0.02864	-1.60071	0.11290	
VE(42)	0.58561	0.10534	5.55922	0.00000	
VE(43)	0.08792	0.02016	4.36122	0.00000	
VE(44)	-0.11763	0.02861	-4.11098	0.00010	Observations: 19
VE(45)	-0.17379	0.02963	-5.86519	0.00000	R-squared 0.84 / Mean dependent var 5.87
VE(46)	0.16514	0.01695	9.74592	0.00000	Adjusted R-squared 0.71 / S.D. dependent var 0.04
VE(47)	0.00813	0.00191	4.25738	0.00010	S.E. of regression 0.02 / Sum squared resid 0
					Durbin-Watson stat 2.51

VE(50)	24.14808	6.87006	3.51497	0.00070					
VE(51)	-0.51810	0.17973	-2.88275	0.00490		Equation: LOG(SA::VEIMS)=VE(50)+VE(51)*LOG(SA::VE_REER(-1)) +VE(52)*LOG(SA::VEIMS(-1))+VE(53)*LOG(TIME)+VE(54)*LOG (SA::VE_GDPPC95(-1))+VE(55)*LOG(SA::VEPP3DD(-1)/ SA::MAIZE_95(-1))+VE(56)*LOG(SA::VENWAY)			
VE(52)	0.38477	0.13143	2.92747	0.00430					
VE(53)	0.32420	0.08356	3.87963	0.00020					
VE(54)	-0.95438	0.39629	-2.40826	0.01810		Observations: 16			
VE(55)	0.42758	0.11958	3.57561	0.00060		R-squared	0.9	Mean dependent var	7.26
VE(56)	-0.67310	0.36513	-1.84348	0.06860		Adjusted R-squared	0.84	S.D. dependent var	0.3
						S.E. of regression	0.12	Sum squared resid	0.13
						Durbin-Watson stat	1.75		
VE(60)	12.92737	4.28396	3.01762	0.00330					
VE(61)	-0.36611	0.28508	-1.28425	0.20240		Equation: LOG(SA::VE_REER)=VE(60)+VE(61)*LOG(SA::AVERAGE_ 95)+VE(62)*LOG(SA::VE_DIR)+VE(63)*LOG(SA::LIBOR90)+VE(64) *LOG(SA::VEPUI)+VE(65)*LOG(SA::VENWR)			
VE(62)	-0.01928	0.08442	-0.22837	0.81990					
VE(63)	0.44852	0.16538	2.71201	0.00800		Observations: 19			
VE(64)	0.58255	0.19616	2.96981	0.00380		R-squared	0.6	Mean dependent var	4.62
VE(65)	-1.81330	0.91057	-1.99139	0.04950		Adjusted R-squared	0.44	S.D. dependent var	0.3
						S.E. of regression	0.22	Sum squared resid	0.64
						Durbin-Watson stat	0.88		
VE(70)	6.47568	0.37762	17.14873	0.00000					
VE(71)	0.25474	0.04730	5.38584	0.00000		Equation: LOG(SA::VE_GDPPC95)=VE(70)+VE(71)*LOG(SA::VETIN(-1))+VE(72)*LOG(SA::VEED2(-1))+VE(73)*LOG(VEN_INF(-1)) +VE(75)*LOG(SA::VE_TB2000(-1))+VE(76)*LOG(SA::VETTP(-1)) +VE(77)*LOG(SA::VEGCP(-1))			
VE(72)	0.15634	0.05324	2.93673	0.00420					
VE(73)	-0.03910	0.02093	-1.86816	0.06500					
VE(75)	0.04109	0.00782	5.25554	0.00000		Observations: 17			
VE(76)	0.19647	0.05499	3.57303	0.00060		R-squared	0.7	Mean dependent var	8.71
VE(77)	-0.01338	0.05095	-0.26250	0.79350		Adjusted R-squared	0.52	S.D. dependent var	0.05
						S.E. of regression	0.04	Sum squared resid	0.01
Determinant residual covariance			9.87E-021			Durbin-Watson stat	1.76		

12.5. Argentina: Complete set of results

	Const.	C DUM	RER	LAG	Income	DUM RER	Income W	Average	TAX	Time	Price	Beef/Petro	R2
Exports	-1.682		-0.490	0.369	0.725		0.229	0.425	-0.162			-0.355	0.705
	(40.79)		(2.07)	(0.54)	(8.38)		(6.85)	(17.59)	(9.12)			(0.02%)	
Imports	47.096		0.703	0.860	-4.379		-0.301				-1.482		0.945
	(0.00)		(0.11)	(0.00)	(0.00)		(16.23)				(0.09)		
Non-tradables	1.177		0.021	0.327	0.434		0.161	-0.076	0.073				0.753
	(29.45)		(29.63)	(0.94)	(0.25)		(0.32)	(12.74)	(0.79)				
Total Production	3.089	1.734	0.069	0.358	0.615	-0.452	0.069		-0.105	0.025			0.827
	(12.54)	(0.01)	(16.74)	(2.96)	(0.96)	(0.00)	(16.74)		(0.74)	(0.63)			
Per Capita Agriculture Supply	1.600		0.013	0.257	0.331	-0.001							0.869
	(1.87)		(25.86)	(5.09)	(0.05)	(36.44)							
Imports Substitutes	7.119		-0.688	0.489				-0.296	-0.179		-0.394		0.869
	(4.71)		(0.01)	(0.00)				(2.93)	(2.47)		(14.07)		

	Const.	Average	DIR	Libor90	PIP	ARGWR	R2
RER	-3.774	0.478	-0.147	-0.217	-0.304	1.551	0.843
	(8.91)	6.22	(0.00)	(4.52%)	(22.69)	(0.04)	
	Const.	**TIN**	**GCP**	**INF**	**TTP**	**TB5000**	**R2**
GDPPC	4.056	1.188	0.082	-0.012	0.266	0.018	0.999
	(0.00)	(0.00)	(0.09)	(0.02)	(0.00)	(0.05)	

12.6. Bolivia: Complete set of results

	Const.	C DUM	RER	LAG	Income	DUM LAG	Income W	Average	NT price	Wheat	Time	Sugar	Soybean	Don.	R^2
Exports	-4.645		-3.766	0.373	1.508		0.731					0.421	0.592		0.879
	(39.85)		(0.43)	(0.15)	(23.88)		(12.44)					(6.29)	(23.95)		
Imports	7.467	-7.631	0.647	-0.987	-2.208	1.935				-0.418				0.250	0.685
	(0.07)	(0.00)	(3.52)	(0.00)	(33.35)	(0.00)				(2.15)				(0.07)	
Non-tradables	21.480	-2.766	0.634	0.731	-1.153	-0.404		-0.525	0.070		0.018			-0.025	0.985
	(0.00)	(0.30)	(0.00)	(0.00)	(0.02)	(0.05)		(0.00)	(0.19)		(0.28)			(0.79)	
Total Production	-6.994	-3.747	-1.347	-0.302	2.745	0.426	-1.347	0.442	0.493						0.930
	(2.40)	(7.01)	(0.00)	(11.79)	(0.00)	(6.79)	(0.00)	(0.01)	(0.00)						
Per Capita Agri. Supply	11.348	-5.521	0.109	-0.736	-0.227	0.960									0.832
	(0.00)	(0.03)	(0.66)	(0.00)	(7.36)	(0.02)									
Imports Substitutes	-12.299	-3.698	-2.000	-0.286	4.648	0.797	-0.615			0.285					0.740
	(18.12)	(0.87)	(0.10)	(10.13)	(0.33)	(1.01)	(6.62)			(30.21)					

	Const.	Average	DIR	Libor90	PIP	BOGWR		R^2
RER	2.861	0.400	0.081	0.231	0.182	-0.390		0.849
	(4.64)	(0.28)	(18.20)	(0.37)	(8.64)	(3.78)		

	Const.	TIN	ED2	GCP	INF	TTP	TB1000	R^2
GDPPC	5.721	0.039	0.224	0.035	-0.013	0.134	0.027	0.949
	(0.00)	(12.20)	(0.00)	(1.82)	(0.00)	(0.00)	(1.76)	

12.7. Brazil: Complete set of results

	Const.	C DUM	RER	LAG	Income	DUM RER	DUM LAG	Income W	Average	Maize	Wheat	Time	R^2
Exports	15.683	-8.760	-0.193	-0.488	-0.170		0.892	-0.153	0.408			0.080	0.954
	(0.02)	(0.01)	(2.27)	(0.13)	(34.16)		(0.01)	(10.00)	(1.38)			(0.00)	
Imports	-2.149		1.040	0.584	1.363			-1.193			-0.666		0.718
	(42.33)		(0.08)	(0.00)	(16.66)			(2.51%)			(1.78)		
Non-tradables	15.530	-6.964	0.043	-0.460	-0.422		0.611	0.275		0.070			0.809
	(0.00)	(2.66)	(21.21)	(4.34)	(3.11)		(2.68)	(0.00)		(17.27)			
Total Production	7.858		-0.093	0.274	0.408			-0.093	0.024			0.027	0.944
	(0.10)		(2.94)	(4.84)	(5.78)			(2.94)	(19.21)			(0.01)	
Per Capita Ag. Supply	5.990	-11.335	0.044	-0.913	0.744	0.083	1.829			0.042	-0.180	-0.052	0.859
	(0.00)	(0.00)	(0.51)	(0.00)	(0.00)	(0.31)	(0.00)			(11.39)	(0.00)	(0.00)	
Imports Substitutes	-9.347		-1.295	0.273	2.682					0.835	-1.072		0.693
	(17.20)		(0.00)	(3.77)	(1.77)					(7.70)	(3.34)		

	Const.	Average	DIR	Libor90	PIP	BRGWR		R^2
RER	-1.684	-0.856	0.054	0.543	-0.067	2.273		0.784
	(9.51)	(0.00)	(0.24)	(0.01)	(41.93)	(0.00)		

	Const.	TIN	ED2	GCP	INF	TTP	TB7000	R^2
GDPPC	6.874	0.182	0.321	-0.067	-0.012	-0.150	0.038	0.770
	(0.00)	(0.31)	(0.01)	(1.08%)	(9.40)	(0.11)	(1.04)	

12.8. Venezuela: Complete set of results

	Const.	C DUM	RER	LAG	Income	DUM RER	DUM LAG	Income W	Petro	Average	Wheat	Rice	Maize	Time	Sugar	R^2
Exports	-49.501		-0.629	0.705	3.472			1.256				0.182	0.932			0.853
	(1.54)		(8.17)	(0.00)	(1.51)			(6.86)				(25.52)	(2.38)			
Imports	4.090	-3.689	0.360	-0.339	0.089		0.733				0.054					0.653
	(24.48)	(0.87)	(0.31)	(8.34)	(44.61)		(0.82)				(36.43)					
Non-tradables	1.203	-1.622	-0.251	0.652		0.351		0.203	0.102						-0.043	0.936
	(27.73)	(0.09)	(0.55)	(0.01)		(0.15)		(8.69)	(1.58)						(5.48)	
Total Production	6.760		-0.176	0.608					0.124	-0.449				0.008		0.925
	(0.03)		(0.07)	(0.00)					(0.97)	(0.03)				(1.73)		
Per Capita Ag. Supply	2.701	0.424	-0.046	0.586		-0.118			0.088		-0.174			0.008	0.165	0.840
	(0.00)	(0.10)	(5.65)	(0.00)		(0.01)			(0.00)		(0.00)			(0.01)	(0.00)	
Imports Substitutes	24.148		-0.518	0.385	-0.954			-0.673					0.428	0.324		0.905
	(0.04)		(0.25)	(0.22)	(0.91)			(3.43)					(0.03)	(0.01)		

	Const.	Average	DIR	Libor90	PIP	VEGWR		R^2
RER	12.927	-0.366	-0.019	0.449	0.583	-1.813		0.596
	(0.17)	(10.12)	(41.00)	(0.40)	(0.19)	(2.48)		

	Const.	TIN	ED2	GCP	INF	TTP	TB2000	R^2
GDPPC	6.476	0.255	0.156	-0.013	-0.039	0.196	0.041	0.700
	(0.00)	(0.00)	(0.21)	(39.68)	(3.25)	(0.03)	(0.00)	

