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Growth Volatility in Paraguay

Sources, Effects, and Options

Supplementary volume with selected background papers

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Preface

This supplementary volume of the study on Growth Volatility in Paraguay—Sources, Effects, and Options provides a number of background papers and material that was prepared as part of this study. The topics are closely linked with the overarching story telling presented in the first volume of the report.

1) *Business Cycles Accounting for Paraguay, by Viktoria Hnatkovska and Friederike (Fritzi) Koehler-Geib*
2) *Agricultural Performance and Macroeconomic Outcomes in Paraguay, by Hakan Berument*
3) *Paraguayan Agricultural and Macroeconomic Performance: A Wavelet Approach, by Hakan Berument*
4) *A study of the Volatility of the Agricultural GDP in Paraguay and its impact in the Rest of the Economy, by Dionisio Borda, Franchesco Anichini, and Julio Ramirez*

CHAPTER 1: BUSINESS CYCLES ACCOUNTING FOR PARAGUAY[1]

By

Viktoria Hnatkovska and Friederike (Fritzi) Koehler-Geib

Abstract

This study investigates the role of domestic and external shocks in business cycle fluctuations in Paraguay during 1991-2012 period. We conduct an integrated analysis of business cycles using both time-series methods and a more structural model-based approach. We begin by performing a structural vector autoregression (SVAR) analysis of the Paraguayan business cycles. We assess the role played by both external factors and domestic shocks in driving GDP fluctuations by the means of impulse response functions and variance decompositions. We find that external shocks (which include shocks to terms of trade, world interest rate and foreign demand) account for over 50 percent of real GDP fluctuations in Paraguay. Shocks to domestic variables (which include shocks to government consumption, real interest rate, trade balance, investment, and output) account for the remaining share of real GDP volatility.

We then split aggregate GDP into its sectoral components: agriculture and non-agriculture and investigate the sources of their volatility separately. This analysis is motivated by the high dependence of Paraguayan economy on agriculture and higher volatility of agricultural GDP. Using the same external and domestic factors, we find some important contrasts in the sectoral business cycle dynamics. The first is that non-agricultural GDP is to a large extent driven by external shocks which account for over 50 percent of its volatility, in line with our findings for the aggregate GDP. In contrast, the volatility of agricultural GDP is primarily due to shocks to domestic variables, mainly shocks to agricultural output itself. These include productivity, weather, mechanization and fertilizer price shocks, etc. The second is that sectoral outputs respond differently to the policy shocks. Shocks to government consumption are more important for agricultural GDP, while shocks to domestic real interest rate play a larger role in non-agricultural GDP volatility.

We then investigate the sources of business cycle fluctuations through the lens of a structural model. In particular, we use a standard neoclassical growth model with two sectors – agriculture and non-agriculture – and amend it to include time-varying frictions or wedges. We then analyze the importance of labor, capital, efficiency, government consumption wedges and inter-sectoral labor and capital allocation wedges in driving GDP volatility in Paraguay. We find some signs of improvements, as labor market distortions have declined, firms' assess to credit improved and agricultural efficiency rose over time. Nevertheless challenges remain as gaps in labor and capital returns between agriculture and non-agriculture remain large, efficiency in non-agricultural sector shows no signs of improvement and households' access to finance have deteriorated.

[1] We thank Guillermo Cabral for excellent research assistance.

1. Introduction

Paraguay used to be one of the less volatile economies in the Latin America. This, however, changed at the turn of the century, when its economic growth has become one of the most volatile in the region. Thus, Paraguay's GDP volatility during 1960-1999 period was below average of the Latin American countries (see Table 1). Based on the percentage std dev of GDP growth rate Paraguayan volatility was just 3.88 compared to 4.72 average and 4.59 median volatility in the region. Similar result holds for an alternative measure of volatility – percentage std dev of output gap -- based on which Paraguayan GDP volatility was 4.22, well below the average (4.73) and median (4.98) volatility in the region.[2] This contrasts with the last decade when the volatility in Paraguay has exceeded both, the regional average and median. In fact, during 2000-2011 period the volatility of GDP growth rate in Paraguay was fourth highest in the region after Venezuela, Argentina and Trinidad and Tobago. This rise in GDP volatility in Paraguay is particularly striking on the backdrop of falling volatility in the rest of the Latin America during the same period (see Table 1).