Annex 5

13. Annex 5: Mathematical analysis of the overshooting effect on agricultural and non-agricultural prices (Chapter 4)

We use the logarithmic form of the model described in the paper (equations 4.1a through 4.1h'), then:

$$r = r' + x \quad \text{Eq. 13.1}$$

$$x = \dot{e} \quad \text{Eq. 13.2}$$

$$m - p = X y - \lambda r \quad \text{Eq. 13.3}$$

$$p = \alpha_1 p_{AF} + \alpha_2 p_{NAF} + \alpha_3 p_{AS} + \alpha_4 p_{NAS} \quad \text{Eq. 13.4}$$

$$y^s_{AF} = \gamma_1 (e + p' - p_{AF}) + \gamma_2 (p_{AS} - p_{AF}) + \gamma_3 (p_{NAS} + p_{AF}) - \gamma_4 (r - \dot{p}) + \gamma_5 y \quad \text{Eq. 13.5}$$

$$y^s_{NAF} = \phi_1 (e + p' - p_{NAF}) + \phi_2 (p_{AS} - p_{NAF}) + \phi_3 (p_{NAS} + p_{NAF}) - \phi_4 (r - \dot{p}) + \phi_5 y \quad \text{Eq. 13.6}$$

$$\dot{p_{AS}} = \pi_1 \left[y^s_{AS} - y^d_{AS} \right] \quad \text{Eq. 13.7}$$

$$\dot{p_{NAS}} = \pi_2 \left[y^s_{NAS} - y^d_{NAS} \right] \quad \text{Eq. 13.8}$$

$$y^d_{AS} = \delta_1 (e + p' - p_{AS}) + \delta_2 (p_{AF} - p_{AS}) + \delta_3 (p_{NAS} + p_{AS}) - \delta_4 (r - \dot{p}) + \delta_5 y \quad \text{Eq. 13.9}$$

$$y^d_{NAS} = \omega_1 (e + p' - p_{NAS}) + \omega_2 (p_{AF} - p_{NAS}) + \omega_3 (p_{AS} + p_{NAS}) - \omega_4 (r - \dot{p}) + \omega_5 y \quad \text{Eq. 13.10}$$

Substituting (13.2) in (13.1) we have:

$$m - p = xy - \lambda (r' + \dot{e}) \quad \text{Eq. 13.11}$$

Replacing ***p*** from (13.3) in (13.11) yields,

$$m-\left(\alpha_1 p_{AF}+\alpha_2 p_{NAF}+\alpha_3 p_{AS}+\alpha_4 p_{NAS}\right)=X\,y-\lambda\left(r'+\dot{e}\right) \qquad \textbf{Eq. 13.12}$$

Taking the long-run values of (13.12),

$$\bar{m}-\left(\alpha_1 \bar{p}_{AF}+\alpha_2 \bar{p}_{NAF}+\alpha_3 \bar{p}_{AS}+\alpha_4 \bar{p}_{NAS}\right)=X\,\bar{y}-\lambda\left(r'+\dot{e}\right) \qquad \textbf{Eq. 13.13}$$

Where we have used the assumption that in the long run r' = 0. Subtracting (13.13) from (13.12) we have,

$$\begin{aligned}&m-\bar{m}-\alpha_1 p_{AF}+\alpha_1 \bar{p}_{AF}-\alpha_2 p_{NAF}+\alpha_2 \bar{p}_{NAF}-\alpha_3 p_{AS}+\alpha_3 \bar{p}_{AS}-\alpha_4 p_{NAS}\\&+\alpha_4 \bar{p}_{NAS}=X\,y-\lambda r+\lambda r'-X\,\bar{y}-\lambda\dot{e}\end{aligned} \qquad \textbf{Eq. 13.14}$$

In the long run $m=\bar{m}$ and r=r', also $y=\bar{y}$, therefore, rearranging (13.14) we have,

$$-\alpha_1\left(p_{AF}-\bar{p}_{AF}\right)-\alpha_2\left(p_{NAF}-\bar{p}_{NAF}\right)-\alpha_3\left(p_{AS}-\bar{p}_{AS}\right)-\alpha_4\left(p_{NAS}-\bar{p}_{NAS}\right)=-\lambda\dot{e}$$

$$\dot{e}=\frac{1}{\lambda}\left\{\alpha_1\left(p_{AF}-\bar{p}_{AF}\right)+\alpha_2\left(p_{NAF}-\bar{p}_{NAF}\right)+\alpha_3\left(p_{AS}-\bar{p}_{AS}\right)+\alpha_4\left(p_{NAS}-\bar{p}_{NAS}\right)\right\} \qquad \textbf{Eq. 13.15}$$

Now we turn to the supply and demand equations. We will start with the sluggish sector, replacing (13.9) in (13.7) we have,

$$\begin{aligned}&\dot{p}_{AS}=\pi_1\left[\delta_1\left(e+p'-p_{AS}\right)+\delta_2\left(p_{AF}-p_{AS}\right)+\delta_3\left(p_{NAS}+p_{AS}\right)\right.\\&\left.-\delta_4\left(r-\dot{p}\right)+\delta_5 y-y^s_{AS}\right]+u\end{aligned} \qquad \textbf{Eq. 13.16}$$

Taking the long-run values of (13.16),

$$\dot{p}_{AS}=\pi_1\Big[\delta_1\big(\bar{e}+p'-\bar{p}_{AS}\big)+\delta_2\big(\bar{p}_{AF}-\bar{p}_{AS}\big)+\delta_3\big(\bar{p}_{NAS}+\bar{p}_{AS}\big)$$
$$-\delta_4\big(r-\dot{p}\big)+\delta_5\bar{y}-\bar{y}^s_{AS}\Big]+u \qquad \textbf{Eq. 13.17}$$

In the long-run $y^d_{AS} = \bar{y}^s_{AS}$, therefore, replacing (13.9) in (13.17) we have:

$$\dot{p}_{AS}=\pi_1\begin{bmatrix}\delta_1\big(\bar{e}+p'-\bar{p}_{AS}\big)+\delta_2\big(\bar{p}_{AF}-\bar{p}_{AS}\big)+\delta_3\big(\bar{p}_{NAS}+\bar{p}_{AS}\big)-\delta_4\big(r'-\dot{p}\big)\\ +\delta_5\bar{y}-\delta_1\big(e+p'-p_{AS}\big)+\delta_2\big(p_{AF}-p_{AS}\big)+\delta_3\big(p_{NAS}+p_{AS}\big)\\ -\delta_4\big(r-\dot{p}\big)+\delta_5 y\end{bmatrix}+u$$

$$\dot{p}_{AS}=\pi_1\Big[\delta_1(e-\bar{e})+\delta_1(p_{AS}-\bar{p}_{AS})-\delta_2(p_{AF}-\bar{p}_{AF})+\delta_2(p_{AS}-\bar{p}_{AS})-$$
$$\delta_3(p_{NAS}+\bar{p}_{NAS})+\delta_3(p_{AS}-\bar{p}_{AS})+\delta_4(r-r')-\delta_5(y-\bar{y})-\delta_4\dot{p}\Big]+u \qquad \textbf{Eq. 13.18}$$

Recalling that in the long-run $y=\bar{y}$ and $r=r'+\dot{e}$ and replacing (13.15) into (13.18) we have,

$$\dot{p}_{AS}=\pi_1\Big[-\delta_1(e-\bar{e})+\delta_1(p_{AS}-\bar{p}_{AS})-\delta_2(p_{AF}-\bar{p}_{AF})+\delta_2(p_{AS}-\bar{p}_{AS})-$$
$$\delta_3(p_{NAS}+\bar{p}_{NAS})+\delta_3(p_{AS}-\bar{p}_{AS})+\delta_4\dot{e}-\delta_4\dot{p}\Big]+u$$

$$\dot{p}_{AS}=\pi_1\begin{bmatrix}-\delta_1\big(e-\bar{e}\big)+\delta_1\big(p_{AS}-\bar{p}_{AS}\big)-\delta_2\big(\bar{p}_{AF}-\bar{p}_{AF}\big)+\delta_2\big(p_{AS}-\bar{p}_{AS}\big)-\delta_3\big(p_{NAS}+\bar{p}_{NAS}\big)\\ +\delta_3\big(p_{AS}-\bar{p}_{AS}\big)+\delta_4\left\{\dfrac{1}{\lambda}\begin{Bmatrix}\alpha_1\big(p_{AF}-\bar{p}_{AF}\big)+\alpha_2\big(p_{NAF}-\bar{p}_{NAF}\big)+\alpha_3\big(p_{AS}-\bar{p}_{AS}\big)\\ +\alpha_4\big(p_{NAS}-\bar{p}_{NAS}\big)\end{Bmatrix}\right\}\\ -\delta_4\dot{p}\end{bmatrix}+u$$

$$\dot{p}_{AS}=\pi_1\Big\{\delta_1(e-\bar{e})+\delta_1(p_{AS}-\bar{p}_{AS})-\delta_2(p_{AF}-\bar{p}_{AF})+\delta_2(p_{AS}-\bar{p}_{AS})$$
$$-\delta_3(p_{NAS}+\bar{p}_{NAS})+\delta_3(p_{AS}-\bar{p}_{AS})$$
$$+\delta_4\left[\frac{1}{\lambda}\{\alpha_1(p_{AF}-\bar{p}_{AF})+\alpha_2(p_{NAF}-\bar{p}_{NAF})+\alpha_3(p_{AS}-\bar{p}_{AS})+\alpha_4(p_{NAS}-\bar{p}_{NAS})\}\right] \qquad \textbf{Eq. 13.19}$$
$$-\delta_4\dot{p}\Big\}+u$$

Taking the total differential of (13.4) with respect to time and replacing in (13.19) and after some rearranging,

$$\dot{p}_{AS}=\pi_1\Bigg\{-\delta_1(e-\bar{e})+\left(\frac{\delta_4\alpha_3}{\lambda}+\delta_1+\delta_2+\delta_3\right)(p_{AS}-\bar{p}_{AS})-\left(\frac{\delta_4\alpha_1}{\lambda}-\delta_2\right)$$
$$(p_{AF}-\bar{p}_{AF})-\left(\frac{\delta_4\,\alpha_4}{\lambda}+\delta_3\right)(p_{NAS}+\bar{p}_{NAS})+\frac{\delta_4\alpha_2}{\lambda}(p_{NAF}-\bar{p}_{NAF})-$$
$$\delta_4(\alpha_1\dot{p}_{AF}+\alpha_2\dot{p}_{NAF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS})\Bigg\}+u$$

$$\dot{p}_{AS}(1+\delta_4\pi_1\alpha_3)=\pi_1\Bigg\{-\delta_1(e-\bar{e})+\left(\frac{\delta_4\alpha_3}{\lambda}+\delta_1+\delta_2+\delta_3\right)(p_{AS}-\bar{p}_{AS})$$
$$-\left(\frac{\delta_4\alpha_1}{\lambda}-\delta_2\right)(p_{AF}-\bar{p}_{AF})-\left(\frac{\delta_4\,\alpha_4}{\lambda}+\delta_3\right)(p_{NAS}+\bar{p}_{NAS})+\frac{\delta_4\alpha_2}{\lambda}(p_{NAF}-\bar{p}_{NAF})-$$
$$\delta_4(\alpha_1\dot{p}_{AF}+\alpha_2\dot{p}_{NAF}+\alpha_4\dot{p}_{NAS})\Bigg\}+u$$

Eq. 13.20

Following the same steps for equations (13.8) and (13.10) and with the same assumptions we have,

$$\dot{p}_{NAS}=\pi_2\left[\omega_1(e+p'-p_{NAS})+\omega_2(p_{AF}-p_{NAS})+\omega_3(p_{AS}+p_{NAS})-\omega_4(r-\dot{p})+\omega_5 y-y^s_{NAS}\right]+u$$

Taking the long-run values:

$$\dot{p}_{NAS}=\pi_2\Big[\omega_1(\bar{e}+p'-\bar{p}_{NAS})+\omega_2(\bar{p}_{AF}-\bar{p}_{NAS})+\omega_3(\bar{p}_{AS}+\bar{p}_{NAS})$$
$$-\omega_4(r'-\dot{p})+\omega_5\bar{y}-\bar{y}^s_{NAS}\Big]+u$$

Eq. 13.21

Recalling that in the long-run $y^d_{NAS}=\bar{y}^s_{NAS}$ then, using (13.10) in (13.21) yields,

$$\dot{p}_{NAS}=\pi_2\begin{bmatrix}\omega_1(\bar{e}+p'-\bar{p}_{NAS})+\omega_2(\bar{p}_{AF}-\bar{p}_{NAS})+\omega_3(\bar{p}_{AS}+\bar{p}_{NAS})-\omega_4(r'-\dot{p})\\ +\omega_5\bar{y}-\omega_1(e+p'-p_{NAS})+\omega_2(p_{AF}-p_{NAS})+\omega_3(p_{AS}+p_{NAS})\\ -\omega_4(r-\dot{p})+\omega_5 y\end{bmatrix}+u$$

$$\dot{p}_{NAS} = \pi_2 \begin{bmatrix} -\omega_1(e-\bar{e}) + \omega_1(p_{NAS} - \bar{p}_{NAS}) - \omega_2(p_{AF} + \bar{p}_{AF}) + \omega_2(p_{NAS} - \bar{p}_{NAS}) \\ -\omega_3(p_{AS} - \bar{p}_{AS}) + \omega_3(p_{NAS} - \bar{p}_{NAS}) + \omega_4(r - r') - \omega_4 \dot{p} - \omega_5(y - \bar{y}) \end{bmatrix} + u$$

Using the long-run properties $y = \bar{y}$ and $r = r' + \dot{e}$ and using (13.15) we have,

$$\dot{p}_{NAS} = \pi_2 \begin{bmatrix} -\omega_1(e-\bar{e}) + \omega_1(p_{NAS} - \bar{p}_{NAS}) - \omega_2(p_{AF} + \bar{p}_{AF}) + \omega_2(p_{NAS} - \bar{p}_{NAS}) \\ -\omega_3(p_{AS} - \bar{p}_{AS}) + \omega_3(p_{NAS} - \bar{p}_{NAS}) + \omega_4 \dot{e} - \omega_4 \dot{p} \end{bmatrix} + u$$

$$\dot{p}_{NAS} = \pi_2 \begin{bmatrix} -\omega_1(e-\bar{e}) + \omega_1(p_{NAS} - \bar{p}_{NAS}) - \omega_2(p_{AF} + \bar{p}_{AF}) + \omega_2(p_{NAS} - \bar{p}_{NAS}) \\ -\omega_3(p_{AS} - \bar{p}_{AS}) + \omega_3(p_{NAS} - \bar{p}_{NAS}) \\ +\omega_4 \frac{1}{\lambda}\{\alpha_1(p_{AF} - \bar{p}_{AF}) + \alpha_2(p_{NAF} - \bar{p}_{NAF}) + \alpha_3(p_{AS} - \bar{p}_{AS}) + \alpha_4(p_{NAS} - \bar{p}_{NAS})\} - \omega_4 \dot{p} \end{bmatrix} + u$$

Replacing the total differential of (13.4) with respect to time ($\dot{p} = \alpha_1 \dot{p}_{AF} + \alpha_2 p_{NAF} + \alpha_3 p_{AS} + \alpha_4 p_{NAS}$) and rearranging we have,

$$\dot{p}_{NAS} = \pi_2 \begin{bmatrix} -\omega_1(e-\bar{e}) + \left(\frac{\omega_4\alpha_4}{\lambda} + \omega_1 + \omega_2 + \omega_3\right)(p_{NAS} - \bar{p}_{NAS}) + \\ \left(\frac{\omega_4\alpha_1}{\lambda} - \omega_2\right)(p_{AF} + \bar{p}_{AF}) + \left(\frac{\omega_4\alpha_3}{\lambda} - \omega_3\right)(p_{AS} - \bar{p}_{AS}) \\ + \frac{\omega_4\alpha_2}{\lambda}(p_{NAF} - \bar{p}_{NAF}) - \omega_4(\alpha_1\dot{p}_{AF} + \alpha_2\dot{p}_{NAF} + \alpha_3\dot{p}_{AS}) \end{bmatrix} - \omega_4\alpha_4\pi_2\dot{p}_{NAS} + u$$

$$\begin{aligned} \dot{p}_{NAS}(1+\omega_4\alpha_4\pi_2) = \pi_2 \Bigg[& -\omega_1(e-\bar{e}) + \left(\frac{\omega_4\alpha_4}{\lambda} + \omega_1 + \omega_2 + \omega_3\right)(p_{NAS} - \bar{p}_{NAS}) \\ & + \left(\frac{\omega_4\alpha_4}{\lambda} - \omega_2\right)(p_{AF} - \bar{p}_{AF}) + \left(\frac{\omega_4\alpha_3}{\lambda} - \omega_3\right)(p_{AS} - \bar{p}_{AS}) \\ & + \frac{\omega_4\lambda_2}{\lambda}(p_{NAF} - \bar{p}_{NAF}) - \omega_4(\alpha_1\dot{p}_{AF} + \alpha_2\dot{p}_{NAF} + \alpha_3\dot{p}_{AS}) \Bigg] + u \end{aligned}$$

Eq. 13.22

So far we have worked with sluggish prices, and we have to do the same with the flexible ones. Taking the long-run values of (13.5) we have,

$$\bar{y}^{s}_{AF}=\gamma_1(\bar{e}+p'-\bar{p}_{AF})+\gamma_2(\bar{p}_{AS}-\bar{p}_{AF})+\gamma_3(\bar{p}_{NAS}+\bar{p}_{AF})$$
$$-\gamma_4(r'-\dot{p})+\gamma_5\bar{y}$$ **Eq. 13.23**

In the long-run $y^{d}_{AF}=\bar{y}^{s}_{AF}$ and $\dot{p}=0$. Therefore, using (13.5) and replacing in (13.23) we have,

$$\gamma_1(e+p'-p_{AF})+\gamma_2(p_{AS}-p_{AF})+\gamma_3(p_{NAS}+p_{AF})-\gamma_4(r-\dot{p})+\gamma_5 y=\gamma_1(\bar{e}+p'-\bar{p}_{AF})$$
$$+\gamma_2(\bar{p}_{AS}-\bar{p}_{AF})+\gamma_3(\bar{p}_{NAS}+\bar{p}_{AF})-\gamma_4(r'-\dot{p})+\gamma_5\bar{y}$$

$$\gamma_4\dot{p}=-\gamma_1 e+\gamma_1 p_{AF}-\gamma_2 p_{AS}+\gamma_2 p_{AF}-\gamma_3 p_{NAS}+\gamma_3 p_{AF}+\gamma_4 r$$
$$-\gamma_5 y+\gamma_5\bar{y}+\gamma_1\bar{e}+\gamma_1\bar{p}_{AF}+\gamma_2\bar{p}_{AS}-\gamma_2\bar{p}_{AF}+\gamma_3\bar{p}_{NAS}-\gamma_3\bar{p}_{AF}+\gamma_4 r'$$ **Eq. 13.24**

Replacing $\dot{p}=\alpha_1\dot{p}_{AF}+\alpha_2\dot{p}_{NAF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS}$ and $r-r'=\dot{e}$ in (13.24) and recalling that in the long-run $y=\bar{y}$ we have,

$$\gamma_4(\alpha_1\dot{p}_{AF}+\alpha_2\dot{p}_{NAF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS})=-\gamma_1(e-\bar{e})+(\gamma_1+\gamma_2+\gamma_3)(p_{AF}-\bar{p}_{AF})$$
$$-\gamma_2(p_{AS}-\bar{p}_{AS})-\gamma_3(p_{NAS}-\bar{p}_{NAS})-\gamma_4(\dot{e})$$ **Eq. 13.25**

Replacing (13.15) in (13.25) we have,

$$\gamma_4(\alpha_1\dot{p}_{AF}+\alpha_2\dot{p}_{NAF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS})=-\gamma_1(e-\bar{e})+(\gamma_1+\gamma_2+\gamma_3)(p_{AF}-\bar{p}_{AF})$$
$$-\gamma_2(p_{AS}-\bar{p}_{AS})-\gamma_3(p_{NAS}-\bar{p}_{NAS})-\gamma_4\left(\frac{1}{\lambda}\begin{Bmatrix}\alpha_1(p_{AF}-\bar{p}_{AF})+\alpha_2(p_{NAF}-\bar{p}_{NAF})\\+\alpha_3(p_{AS}-\bar{p}_{AS})+\alpha_4(p_{NAS}-\bar{p}_{NAS})\end{Bmatrix}\right)$$

$$\gamma_4\alpha_1\dot{p}_{AF}=-\gamma_1(e-\bar{e})+\left(\frac{\gamma_4\alpha_3}{\lambda}-\gamma_2\right)(p_{AS}-\bar{p}_{AS})$$
$$+\left(\frac{\gamma_4\alpha_1}{\lambda}+\gamma_1+\gamma_2+\gamma_3\right)(p_{AF}-\bar{p}_{AF})+\left(\frac{\gamma_4\alpha_4}{\lambda}-\gamma_3\right)(p_{NAS}-\bar{p}_{NAS}) \quad \textbf{Eq. 13.26}$$
$$+\frac{\gamma_4\alpha_2}{\lambda}(p_{NAF}-\bar{p}_{NAF})-\gamma_4(\alpha_2\dot{p}_{NAF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS})$$

Following the same procedure for $\boldsymbol{p_{NAF}}$ and using the long-run values of (13.6) yields,

$$\bar{y}^s_{NAF}=\phi_1(\bar{e}+p'-\bar{p}_{NAF})+\phi_2(\bar{p}_{AS}-\bar{p}_{NAF})+\phi_3(\bar{p}_{NAS}+\bar{p}_{NAF})-\phi_4 r'+\phi_5\bar{y} \quad \textbf{Eq. 13.27}$$

Where in (13.27) we have used the fact that in the long-run $\dot{p}=0$. Substituting (13.6) in (13.27) and rearranging we have,

$$\phi_1(e+p'-p_{NAF})+\phi_2(p_{AS}-p_{NAF})+\phi_3(p_{NAS}+p_{NAF})-\phi_4(r-\dot{p})$$
$$+\gamma_5 y=\phi_1(\bar{e}-p'-\bar{p}_{NAF})+\phi_2(\bar{p}_{AS}-\bar{p}_{NAF})+\phi_3(\bar{p}_{NAS}+\bar{p}_{NAF})-\phi_4 r'+\phi_5\bar{y}$$
$$\phi_4\dot{p}=-\phi_1(e-\bar{e})+\phi_1(p_{NAF}-\bar{p}_{NAF})-\phi_2(p_{AS}-\bar{p}_{AS})+\phi_2(p_{NAF}+\bar{p}_{NAF})$$
$$-\phi_3(p_{NAS}-\bar{p}_{NAS})+\phi_3(p_{NAF}-\bar{p}_{NAF})+\phi_4(r-r')-\phi_5(y-\bar{y}) \quad \textbf{Eq. 13.28}$$

Using the relations $\dot{p}=\alpha_1\dot{p}_{AF}+\alpha_2\dot{p}_{NAF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS}$ and $r-r'=\dot{e}$ in (13.28) and recalling that in the long-run $y=\bar{y}$ we have,

$$\phi_4(\alpha_1\dot{p}_{AF}+\alpha_2\dot{p}_{NAF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS})=-\phi_1(e-\bar{e})+\phi_1(p_{NAF}-\bar{p}_{NAF})-\phi_2(p_{AS}-\bar{p}_{AS})$$
$$+\phi_2(p_{NAF}-\bar{p}_{NAF})-\phi_3(\bar{p}_{NAS}-\bar{p}_{NAS})+\phi_3(\bar{p}_{NAF}-\bar{p}_{NAF})+\phi_4\dot{e}$$
$$\phi_4\alpha_2\dot{p}_{NAF}=-\phi_1(e-\bar{e})+(\phi_1+\phi_2+\phi_3)(p_{NAF}-\bar{p}_{NAF})-\phi_2(p_{AS}-\bar{p}_{AS})-\phi_3(\bar{p}_{NAS}-\bar{p}_{NAS})$$
$$+\phi_4\frac{1}{\lambda}\begin{Bmatrix}\alpha_1(p_{AF}-\bar{p}_{AF})+\alpha_2(p_{NAF}-\bar{p}_{NAF})\\+\alpha_3(p_{AS}-\bar{p}_{AS})+\alpha_4(p_{NAS}-\bar{p}_{NAS})\end{Bmatrix}-\phi_4(\alpha_1\dot{p}_{AF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS})$$

$$\phi_4\alpha_2\dot{p}_{NAF} = -\phi_1(e-\bar{e}) + \left(\frac{\phi_4\alpha_2}{\lambda}+\phi_1+\phi_2+\phi_3\right)(p_{NAF}-\bar{p}_{NAF})$$
$$+\frac{\phi_4\alpha_1}{\lambda}(p_{AF}-\bar{p}_{AF}) + \left(\frac{\phi_4\alpha_3}{\lambda}-\phi_2\right)(p_{AS}-\bar{p}_{AS}) + \left(\frac{\phi_4\alpha_4}{\lambda}-\phi_3\right)(p_{AS}-\bar{p}_{AS})$$
$$-\phi_4(\alpha_1\dot{p}_{AF}+\alpha_3\dot{p}_{AS}+\alpha_4\dot{p}_{NAS})$$