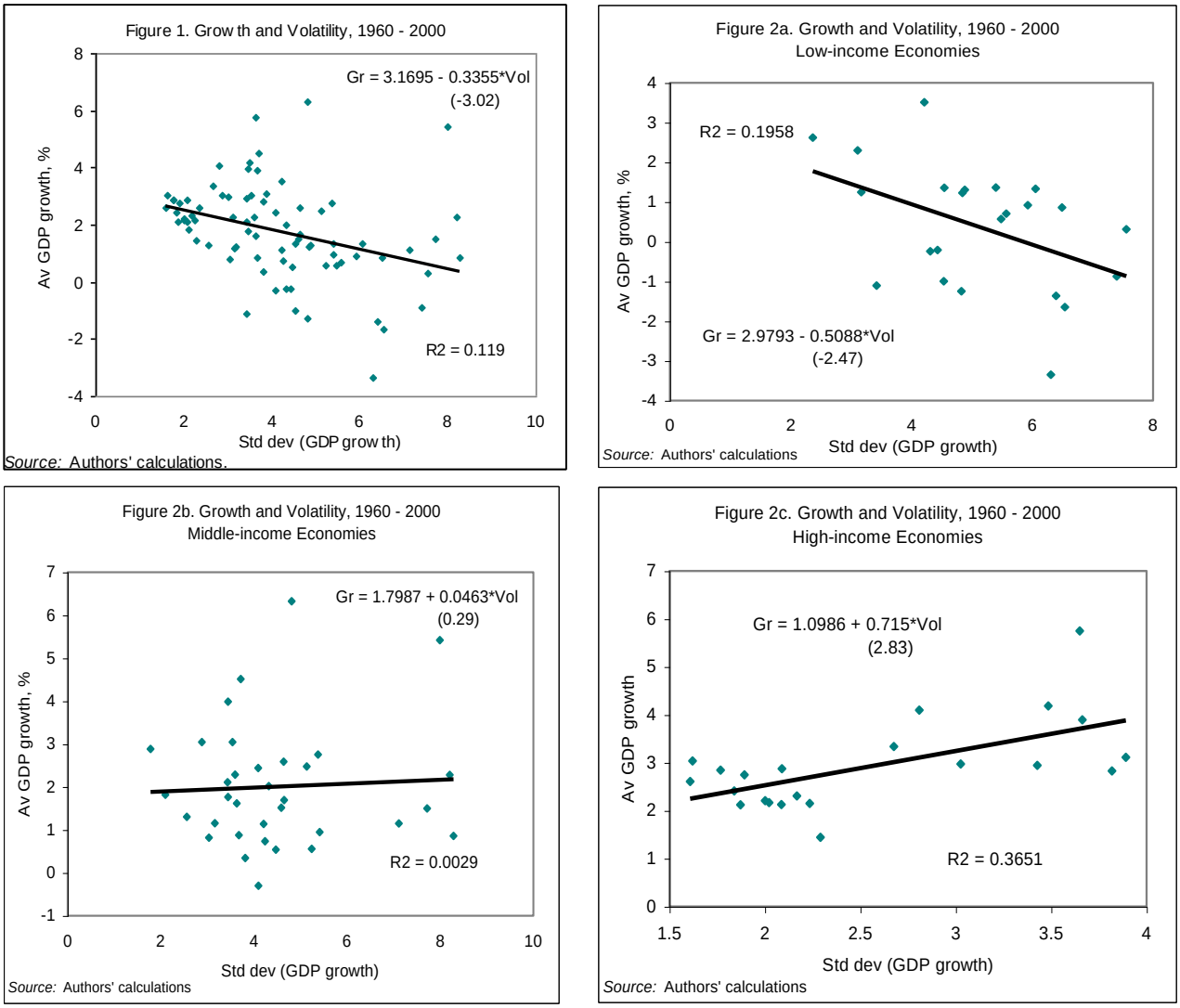
Studying volatility in Paraguay, thus, is highly relevant, in particular due to potential negative effects that high volatility can have on growth and equity. First, volatility may lead to lower growth in Paraguay. Hnatkovska and Loayza (2005) show that the link between volatility and growth, to a large extent, is driven by the level of economic development. In particular, they show that in high income countries higher GDP volatility is associated with higher growth, the relationship is weak in middle income countries, but is strongly negative in low-income countries (see Figures 1-2c below). The negative effect of volatility is also economically significant for this group of countries: each std. dev. increase in volatility is associated with 0.56 percent decline in GDP growth.[3] Second, macroeconomic volatility may have a negative effect on equality.[4] According to Breen and Garcia-Penalosa (2005) a country like Chile could reduce its Gini coefficient by 6 points if it were to reduce its volatility to the same level as Sweden or Norway. Motivated by these observations, in this study we perform a detailed analysis of the sources of GDP volatility in Paraguay during 1994-2012 period.[5]