Eq. 13.29

Changing variables in equations (13.15), (13.20), (13.22), (13.26) and (13.26) to facilitate the second part of the discussion we have:

$$\dot{e} = \frac{1}{\lambda}\{\alpha_1(p_{AF}-\bar{p}_{AF}) + \alpha_2(p_{NAF}-\bar{p}_{NAF}) + \alpha_3(p_{AS}-\bar{p}_{AS})$$
$$+\alpha_4(p_{NAS}-\bar{p}_{NAS})\}$$

Eq. 13.30

$$\dot{p}_{AS}(1+a_5) = \pi_1[A-\delta_4\alpha_1\dot{p}_{AF}-\delta_4\alpha_2\dot{p}_{NAF}-\delta_4\alpha_4\dot{p}_{NAS}]+u$$ **Eq. 13.31**

$$\dot{p}_{NAS}(1+a_6) = \pi_2[B-\omega_4\alpha_1\dot{p}_{AF}-\omega_4\alpha_2\dot{p}_{NAF}-\omega_4\alpha_3\dot{p}_{AS}]+u$$ **Eq. 13.32**

$$\gamma_4\alpha_1\dot{p}_{AF} = C-\gamma_4\alpha_2\dot{p}_{NAF}-\gamma_4\alpha_3\dot{p}_{AS}-\gamma_4\alpha_4\dot{p}_{NAS}$$ **Eq. 13.33**

$$\phi_4\alpha_2\dot{p}_{NAF} = D-\phi_4\alpha_1\dot{p}_{AF}-\phi_4\alpha_3\dot{p}_{AS}-\phi_4\alpha_4\dot{p}_{NAS}$$ **Eq. 13.34**

where:

$$a_1 = \frac{\delta_4\alpha_3}{\lambda}+\delta_1+\delta_2+\delta_3 \qquad a_4 = \frac{\delta_4\alpha_2}{\lambda}$$
$$a_5 = \frac{\delta_4\alpha_1}{\lambda}-\delta_2 \qquad a_2 = \delta_4\pi_1\alpha_3$$
$$a_3 = \frac{\delta_4\alpha_4}{\lambda}-\delta_3$$
$$A = -\delta_1(e-\bar{e})+a_1(p_{AS}-\bar{p}_{AS})-a_5(p_{AF}-\bar{p}_{AF})-a_3(p_{NAS}-\bar{p}_{NAS})+a_4(p_{NAF}-\bar{p}_{NAF})$$
$$a_6 = \omega_4\alpha_4\pi_2 \qquad a_9 = \frac{\omega_4\alpha_3}{\lambda}-\omega_3$$
$$a_7 = \frac{\omega_4\alpha_4}{\lambda}+\omega_1+\omega_2+\omega_3 \qquad a_{10} = \frac{\omega_4\alpha_2}{\lambda}$$
$$a_8 = \frac{\omega_4\alpha_1}{\lambda}-\omega_2$$
$$B = -\omega_1(e-\bar{e})+a_7(p_{NAS}-\bar{p}_{NAS})-a_8(p_{AF}-\bar{p}_{AF})-a_9(p_{AS}-\bar{p}_{AS})+a_{10}(p_{NAF}-\bar{p}_{NAF})$$

$$a_{11} = \frac{\gamma_4 \alpha_3}{\lambda} - \gamma_2 \qquad a_{13} = \frac{\gamma_4 \alpha_4}{\lambda} - \gamma_3$$

$$a_{12} = \frac{\gamma_4 \alpha_1}{\lambda} + \gamma_1 + \gamma_2 + \gamma_3 \qquad a_{14} = \frac{\gamma_4 \alpha_2}{\lambda}$$

$$C = -\gamma_1 (e - \bar{e}) + a_{11}(p_{AS} - \bar{p}_{AS}) + a_{12}(p_{AF} - \bar{p}_{AF}) + a_{13}(p_{NAS} - \bar{p}_{NAS}) + a_{14}(p_{NAF} - \bar{p}_{NAF})$$

$$a_{15} = \frac{\phi_4 \alpha_2}{\lambda} + \phi_1 + \phi_2 + \phi_3 \qquad a_{17} = \frac{\phi_4 \alpha_3}{\lambda} - \phi_2$$

$$a_{16} = \frac{\phi_4 \alpha_1}{\lambda} \qquad a_{18} = \frac{\phi_4 \alpha_4}{\lambda} - \phi_3$$

$$D = -\phi_1 (e - \bar{e}) + a_{15}(p_{NAF} - \bar{p}_{NAF}) + a_{16}(p_{AF} - \bar{p}_{AF}) + a_{17}(p_{AS} - \bar{p}_{AS}) + a_{18}(p_{NAS} - \bar{p}_{NAS})$$

Replacing (13.31) in (13.32) and solving for $\boldsymbol{p_{NAS}}$ we have:

$$\dot{p}_{NAS}(1 + a_6) = \pi_1 \left[\begin{array}{l} B - \omega_4 \alpha_1 \dot{p}_{AF} - \omega_4 \alpha_2 \dot{p}_{NAF} - \\ \omega_4 \alpha_3 \left\{ \frac{\pi_1}{(1 + a_3)} [A - \delta_4 \alpha_1 \dot{p}_{AF} - \delta_4 \alpha_2 \dot{p}_{NAF} - \delta_4 \alpha_4 \dot{p}_{NAS}] + \frac{u}{(1 + a_6)} \right\} \end{array} \right] + u$$

$$\dot{p}_{NAS} = \frac{\pi_1}{(1 + a_6)} \left[\begin{array}{l} B - \omega_4 \alpha_1 \dot{p}_{AF} - \omega_4 \alpha_2 \dot{p}_{NAF} + \frac{\omega_4 \alpha_3 \delta_4 \alpha_4}{(1 + a_6)} \dot{p}_{NAS} - \\ \frac{\pi_1 \omega_4 \alpha_3}{(1 + a_3)} [A - \delta_4 \alpha_1 \dot{p}_{AF} - \delta_4 \alpha_2 \dot{p}_{NAF}] - \frac{\omega_4 \alpha_3 u}{(1 + a_6)} \end{array} \right] + \frac{u}{(1 + a_6)}$$

$$\dot{p}_{NAS} = \frac{(1 + a_6)(1 + a_5)}{(1 + a_6)(1 + a_5) - \omega_4 \alpha_3 \delta_4 \alpha \pi_1 \pi_2} \left\{ \begin{array}{l} \frac{\pi_1}{(1 + a_6)} \left[\begin{array}{l} B - \omega_4 \alpha_1 \dot{p}_{AF} - \omega_4 \alpha_2 \dot{p}_{NAF} + \frac{\omega_4 \alpha_3 \delta_4 \alpha_4}{(1 + a_6)} \dot{p}_{NAS} - \\ \frac{\pi_1 \omega_4 \alpha_3}{(1 + a_3)} [A - \delta_4 \alpha_1 \dot{p}_{AF} - \delta_4 \alpha_2 \dot{p}_{NAF}] - \frac{\omega_4 \alpha_3 u}{(1 + a_6)} \end{array} \right] \\ + \frac{u}{(1 + a_6)} \end{array} \right\}$$

$$\dot{p}_{NAS} = b_1 (b_2 B + b_2' \dot{p}_{AF} - b_3' \dot{p}_{NAF} - b_7' u) \qquad \textbf{Eq. 13.35}$$

where:

$$b_1 = \frac{(1 + a_6)(1 + a_5)}{(1 + a_6)(1 + a_5) - \omega_4 \alpha_3 \delta_4 \alpha \pi_1 \pi_2} \qquad b_2 = \frac{\pi_2}{(1 + a_6)}$$

$$b_2 = \frac{\omega_4 \alpha_3}{(1 + a_5)} \qquad b_2' = b_2 \omega_4 \alpha_1 - b_3 \pi_1 \delta_4 \alpha_1$$

$$b_3' = b_2 \omega_4 \alpha_2 - b_3 \pi_1 \delta_4 \alpha_2 \qquad b'_7 = b_2 b_3 - b_7$$

No we turn to equation (13.33), where we replace (13.31) to have,

$$\gamma_4 \alpha_1 \dot{p}_{AF} = C - \gamma_4 \alpha_2 \dot{p}_{NAF} - \gamma_4 \alpha_3 \left\{ \frac{\pi_1}{(1+a_5)} \left[A - \delta_4 \alpha_1 \dot{p}_{AF} - \delta_4 \alpha_2 \dot{p}_{NAF} - \delta_4 \alpha_4 \dot{p}_{NAS} \right] + \frac{u}{(1+a_5)} \right\} - \gamma_4 \alpha_4 \dot{p}_{NAS}$$

$$\dot{p}_{AF}\left(\gamma_4\alpha_1 - \frac{\gamma_4\alpha_3\pi_1\delta_4\alpha_1}{(1+a_5)} \right) = C + \left(\frac{\gamma_4\alpha_3\pi_1\delta_4\alpha_2}{(1+a_5)} - \gamma_4\alpha_2 \right)\dot{p}_{NAF} + \left(\frac{\gamma_4\alpha_3\pi_1\delta_4\alpha_2}{(1+a_5)} - \gamma_4\alpha_4 \right)\dot{p}_{NAS} - \frac{\gamma_4\alpha_3\pi_1}{(1+a_5)}A - \frac{\gamma_4\alpha_3}{(1+a_5)}u$$

$$\dot{p}_{AF} = \left[\frac{(1+a_5)}{\gamma_4\alpha_1(1+a_5) - \gamma_4\alpha_3\pi_1\delta_4\alpha_1} \right] \left[C + \left(\frac{\gamma_4\alpha_3\pi_1\delta_4\alpha_2}{(1+a_5)} - \gamma_4\alpha_2 \right)\dot{p}_{NAF} + \left(\frac{\gamma_4\alpha_3\pi_1\delta_4\alpha_2}{(1+a_5)} - \gamma_4\alpha_4 \right)\dot{p}_{NAS} - \frac{\gamma_4\alpha_3\pi_1}{(1+a_5)}A - \frac{\gamma_4\alpha_3}{(1+a_5)}u \right]$$

$$\dot{p}_{AF} = b_4\left(C + b_5^{'}\dot{p}_{NAF} + b_8^{'}\dot{p}_{NAS} - b_4^{'}\pi_1 A - b_4^{'}u \right)$$ **Eq. 13.36**

where:

$$b_4 = \frac{(1+a_5)}{\gamma_4\alpha_1(1+a_5) - \gamma_4\alpha_3\pi_1\delta_4\alpha_1} \qquad b_5 = \frac{\gamma_4\alpha_3\pi_1\delta_4\alpha_2}{(1+a_5)} - \gamma_4\alpha_2$$

$$b_4^{'} = \frac{\gamma_4\alpha_3}{(1+a_5)} \qquad b_5 = \frac{\gamma_4\alpha_3\pi_1\delta_4\alpha_2}{(1+a_5)} - \gamma_4\alpha_4$$

Replacing (13.31) in (13.34) we have,

$$\phi_4\alpha_2\dot{p}_{NAF} = D - \phi_4\alpha_1\dot{p}_{AF} - \phi_4\alpha_3 \left\{ \frac{\pi_1}{(1+a_5)}\left[A - \delta_4\alpha_1\dot{p}_{AF} - \delta_4\alpha_2\dot{p}_{NAF} - \delta_4\alpha_4\dot{p}_{NAS} \right] + \frac{u}{(1+a_5)} \right\} - \phi_4\alpha_4\dot{p}_{NAS}$$

$$\dot{p}_{NAF}\left(\phi_4\alpha_2 - \frac{\phi_4\alpha_3\pi_1\delta_4\alpha_2}{(1+a_5)} \right) = D + \left(\frac{\phi_4\alpha_3\pi_1\delta_4\alpha_1}{(1+a_5)} - \phi_4\alpha_1 \right)\dot{p}_{AF} + \left(\frac{\phi_4\alpha_3\pi_1\delta_4\alpha_4}{(1+a_5)} - \phi_4\alpha_4 \right)\dot{p}_{NAS} - \frac{\phi_4\alpha_3\pi_1}{(1+a_5)}A - \frac{\phi_4\alpha_3}{(1+a_5)}u$$

$$\dot{p}_{NAF} = \left[\frac{(1+a_5)}{\phi_4\alpha_2(1+a_5)-\phi_4\alpha_3\pi_1\delta_4\alpha_2}\right]\left[\begin{matrix} D+\left(\frac{\phi_4\alpha_3\pi_1\delta_4\alpha_1}{(1+a_5)}-\phi_4\alpha_1\right)\dot{p}_{AF}+\left(\frac{\phi_4\alpha_3\pi_1\delta_4\alpha_4}{(1+a_5)}-\phi_4\alpha_4\right)\dot{p}_{NAS} \\ -\frac{\phi_4\alpha_3\pi_1}{(1+a_5)}A-\frac{\phi_4\alpha_3}{(1+a_5)}u \end{matrix}\right]$$

$$\dot{p}_{NAF} = b_6\left(D+b_9\dot{p}_{AF}+b_6^{'}\dot{p}_{NAS}-b_9^{'}\pi_1 A-b_9^{'}u\right)$$ **Eq. 13.37**

where:

$$b_6 = \frac{(1+a_5)}{\phi_4\alpha_2(1+a_5)-\phi_4\alpha_3\pi_1\delta_4\alpha_2} \qquad b_6^{'} = \frac{\phi_4\alpha_3\pi_1\delta_4\alpha_4}{(1+a_5)}-\phi_4\alpha_4$$

$$b_9 = \frac{\phi_4\alpha_3\pi_1\delta_4\alpha_1}{(1+a_5)}-\phi_4\alpha_1 \qquad b_9^{'} = \frac{\phi_4\alpha_3}{(1+a_5)}$$

Replacing (13.36) in (13.35) and simplifying we have,

$$\dot{p}_{NAS} = b_1\left(b_2B+b_2^{'}\left[b_4\left(C+b_5^{'}\dot{p}_{NAF}+b_8^{'}\dot{p}_{NAS}-b_4^{'}\pi_1 A-b_4^{'}u\right)\right]-b_3^{'}\dot{p}_{NAF}-b_7^{'}u\right)$$

$$\begin{aligned}\dot{p}_{NAS}(1+b_1b_2b_4b_8) = b_1b_2B-b_1b_2^{'}b_4C-\left(b_1b_2^{'}b_4b_5+b_1b_3^{'}\right)\dot{p}_{NAF}+b_1b_2^{'}b_4b_4^{'}\pi_1 A \\ +\left(b_1b_2^{'}b_4b_4^{'}-b_1b_7^{'}\right)u\end{aligned}$$

$$\dot{p}_{NAS} = \frac{1}{(1+b_1b_2b_4b_8)}\left[\begin{matrix} b_1b_2B-b_1b_2^{'}b_4C-\left(b_1b_2^{'}b_4b_5+b_1b_3^{'}\right)\dot{p}_{NAF}+b_1b_2^{'}b_4b_4^{'}\pi_1 A \\ +\left(b_1b_2^{'}b_4b_4^{'}-b_1b_7^{'}\right)u \end{matrix}\right]$$

$$\dot{p}_{NAS} = b_{10}\left[b_{11}B-b_{12}C-b_{13}\dot{p}_{NAF}+b_{14}A+b_{14}^{'}u\right]$$ **Eq. 13.38**

where:

$$b_{10} = \frac{1}{(1+b_1b_2b_4b_8)} \qquad b_{12} = b_1b_2^{'}b_4 \qquad b_{14} = b_1b_2^{'}b_4b_4^{'}\pi_1$$

$$b_{11} = b_1b_2 \qquad b_{13} = b_1b_2^{'}b_4b_5+b_1b_3^{'} \qquad b_{14}^{'} = b_1b_2^{'}b_4b_4^{'}-b_1b_7^{'}$$

Replacing (13.36) in (13.37) and solving for $\dot{p}_{NAF}$ we have,

$$\dot{p}_{NAF} = b_6\left(D+b_9\left\{b_4\left(C+b_5^{'}\dot{p}_{NAF}+b_8^{'}\dot{p}_{NAS}-b_4^{'}\pi_1 A-b_4^{'}u\right)\right\}+b_6^{'}\dot{p}_{NAS}-b_9^{'}\pi_1 A-b_9^{'}u\right)$$

$$\dot{p}_{NAF}(1-b_6b_9b_4b_5) = b_6\left(D+\left(b_9b_4b_8+b_6^{'}\right)\dot{p}_{NAS}-b_9b_4b_4^{'}\pi_1 A+b_9b_4C-\left(b_9b_4b_4^{'}+b_9^{'}\right)u\right)$$

$$\dot{p}_{NAF} = \frac{1}{(1 - b_6 b_9 b_4 b_5)}\left[b_6\left(D + \left(b_9 b_4 b_8 + b_6^{'}\right)\dot{p}_{NAS} - b_9 b_4 b_4^{'}\pi_1 A + b_9 b_4 C - \left(b_9 b_4 b_4^{'} + b_9^{'}\right)u\right)\right]$$

$$\dot{p}_{NAF} = b_{15}\left(D + b_{16}\dot{p}_{NAS} - b_{17}A + b_9 b_4 C - b_{18}u\right) \qquad \textbf{Eq. 13.39}$$

where:

$$b_{15} = \frac{b_6}{(1 - b_6 b_9 b_4 b_5)} \qquad b_{16} = b_9 b_4 b_8 + b_6^{'}$$

$$b_{17} = b_9 b_4 b_4^{'}\pi_1 \qquad b_{18} = -\left(b_9 b_4 b_4^{'} + b_9^{'}\right)$$

Replacing (13.39) into (13.38) to find $\dot{p}_{NAS}$ as a function of the variables of the system we have,

$$\dot{p}_{NAS} = b_{10}\left[b_{11}B - b_{12}C - b_{13}\left(b_{15}\left(D + b_{16}\dot{p}_{NAS} - b_{17}A + b_9 b_4 C - b_{18}u\right)\right) + b_{14}A + b_{14}^{'}u\right]$$

$$\dot{p}_{NAS} + b_{10}b_{13}b_{15}b_{16}\dot{p}_{NAS} = b_{10}\begin{bmatrix} b_{11}B - b_{13}b_{15}D - \left(b_{13}b_{15}b_9 b_4 + b_{12}\right)C + \left(b_{13}b_{15}b_{17} + b_{14}\right)A \\ + \left(b_{14}^{'} - b_{13}b_{15}b_{18}\right)u \end{bmatrix}$$

$$\dot{p}_{NAS} = \frac{b_{10}}{1 + b_{10}b_{13}b_{15}b_{16}}\begin{bmatrix} b_{11}B - b_{13}b_{15}D - \left(b_{13}b_{15}b_9 b_4 + b_{12}\right)C + \left(b_{13}b_{15}b_{17} + b_{14}\right)A \\ + \left(b_{14}^{'} - b_{13}b_{15}b_{18}\right)u \end{bmatrix}$$

$$\dot{p}_{NAS} = b_{19}\left[b_{11}B - b_{13}b_{15}D - b_{20}C + b_{21}A + b_{22}u\right] \qquad \textbf{Eq. 13.40}$$

where:

$$b_{19} = \frac{b_{10}}{1 + b_{10}b_{13}b_{15}b_{16}} \qquad b_{20} = b_{13}b_{15}b_9 b_4 + b_{12}$$

$$b_{21} = b_{13}b_{15}b_{17} + b_{14} \qquad b_{22} = b_{14}^{'} - b_{13}b_{15}b_{18}$$

Replacing $\dot{p}_{NAS}$ in (13.39) to find $\dot{p}_{NAF}$,

$$\dot{p}_{NAF} = b_{15}\left(D + b_{16}b_{19}\left[b_{11}B - b_{13}b_{15}D - b_{20}C + b_{21}A + u\right] - b_{17}A + b_9 b_4 C - b_{18}u\right)$$

$$\dot{p}_{NAF} = b_{15}\begin{pmatrix} \left(1 - b_{16}b_{19}b_{13}b_{15}\right)D + b_{16}b_{19}b_{11}B + \left(b_9 b_4 - b_{16}b_{19}b_{20}\right)C + \left(b_{16}b_{19}b_{21} - b_{17}\right)A + \\ \left(b_{16}b_{19}b_{22} + b_{18}\right)u \end{pmatrix}$$

$$\dot{p}_{NAF} = b_{15}\left(b_{23}D + b_{24}B + b_{25}C + b_{26}A + b_{27}u\right) \qquad \textbf{Eq. 13.41}$$

where:

$b_{23} = 1 - b_{16}b_{19}b_{13}b_{15}$ $\qquad b_{24} = b_{16}b_{19}b_{11}$ $\qquad b_{25} = b_9 b_4 - b_{16}b_{19}b_{20}$

$b_{26} = b_{16}b_{19}b_{21} - b_{17}$ $\qquad b_{27} = b_{16}b_{19}b_{22} + b_{18}$

Replacing $\dot{p}_{NAS}$ and $\dot{p}_{NAF}$ in (13.36) yields,

$$\dot{p}_{AF} = b_4\begin{pmatrix} C + b_5^{'}b_{15}\left(b_{23}D + b_{24}B + b_{25}C + b_{26}A + b_{27}u\right) + b_8^{'}b_{19}\left[b_{11}B - b_{13}b_{15}D - b_{20}C + b_{21}A + u\right] \\ -b_4^{'}\pi_1 A - b_4^{'}u \end{pmatrix}$$

$$\dot{p}_{AF} = b_4\begin{pmatrix} \left(1 + b_5^{'}b_{15}b_{25} - b_8^{'}b_{19}b_{20}\right)C + \left(b_5^{'}b_{15}b_{23} - b_8^{'}b_{19}b_{13}b_{15}\right)D + \left(b_5^{'}b_{15}b_{24} - b_8^{'}b_{19}b_{11}\right)B \\ + \left(b_5^{'}b_{15}b_{26} + b_8^{'}b_{19}b_{21} - b_4^{'}\pi_1\right)A + \left(b_5^{'}b_{15}b_7 + b_8^{'}b_{19}b_{22} - b_4^{'}\right)u \end{pmatrix}$$

$$\dot{p}_{AF} = b_4\left(b_{28}C + b_{29}D + b_{30}B + b_{31}A + b_{32}u\right) \qquad \textbf{Eq. 13.42}$$

where:

$b_{28} = 1 + b_5^{'}b_{15}b_{25} - b_8^{'}b_{19}b_{20}$ $\qquad b_{29} = b_5^{'}b_{15}b_{23} - b_8^{'}b_{19}b_{13}b_{15}$ $\qquad b_{30} = b_5^{'}b_{15}b_{24} - b_8^{'}b_{19}b_{11}$

$b_{31} = b_5^{'}b_{15}b_{26} + b_8^{'}b_{19}b_{21} - b_4^{'}\pi_1$ $\qquad b_{32} = b_5^{'}b_{15}b_7 + b_8^{'}b_{19}b_{22} - b_4^{'}$

Finally, to obtain $\dot{p}_{AS}$ we replace (13.42), (13.41) and (13.40) in (13.31) to have,

$$\dot{p}_{AS} = \frac{\pi_1}{\left(1 + a_5\right)}\begin{bmatrix} A - \delta_4\alpha_1 b_4\left(b_{28}C + b_{29}D + b_{30}B + b_{31}A + b_{32}u\right) - \\ \delta_4\alpha_2 b_{15}\left(b_{23}D + b_{24}B + b_{25}C + b_{26}A + b_{27}u\right) \\ -\delta_4\alpha_4 b_{19}\left[b_{11}B - b_{13}b_{15}D - b_{20}C + b_{21}A + b_{22}u\right] \end{bmatrix} + u$$

$$\dot{p}_{AS} = b_{33}\left[b_{34}A - b_{35}B - b_{36}C - b_{37}D + b_{38}u\right] + u \qquad \textbf{Eq. 13.43}$$

where:

$b_{33} = \dfrac{\pi_1}{\left(1 + a_5\right)}$ $\qquad b_{34} = 1 - \delta_4\alpha_1 b_4 b_{31} - \delta_4\alpha_2 b_{15}b_{26} - \delta_4\alpha_4 b_{19}b_{21}$

$b_{35} = \delta_4\alpha_1 b_4 b_{30} + \delta_4\alpha_2 b_{15}b_{24} + \delta_4\alpha_4 b_{19}b_{11}$ $\qquad b_{36} = \delta_4\alpha_1 b_4 b_{28} + \delta_4\alpha_2 b_{15}b_{25} - \delta_4\alpha_4 b_{19}b_{20}$

$b_{37} = \delta_4\alpha_1 b_4 b_{29} + \delta_4\alpha_2 b_{15}b_{23} + \delta_4\alpha_4 b_{19}b_{13}b_{15}$ $\qquad b_{38} = 1 - \delta_4\alpha_1 b_4 b_{32} - \delta_4\alpha_2 b_{15}b_{27} - \delta_4\alpha_4 b_{19}b_{22}$

Equations (13.40) to (13.43) plus (13.30) represent the systems of variables of our model in function of the deviations from the long-run trend. However, to calculate the overshooting coefficient we need to find the solutions to the system. Replacing the values of A, B, C and D and rearranging the system we have,

$$
\begin{aligned}
&\dot{e} = z_2(p_{AF} - \bar{p}_{AF}) + z_3(p_{AS} - \bar{p}_{AS}) + z_4(p_{NAF} - \bar{p}_{NAF}) + z_5(p_{NAS} - \bar{p}_{NAS}) \\
&\dot{p}_{AF} = z_6(e - \bar{e}) + z_7(p_{AF} - \bar{p}_{AF}) + z_8(p_{AS} - \bar{p}_{AS}) + z_9(p_{NAF} - \bar{p}_{NAF}) \\
&+ z_{10}(p_{NAS} - \bar{p}_{NAS}) + h_2 u \\
&\dot{p}_{AS} = z_{11}(e - \bar{e}) + z_{12}(p_{AF} - \bar{p}_{AF}) + z_{13}(p_{AS} - \bar{p}_{AS}) + z_{14}(p_{NAF} - \bar{p}_{NAF}) \\
&+ z_{15}(p_{NAS} - \bar{p}_{NAS}) + h_3 u \\
&\dot{p}_{NAF} = z_{16}(e - \bar{e}) + z_{17}(p_{AF} - \bar{p}_{AF}) + z_{18}(p_{AS} - \bar{p}_{AS}) + z_{19}(p_{NAF} - \bar{p}_{NAF}) \\
&+ z_{20}(p_{NAS} - \bar{p}_{NAS}) + h_4 u \\
&\dot{p}_{NAS} = z_{21}(e - \bar{e}) + z_{22}(p_{AF} - \bar{p}_{AF}) + z_{23}(p_{AS} - \bar{p}_{AS}) + z_{24}(p_{NAF} - \bar{p}_{NAF}) \\
&+ z_{25}(p_{NAS} - \bar{p}_{NAS}) h_5 u
\end{aligned}
$$

where the $\boldsymbol{z_i}$ coefficients are a linear relations of the $\boldsymbol{b_i}$, $\boldsymbol{a_i}$ and the parameters of the model. Writing the equations in a matrix we have,

$$
\begin{bmatrix} \dot{e}(t) \\ \dot{p}_{AF}(t) \\ \dot{p}_{AS}(t) \\ \dot{p}_{NAF}(t) \\ \dot{p}_{NAS}(t) \end{bmatrix} = \begin{bmatrix} 0 & z_{12} & z_{13} & z_{14} & z_{15} \\ z_{21} & z_{22} & z_{23} & z_{24} & z_{25} \\ z_{31} & z_{32} & z_{33} & z_{34} & z_{35} \\ z_{41} & z_{42} & z_{43} & z_{44} & z_{45} \\ z_{51} & z_{52} & z_{53} & z_{54} & z_{55} \end{bmatrix} \cdot \begin{bmatrix} (e - \bar{e}) \\ (p_{AF} - \bar{p}_{AF}) \\ (p_{AS} - \bar{p}_{AS}) \\ (p_{NAF} - \bar{p}_{NAF}) \\ (p_{NAS} - \bar{p}_{NAS}) \end{bmatrix} + \begin{bmatrix} 0 \\ h_2 \\ h_3 \\ h_4 \\ h_5 \end{bmatrix} \cdot u \qquad \textbf{Eq. 13.44}
$$

The solutions to the system in (13.44) are the characteristic roots β_i of the characteristic polynomial $\boldsymbol{det(B-\lambda I)=0}$, where $\boldsymbol{B}$ is the matrix in the system equation $\boldsymbol{dX/dt=BX}$ of (13.44). There are five solutions to the system, and only the negative ones are chosen for stability (Frankel, 1986; Stamoulis and Rausser, 1988). The solutions for the expected future paths of the variables in the system can be written in levels as $\boldsymbol{t}$ goes from 0 to ∞.

$$
\begin{aligned}
&e(t)-\bar{e}(t)=\exp(-\beta t)[e(0)-\bar{e}(0)]\\
&p_{AF}(t)-\bar{p}_{AF}(t)=\exp(-\beta t)[p_{AF}(0)-\bar{p}_{AF}(0)]\\
&p_{NAF}(t)-\bar{p}_{NAF}(t)=\exp(-\beta t)[p_{NAF}(0)-\bar{p}_{NAF}(0)]\\
&p_{AS}(t)-\bar{p}_{AS}(t)=\exp(-\beta t)[p_{AS}(0)-\bar{p}_{AS}(0)]\\
&p_{NAS}(t)-\bar{p}_{NAS}(t)=\exp(-\beta t)[p_{NAS}(0)-\bar{p}_{NAS}(0)]
\end{aligned}
\qquad \textbf{Eq. 13.45}
$$

Expressing equations in (13.45) in a rate of change form,

$$
\begin{aligned}
&\dot{e}=-\beta\left(e-\bar{e}\right)\\
&\dot{p}_{AF}=-\beta\left(p_{AF}-\bar{p}_{AF}\right)+g_{18}u\\
&\dot{p}_{NAF}=-\beta\left(p_{NAF}-\bar{p}_{NAF}\right)+g_{12}u\\
&\dot{p}_{AS}=-\beta\left(p_{AS}-\bar{p}_{AS}\right)+g_{24}u\\
&\dot{p}_{NAS}=-\beta\left(p_{NAS}-\bar{p}_{NAS}\right)+g_{6}u
\end{aligned}
\qquad \textbf{Eq. 13.46}
$$

Now we proceed to analyze the effects of a monetary shock on the variables of the system in (13.44). Replacing the first equation of (13.44) in (13.30) and solving for ***e***, we have,

$$
\begin{aligned}
&\dot{e}=\frac{1}{\lambda}\{\alpha_1(p_{AF}-\bar{p}_{AF})+\alpha_2(p_{NAF}-\bar{p}_{NAF})+\alpha_3(p_{AS}-\bar{p}_{AS})+\alpha_4(p_{NAS}-\bar{p}_{NAS})\}=-\beta\left(e-\bar{e}\right)\\
&e=\bar{e}-\frac{1}{\beta\lambda}\begin{bmatrix}\alpha_1(p_{AF}-\bar{p}_{AF})+\alpha_2(p_{NAF}-\bar{p}_{NAF})+\alpha_3(p_{AS}-\bar{p}_{AS})\\+\alpha_4(p_{NAS}-\bar{p}_{NAS})\end{bmatrix}
\end{aligned}
\qquad \textbf{Eq. 13.47}
$$

Differentiating (13.47) with respect to ***m*** and recalling that in the long run dp_{AS} = dp_{NAS} = 0 (short-run stickiness of prices) and $d\bar{e}=dm=d\bar{p}_{AF}=d\bar{p}_{NAF}=d\bar{p}_{AS}=d\bar{p}_{NAS}$ indicating long-run neutrality of money, we have,

$$\frac{de}{dm} = 1 - \frac{1}{\beta\lambda}\left[\alpha_1\left(\frac{dp_{AF}}{dm} - 1\right) + \alpha_2\left(\frac{dp_{NAF}}{dm} - 1\right) - \alpha_3 - \alpha_4\right]$$

$$\frac{de}{dm} = 1 - \frac{1}{\beta\lambda}\left[\alpha_1\frac{dp_{AF}}{dm} + \alpha_2\frac{dp_{NAF}}{dm} - 1\right] \qquad \textbf{Eq. 13.48}$$

Equation (13.48) represents the overshooting effect of a positive monetary expansion on the exchange rate. The overshooting depends on the reaction of flexible prices to monetary shocks and it is also influenced by the relative share of flexible prices on the general price index (the α_i elements). When both prices undershoot we observe the biggest overshooting in the exchange rate.

Now, to analyze the response of flexible prices to monetary shocks, we simply solve (13.47) for $\boldsymbol{p_{AF}}$ and $\boldsymbol{p_{NAF}}$. Differenciating with respect to the money supply we have,

$$p_{AF} = \bar{p}_{AF} + \frac{\beta\lambda}{\alpha_1}\bar{e} - \frac{\beta\lambda}{\alpha_1}e - \frac{\alpha_2}{\alpha_1}(p_{NAF} - \bar{p}_{NAF}) - \frac{\alpha_3}{\alpha_1}(p_{AS} - \bar{p}_{AS}) - \frac{\alpha_4}{\alpha_1}(-1)$$

$$\frac{dp_{AF}}{dm} = 1 - \frac{\beta\lambda}{\alpha_1}\left(\frac{de}{dm} - 1\right) - \frac{\alpha_2}{\alpha_1}\left(\frac{dp_{NAF}}{dm}\right) + \left(\frac{\alpha_2 + \alpha_3 + \alpha_4}{\alpha_1}\right)$$

$$\frac{dp_{AF}}{dm} = 1 + \frac{\beta\lambda}{\alpha_1}\left(1 - \frac{de}{dm}\right) - \frac{\alpha_2}{\alpha_1}\left(\frac{dp_{NAF}}{dm}\right) + \left(\frac{\alpha_2 + \alpha_3 + \alpha_4 + \alpha_1}{\alpha_1}\right) - \frac{\alpha_1}{\alpha_1}$$

$$\frac{dp_{AF}}{dm} = \frac{1}{\alpha_1}\left[1 + \beta\lambda\left(1 - \frac{de}{dm}\right) - \alpha_2\frac{dp_{NAF}}{dm}\right] \qquad \textbf{Eq. 13.49}$$

$$\frac{dp_{NAF}}{dm} = \frac{1}{\alpha_2}\left[1 + \beta\lambda\left(1 - \frac{de}{dm}\right) - \alpha_1\frac{dp_{AF}}{dm}\right] \qquad \textbf{Eq. 13.50}$$

Equations 13.46 and 13.29 indicates us that the overshooting of the agricultural flexible prices depends on the overshooting of the exchange rate and the overshooting of the non-agricultural flexible prices. If both variables are monetary-neutral, then the overshooting depends on the relative share of agricultural flexible prices on the general price index, but it is positive for any value of α_i. If the exchange rate undershoots, agricultural prices overshoot the most.

Annex 6

14. Annex 6: VEC complete results

The VEC system was estimated with the following relations:

$$\Delta P_{AF} = \sum_{j=1}^{k} \left(\alpha_{1j} \Delta P_{AFt-j} + \beta_{1j} \Delta P_{ASt-j} + \phi_{1j} \Delta P_{INt-j} + \lambda_{1j} \Delta P_{SEt-j} + \delta_{1j} \Delta e_{t-j} + \varphi_{1j} \Delta m_{t-1} \right) + \omega_{11} \varepsilon_{1t-1} + \omega_{12} \varepsilon_{2t-1} + \omega_{13} \varepsilon_{3t-1} + \omega_{14} \varepsilon_{4t-1} + \omega_{15} \varepsilon_{5t-1} + \mu_{1t}$$

$$\Delta P_{AS} = \sum_{j=1}^{k} \left(\alpha_{2j} \Delta P_{AFt-j} + \beta_{2j} \Delta P_{ASt-j} + \phi_{2j} \Delta P_{INt-j} + \lambda_{2j} \Delta P_{SEt-j} + \delta_{2j} \Delta e_{t-j} + \varphi_{2j} \Delta m_{t-1} \right) + \omega_{21} \varepsilon_{1t-1} + \omega_{22} \varepsilon_{2t-1} + \omega_{23} \varepsilon_{3t-1} + \omega_{24} \varepsilon_{4t-1} + \omega_{15} \varepsilon_{5t-1} + \mu_{2t}$$

$$\Delta P_{IN} = \sum_{j=1}^{k} \left(\alpha_{3j} \Delta P_{AFt-j} + \beta_{3j} \Delta P_{ASt-j} + \phi_{3j} \Delta P_{INt-j} + \lambda_{31j} \Delta P_{SEt-j} + \delta_{3j} \Delta e_{t-j} + \varphi_{3j} \Delta m_{t-1} \right) + \omega_{31} \varepsilon_{1t-1} + \omega_{32} \varepsilon_{2t-1} + \omega_{33} \varepsilon_{3t-1} + \omega_{34} \varepsilon_{4t-1} + \omega_{15} \varepsilon_{5t-1} + \mu_{3t}$$

$$\Delta P_{SE} = \sum_{j=1}^{k} \left(\alpha_{4j} \Delta P_{AFt-j} + \beta_{4j} \Delta P_{ASt-j} + \phi_{4j} \Delta P_{INt-j} + \lambda_{4j} \Delta P_{SEt-j} + \delta_{4j} \Delta e_{t-j} + \varphi_{4j} \Delta m_{t-1} \right) + \omega_{41} \varepsilon_{1t-1} + \omega_{42} \varepsilon_{2t-1} + \omega_{43} \varepsilon_{3t-1} + \omega_{44} \varepsilon_{4t-1} + \omega_{15} \varepsilon_{5t-1} + \mu_{4t}$$

$$\Delta e_{t} = \sum_{j=1}^{k} \left(\alpha_{5j} \Delta P_{AFt-j} + \beta_{5j} \Delta P_{ASt-j} + \phi_{5j} \Delta P_{INt-j} + \lambda_{5j} \Delta P_{SEt-j} + \delta_{5j} \Delta e_{t-j} + \varphi_{5j} \Delta m_{t-1} \right) + \omega_{51} \varepsilon_{1t-1} + \omega_{52} \varepsilon_{2t-1} + \omega_{53} \varepsilon_{3t-1} + \omega_{54} \varepsilon_{4t-1} + \omega_{15} \varepsilon_{5t-1} + \mu_{5t}$$

$$\Delta m_{t} = \sum_{j=1}^{k} \left(\alpha_{6j} \Delta P_{AFt-j} + \beta_{6j} \Delta P_{ASt-j} + \phi_{6j} \Delta P_{INt-j} + \lambda_{6j} \Delta P_{SEt-j} + \delta_{6j} \Delta e_{t-j} + \varphi_{6j} \Delta m_{t-1} \right) + \omega_{61} \varepsilon_{1t-1} + \omega_{62} \varepsilon_{2t-1} + \omega_{63} \varepsilon_{3t-1} + \omega_{64} \varepsilon_{4t-1} + \omega_{15} \varepsilon_{5t-1} + \mu_{6t}$$

Where $\boldsymbol{P_i}$ represents prices (AF is agricultural flexible, AS is agricultural sluggish, IN is industrial prices, proxy for non-agricultural flexible and SE is an index price for non-agricultural services, proxy for non-agricultural sluggish[31]); ***e*** is the (nominal) exchange rate and ***m*** is the money supply. μ_i is a white-noise error term. The ω_i coefficients are the overshooting parameters and ε_{it-1} represent the error correction term, which with five cointegrating terms is represented by:

$$\varepsilon_{it-1} = P_{it-1} - \pi_i - \gamma_i t - \tau_i m_{t-1}$$

Where τ is the long-run relation between prices and the money supply, γ is the coefficient for the time trend, π is a constant and ***i*** represents the endogenous variables. In the long run $\varepsilon = 0$, therefore,

$$P_{it-1} = \pi_i + \gamma_i t + \tau_i m_{t-1}$$

Sections 1 and 2 show the complete set of results for the VEC system, which was

[31] Agricultural non-tradables is the proxy for P_{AF}, agricultural tradables is the proxy for P_{AS}.

calculated with four lags, as indicated in the Johansen's cointegration test. All variables were introduced in logarithmic form, therefore "first differences" apply to the logarithmic form the variable. For example, $\Delta \mathbf{P_{ANT}}$ = log(P_{ANT})-log(P_{ANT}(-1)), where the (-1) indicates the lag. Similarly, $\Delta \mathbf{P_{ANT}(-1)}$ = log(P_{ANT}(-1))-log(P_{ANT}(-2)) indicates the first difference of the second lag.

14.1. Complete set of results for the Bolivian data

Lag intervals: 1 - 4, Rank=5, Case=5

Date: 02/25/03 Time: 11:53

Sample(adjusted): 1989:2 2001:4

Included observations: 51 after adjusting endpoints

Standard errors & t-statistics in parentheses

	Cointegrating Eq:	ε_{1t-1}	ε_{2t-1}	ε_{3t-1}	ε_{4t-1}	ε_{5t-1}
1	P_{ANT}	1	0	0	0	0
2	P_{AT}	0	1	0	0	0
3	P_{IN}	0	0	1	0	0
4	P_{SE}	0	0	0	1	0
5	***er***	0	0	0	0	1
6	**Money (τ_i)**	-0.212	-0.819	-0.073	-0.116	-0.151
		(0.113)	(0.195)	(0.069)	(0.042)	(0.055)
		(-1.883)	(-4.194)	(-1.063)	(-2.743)	(-2.753)
7	**TREND (γ_i)**	-0.018	0.022	-0.022	-0.017	-0.015
8	**Constant (π)**	-2.522	0.953	-3.108	-2.957	0.263

	Error Correction:	ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δ ***er***	Δ**M1**
1	ω_1	-0.497	-0.599	0.216	0.208	0.358	-1.802
		(0.319)	(0.668)	(0.144)	(0.135)	(0.146)	(1.354)
		(-1.559)	(-0.896)	(1.505)	(1.549)	(2.457)	(-1.331)

Error Correction:		ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δ *er*	$\Delta M1$
2	ω_2	0.027	-0.173	-0.052	0.006	-0.038	0.429
		(0.081)	(0.170)	(0.037)	(0.034)	(0.037)	(0.344)
		(0.338)	(-1.021)	(-1.412)	(0.187)	(-1.027)	(1.246)
3	ω_3	-0.682	1.293	-1.027	0.078	-0.207	2.509
		(0.730)	(1.531)	(0.329)	(0.308)	(0.334)	(3.102)
		(-0.934)	(0.845)	(-3.119)	(0.253)	(-0.621)	(0.809)
4	ω_4	2.710	-2.444	1.072	-0.842	-1.204	-3.330
		(1.178)	(2.472)	(0.532)	(0.498)	(0.539)	(5.010)
		(2.300)	(-0.989)	(2.015)	(-1.691)	(-2.232)	(-0.665)
5	ω_5	-0.748	1.263	-0.121	0.146	0.305	3.481
		(0.398)	(0.835)	(0.180)	(0.168)	(0.182)	(1.692)
		(-1.881)	(1.513)	(-0.675)	(0.870)	(1.673)	(2.057)
6	$\Delta P_{ANT}(-1)$	0.382	-0.351	-0.024	-0.007	-0.420	-0.189
		(0.323)	(0.678)	(0.146)	(0.136)	(0.148)	(1.374)
		(1.181)	(-0.518)	(-0.165)	(-0.054)	(-2.842)	(-0.137)
7	$\Delta P_{ANT}(-2)$	-0.018	0.817	-0.187	-0.016	-0.377	1.134
		(0.263)	(0.552)	(0.119)	(0.111)	(0.120)	(1.119)
		(-0.069)	(1.480)	(-1.573)	(-0.144)	(-3.132)	(1.013)
8	$\Delta P_{ANT}(-3)$	-0.327	0.667	-0.291	-0.076	-0.135	-0.544
		(0.209)	(0.439)	(0.094)	(0.088)	(0.096)	(0.890)
		(-1.562)	(1.520)	(-3.078)	(-0.859)	(-1.405)	(-0.611)
9	$\Delta P_{ANT}(-4)$	-0.102	0.711	-0.253	-0.124	-0.215	0.636
		(0.221)	(0.464)	(0.100)	(0.093)	(0.101)	(0.940)
		(-0.462)	(1.532)	(-2.532)	(-1.331)	(-2.122)	(0.676)
10	$\Delta P_{AT}(-1)$	0.176	-0.064	0.084	0.077	-0.029	-0.191
		(0.095)	(0.198)	(0.043)	(0.040)	(0.043)	(0.402)
		(1.865)	(-0.321)	(1.964)	(1.938)	(-0.669)	(-0.474)
11	$\Delta P_{AT}(-2)$	-0.008	0.017	-0.009	0.040	0.084	-0.685
		(0.094)	(0.197)	(0.042)	(0.040)	(0.043)	(0.399)
		(-0.085)	(0.089)	(-0.201)	(1.015)	(1.966)	(-1.717)
12	$\Delta P_{AT}(-3)$	-0.095	0.574	-0.069	0.015	0.074	-0.036

Error Correction:		ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δ *er*	ΔM1
		(0.093)	(0.196)	(0.042)	(0.039)	(0.043)	(0.397)
		(-1.015)	(2.930)	(-1.629)	(0.384)	(1.739)	(-0.092)
13	**ΔP_{AT}(-4)**	-0.166	-0.007	-0.075	-0.035	0.098	0.105
		(0.089)	(0.188)	(0.040)	(0.038)	(0.041)	(0.380)
		(-1.853)	(-0.037)	(-1.853)	(-0.915)	(2.398)	(0.276)
14	**ΔP_{IN}(-1)**	0.169	1.783	0.266	0.160	0.444	0.193
		(0.555)	(1.165)	(0.251)	(0.235)	(0.254)	(2.361)
		(0.304)	(1.530)	(1.059)	(0.681)	(1.746)	(0.082)
15	**ΔP_{IN}(-2)**	0.105	-0.628	0.243	-0.054	0.598	-0.352
		(0.496)	(1.040)	(0.224)	(0.209)	(0.227)	(2.107)
		(0.211)	(-0.604)	(1.088)	(-0.257)	(2.637)	(-0.167)
16	**ΔP_{IN}(-3)**	0.499	0.619	0.178	-0.054	0.342	1.512
		(0.421)	(0.884)	(0.190)	(0.178)	(0.193)	(1.791)
		(1.184)	(0.701)	(0.935)	(-0.301)	(1.775)	(0.845)
17	**ΔP_{IN}(-4)**	0.227	0.199	0.237	-0.059	0.441	0.588
		(0.306)	(0.642)	(0.138)	(0.129)	(0.140)	(1.300)
		(0.741)	(0.310)	(1.719)	(-0.458)	(3.150)	(0.452)
18	**ΔP_{SE}(-1)**	-1.581	1.186	-0.348	0.312	0.913	3.048
		(0.803)	(1.685)	(0.363)	(0.339)	(0.368)	(3.415)
		(-1.968)	(0.704)	(-0.960)	(0.919)	(2.482)	(0.893)
19	**ΔP_{SE}(-2)**	-1.251	-1.655	-0.226	0.234	0.634	0.737
		(0.639)	(1.341)	(0.288)	(0.270)	(0.293)	(2.717)
		(-1.957)	(-1.234)	(-0.785)	(0.869)	(2.168)	(0.271)
20	**ΔP_{SE}(-3)**	-0.002	0.155	0.158	0.470	0.213	0.062
		(0.610)	(1.279)	(0.275)	(0.258)	(0.279)	(2.592)
		(-0.003)	(0.121)	(0.576)	(1.824)	(0.765)	(0.024)
21	**ΔP_{SE}(-4)**	-1.005	-0.068	-0.111	0.012	0.293	-0.401
		(0.456)	(0.957)	(0.206)	(0.193)	(0.209)	(1.939)
		(-2.203)	(-0.071)	(-0.539)	(0.060)	(1.403)	(-0.207)
22	**Δ *er*(-1)**	0.161	-2.261	0.186	-0.074	-0.820	-3.970
		(0.442)	(0.927)	(0.199)	(0.187)	(0.202)	(1.878)

Error Correction:		ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δ *er*	ΔM1
		(0.365)	(-2.439)	(0.932)	(-0.396)	(-4.055)	(-2.114)
23	**Δ *er*(-2)**	0.265	-0.680	-0.147	-0.208	-0.383	-3.823
		(0.410)	(0.860)	(0.185)	(0.173)	(0.188)	(1.744)
		(0.645)	(-0.790)	(-0.794)	(-1.199)	(-2.041)	(-2.193)
24	**Δ *er*(-3)**	0.122	0.390	-0.161	0.040	0.090	-3.054
		(0.423)	(0.888)	(0.191)	(0.179)	(0.194)	(1.800)
		(0.289)	(0.439)	(-0.842)	(0.222)	(0.466)	(-1.697)
25	**Δ *er*(-4)**	-0.354	-0.550	-0.252	-0.006	0.217	-1.976
		(0.341)	(0.715)	(0.154)	(0.144)	(0.156)	(1.450)
		(-1.039)	(-0.769)	(-1.638)	(-0.039)	(1.388)	(-1.363)
26	**ΔM1(-1)**	0.106	-0.267	0.035	-0.016	-0.039	-0.101
		(0.064)	(0.135)	(0.029)	(0.027)	(0.029)	(0.273)
		(1.643)	(-1.981)	(1.200)	(-0.575)	(-1.321)	(-0.371)
27	**ΔM1(-2)**	0.029	-0.638	0.045	-0.013	-0.012	-0.155
		(0.064)	(0.135)	(0.029)	(0.027)	(0.029)	(0.273)
		(0.447)	(-4.741)	(1.561)	(-0.489)	(-0.417)	(-0.570)
28	**ΔM1(-3)**	0.191	-0.451	0.100	0.038	-0.058	-0.396
		(0.063)	(0.131)	(0.028)	(0.026)	(0.029)	(0.266)
		(3.059)	(-3.437)	(3.558)	(1.436)	(-2.034)	(-1.490)
29	**ΔM1(-4)**	0.110	-0.392	0.005	-0.026	-0.002	0.100
		(0.060)	(0.126)	(0.027)	(0.025)	(0.027)	(0.254)
		(1.833)	(-3.121)	(0.188)	(-1.034)	(-0.080)	(0.395)
30	**Constant**	0.141	0.025	0.076	0.028	-0.019	0.319
		(0.049)	(0.104)	(0.022)	(0.021)	(0.023)	(0.210)
		(2.850)	(0.244)	(3.392)	(1.351)	(-0.817)	(1.519)
	Trend	-0.002	-0.001	-0.001	0.000	0.000	-0.004
		(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.003)
		(-2.905)	(-0.476)	(-3.647)	(-1.510)	(0.031)	(-1.656)
R-squared		0.826	0.814	0.908	0.889	0.930	0.725
Adj. R-squared		0.564	0.534	0.769	0.721	0.825	0.311
Sum sq. resids		0.007	0.029	0.001	0.001	0.001	0.119

Error Correction:	ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δ *er*	ΔM1
S.E. equation	0.018	0.038	0.008	0.008	0.008	0.077
F-statistic	3.157	2.909	6.563	5.318	8.866	1.753
Log likelihood	156.029	118.247	196.596	199.991	195.882	82.223
Akaike AIC	-4.903	-3.421	-6.494	-6.627	-6.466	-2.009
Schwarz SC	-3.729	-2.247	-5.320	-5.453	-5.292	-0.834
Mean dependent	0.020	-0.015	0.023	0.019	0.020	0.018
S.D. dependent	0.027	0.056	0.017	0.015	0.020	0.093
Determinant Residual Covariance			0.000			
Log Likelihood			993.15			
Akaike Information Criteria			-30.477			
Schwarz Criteria			-22.295			

14.2. Complete set of results for the Japanese data

Lag interval 1-4, CE=4, Case=2

Date: 02/25/03 Time: 11:47

Sample(adjusted): 1986:2 2000:4

Included observations: 59 after adjusting endpoints

Standard errors & t-statistics in parentheses

Cointegrating Eq:	ε_{1t-1}	ε_{2t-1}	ε_{3t-1}	ε_{4t-1}
P_{ANT}	1	0	0	0
P_{AT}	0	1	0	0
P_{IN}	0	0	1	0
P_{SE}	0	0	0	1
ER	-0.12	0.81	0.37	0.48
	(-0.8)	(1.76)	(3.52)	(3.87)
M1	0.64	-1.06	-0.37	-0.61
	(0.17)	(0.56)	(0.13)	(0.15)
	(3.73)	(-1.9)	(-2.9)	(-4.1)
Constant	-7.41	-2.37	-4.36	-3.70
	(0.68)	(2.20)	(0.51)	(0.59)
	(-10.9)	(-1.1)	(-8.5)	(-6.2)

Error Correction:	ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δer	$\Delta M1$
ω_1	-0.86	-0.16	-0.03	-0.02	-0.04	-0.16
	(0.27)	(0.37)	(0.03)	(0.02)	(0.29)	(0.15)
	(-3.2)	(-0.4)	(-1.1)	(-1.0)	(-0.2)	(-1.1)
ω_2	-0.28	-0.27	0.00	0.01	0.33	0.01
	(0.12)	(0.17)	(0.01)	(0.01)	(0.13)	(0.07)
	(-2.3)	(-1.6)	(-0.1)	(0.97)	(2.59)	(0.09)
ω_3	0.34	1.93	0.06	0.08	-1.66	-1.94
	(0.97)	(1.31)	(0.11)	(0.06)	(1.02)	(0.52)
	(0.35)	(1.47)	(0.59)	(1.25)	(-1.6)	(-3.8)
ω_4	-0.44	-0.99	-0.05	-0.08	0.09	1.49
	(0.76)	(1.03)	(0.08)	(0.05)	(0.80)	(0.40)
	(-0.6)	(-1.0)	(-0.6)	(-1.6)	(0.12)	(3.69)
$\Delta P_{ANT}(-1)$	0.23	0.09	0.03	0.02	0.17	0.11
	(0.24)	(0.33)	(0.03)	(0.02)	(0.25)	(0.13)
	(0.94)	(0.29)	(1.08)	(1.10)	(0.67)	(0.90)
$\Delta P_{ANT}(-2)$	0.45	-0.32	0.03	0.01	0.10	0.03
	(0.21)	(0.28)	(0.02)	(0.01)	(0.22)	(0.11)

Error Correction:	ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δer	$\Delta M1$
	(2.21)	(-1.1)	(1.14)	(0.51)	(0.48)	(0.24)
ΔP_{ANT}(-3)	0.31	-0.18	-0.02	0.00	0.29	0.19
	(0.18)	(0.24)	(0.02)	(0.01)	(0.19)	(0.09)
	(1.74)	(-0.7)	(-0.8)	(-0.1)	(1.56)	(2.06)
ΔP_{ANT}(-4)	0.32	-0.03	0.01	0.00	0.12	0.02
	(0.16)	(0.22)	(0.02)	(0.01)	(0.17)	(0.09)
	(1.98)	(-0.2)	(0.38)	(0.00)	(0.73)	(0.25)
ΔP_{AT}(-1)	0.05	0.19	0.01	0.00	0.03	0.06
	(0.14)	(0.20)	(0.02)	(0.01)	(0.15)	(0.08)
	(0.38)	(0.95)	(0.66)	(-0.0)	(0.17)	(0.72)
ΔP_{AT}(-2)	0.18	0.42	0.01	-0.01	-0.24	0.03
	(0.13)	(0.17)	(0.01)	(0.01)	(0.13)	(0.07)
	(1.38)	(2.43)	(0.90)	(-1.4)	(-1.8)	(0.50)
ΔP_{AT}(-3)	0.02	-0.30	0.01	0.01	-0.41	0.09
	(0.15)	(0.20)	(0.02)	(0.01)	(0.16)	(0.08)
	(0.12)	(-1.5)	(0.34)	(0.67)	(-2.6)	(1.17)
ΔP_{AT}(-4)	-0.20	-0.08	0.03	0.03	-0.05	0.00
	(0.15)	(0.21)	(0.02)	(0.01)	(0.16)	(0.08)
	(-1.3)	(-0.4)	(1.81)	(3.22)	(-0.3)	(-0.0)
ΔP_{IN}(-1)	-0.72	-0.75	0.12	0.12	5.13	-0.44
	(2.02)	(2.74)	(0.22)	(0.13)	(2.13)	(1.07)
	(-0.4)	(-0.3)	(0.54)	(0.95)	(2.41)	(-0.4)
ΔP_{IN}(-2)	2.22	1.45	0.11	-0.15	-0.28	1.09
	(1.92)	(2.61)	(0.21)	(0.12)	(2.03)	(1.02)
	(1.15)	(0.56)	(0.51)	(-1.2)	(-0.1)	(1.07)
ΔP_{IN}(-3)	-0.10	-0.55	-0.30	-0.18	-1.61	-0.38
	(1.85)	(2.51)	(0.20)	(0.12)	(1.95)	(0.98)
	(-0.1)	(-0.2)	(-1.5)	(-1.5)	(-0.8)	(-0.4)
ΔP_{IN}(-4)	-2.66	-1.43	0.43	0.06	1.95	0.56
	(1.81)	(2.46)	(0.20)	(0.12)	(1.91)	(0.97)
	(-1.5)	(-0.6)	(2.16)	(0.49)	(1.02)	(0.58)
ΔP_{SE}(-1)	0.63	3.40	-0.70	-0.35	0.50	1.76
	(2.59)	(3.52)	(0.28)	(0.17)	(2.73)	(1.38)
	(0.24)	(0.97)	(-2.5)	(-2.1)	(0.18)	(1.28)
ΔP_{SE}(-2)	1.28	-7.35	0.07	0.08	5.72	-2.76
	(2.51)	(3.41)	(0.28)	(0.16)	(2.65)	(1.34)
	(0.51)	(-2.2)	(0.25)	(0.50)	(2.16)	(-2.1)
ΔP_{SE}(-3)	3.92	-3.79	-0.65	-0.59	3.84	4.30
	(2.85)	(3.88)	(0.31)	(0.18)	(3.01)	(1.52)
	(1.38)	(-1.0)	(-2.1)	(-3.2)	(1.27)	(2.83)
ΔP_{SE}(-4)	4.89	5.23	-0.58	-0.19	3.28	0.22
	(3.19)	(4.34)	(0.35)	(0.21)	(3.37)	(1.70)
	(1.53)	(1.20)	(-1.7)	(-0.9)	(0.97)	(0.13)

Error Correction:	ΔP_{ANT}	ΔP_{AT}	ΔP_{IN}	ΔP_{SE}	Δer	$\Delta M1$
Δer(-1)	-0.23	-0.17	0.04	0.04	0.14	-0.24
	(0.15)	(0.20)	(0.02)	(0.01)	(0.16)	(0.08)
	(-1.5)	(-0.9)	(2.24)	(3.70)	(0.90)	(-3.0)
Δer(-2)	0.07	0.20	0.03	0.00	-0.35	-0.14
	(0.16)	(0.21)	(0.02)	(0.01)	(0.17)	(0.08)
	(0.47)	(0.94)	(1.70)	(0.40)	(-2.1)	(-1.6)
Δer(-3)	-0.11	0.23	0.02	0.03	0.16	-0.26
	(0.15)	(0.20)	(0.02)	(0.01)	(0.16)	(0.08)
	(-0.7)	(1.15)	(1.36)	(3.58)	(1.03)	(-3.3)
Δer(-4)	-0.09	-0.04	0.03	0.01	-0.11	-0.14
	(0.16)	(0.22)	(0.02)	(0.01)	(0.17)	(0.09)
	(-0.5)	(-0.2)	(1.45)	(0.93)	(-0.7)	(-1.6)
ΔM1(-1)	0.09	0.52	-0.06	-0.03	0.41	-0.17
	(0.31)	(0.42)	(0.03)	(0.02)	(0.33)	(0.17)
	(0.30)	(1.23)	(-1.7)	(-1.7)	(1.26)	(-1.1)
ΔM1(-2)	0.59	0.21	-0.01	-0.02	0.17	-0.26
	(0.34)	(0.47)	(0.04)	(0.02)	(0.36)	(0.18)
	(1.73)	(0.44)	(-0.3)	(-0.9)	(0.48)	(-1.4)
ΔM1(-3)	0.07	-0.04	-0.06	-0.09	-0.22	0.08
	(0.33)	(0.45)	(0.04)	(0.02)	(0.35)	(0.18)
	(0.20)	(-0.1)	(-1.7)	(-3.9)	(-0.6)	(0.46)
ΔM1(-4)	-0.41	0.58	-0.09	-0.08	-0.14	0.58
	(0.28)	(0.38)	(0.03)	(0.02)	(0.30)	(0.15)
	(-1.5)	(1.51)	(-2.8)	(-4.6)	(-0.5)	(3.91)
R-squared	0.76	0.62	0.91	0.85	0.65	0.89
Adj. R-squared	0.55	0.28	0.83	0.72	0.35	0.79
Sum sq. resids	0.06	0.10	0.00	0.00	0.06	0.02
S.E. equation	0.04	0.06	0.00	0.00	0.04	0.02
F-statistic	3.64	1.84	11.64	6.46	2.17	8.98
Log likelihood	121.94	103.80	252.30	283.49	118.69	159.09
Akaike AIC	-3.18	-2.57	-7.60	-8.66	-3.07	-4.44
Schwarz SC	-2.20	-1.58	-6.62	-7.67	-2.09	-3.46
Mean dependent	0.00	0.00	0.00	0.00	-0.01	0.01
S.D. dependent	0.06	0.07	0.01	0.01	0.06	0.05
Determinant Residual Covariance					0.00	
Log Likelihood					1079.69	
Akaike Information Criteria					-29.96	
Schwarz Criteria					-23.05	