[2] Output gap is measured as the deviation of log GDP from its Hodrick-Prescott (HP) filtered trend.
[3] See Table 7 in Hnatkovska and Loayza (2005).
[4] See for example Breen and Garcia-Penalosa (2005), Garcia-Penalosa and Turnovsky (2003) or Huang, Fang, and Miller (2012).
[5] The period of study is dictated by the availability of quarterly data for the relevant variables.

Table 1.1: Volatility measures in Latin American Countries

	std dev (GDP growth)			std dev (GDP gap)		
	1960-2011	1960-1999	2000-2011	1960-2011	1960-1999	2000-2011
Argentina	5.83	5.56	6.73	5.66	5.20	6.86
Bahamas, The	7.16	7.91	2.62	7.87	8.84	2.95
Barbados	4.54	4.61	3.51	4.46	4.69	3.62
Belize	4.03	4.17	3.56	4.81	5.30	2.60
Bolivia	3.52	3.93	1.31	3.98	4.49	1.37
Brazil	4.11	4.51	2.29	3.84	4.30	1.63
Chile	4.64	5.21	2.02	4.50	5.05	1.73
Colombia	2.21	2.35	1.77	2.31	2.21	2.56
Costa Rica	3.34	3.49	2.85	3.32	3.49	2.77
Cuba	6.36	7.02	3.65	6.52	7.27	3.90
Dominican Republic	5.26	5.75	3.36	4.63	4.98	3.41
Ecuador	3.55	3.82	2.48	3.17	3.25	2.94
El Salvador	4.18	4.66	1.84	4.63	5.20	1.89
Guatemala	2.49	2.73	1.46	2.56	2.83	1.40
Guyana	5.22	5.74	2.84	5.18	5.69	2.61
Honduras	3.04	3.24	2.42	3.09	3.17	2.92
Jamaica	5.03	5.18	0.33	5.20	5.31	0.26
Mexico	3.78	3.78	3.34	3.25	3.39	2.82
Nicaragua	6.23	7.06	1.96	5.70	6.41	2.12
Panama	4.40	4.56	3.67	4.14	4.34	3.43
Paraguay	**4.28**	**3.88**	**5.50**	**4.31**	**4.22**	**4.45**
Peru	5.03	5.39	3.14	5.01	5.53	2.69
Puerto Rico	3.55	3.10	2.78	2.79	2.73	3.06
Suriname	5.24	5.69	2.10	4.50	5.15	2.68
Trinidad and Tobago	4.99	4.70	5.71	5.36	4.98	6.62
Uruguay	4.44	4.26	5.12	5.37	5.28	5.53
Venezuela, RB	5.32	4.36	7.90	5.17	3.90	8.24
LAC mean (excluding Paraguay)	4.52	4.72	3.11	4.50	4.73	3.18
LAC median (excluding Paraguay)	4.49	4.59	2.81	4.57	4.98	2.80

Figure 1.1: Growth and Volatility Relationship, 1960–2000



Source: Hnatkovska and Loayza (2005).

Our study has several parts. We begin by documenting the key features of Paraguayan business cycles during 1994-2012 period. Then we turn to a more formal analysis based on structural vector autoregressions (SVARs). This allows us to gain insights into the dynamic relationships between variables and to analyze and quantify the effects of various shocks on Paraguayan GDP. Lastly, we turn to the structural analysis to disentangle the results from the SVAR and to give them an economic interpretation. More precisely, we will formalize a model of a small open economy that replicates the key features of the Paraguayan economy – in particular, its dependence on agriculture. We will use this model to perform the business cycle accounting in Paraguay using the methodology of Chari, Kehoe and McGrattan (2007).

1.1 Empirical analysis

Summarizing the data

We start by documenting the properties of business cycles in Paraguay. Table 2 reports volatilities of the key macroeconomic aggregates during 1994Q1-2012Q4 period. Aggregate GDP, agricultural and non-agricultural GDP, investment, public and private consumption, and terms of trade (ratio of export prices to import prices) are all seasonally adjusted using the moving average filter. All variables, but terms of trade are also de-trended by computing their log deviations from a log-linear trend. Real interest rates are obtained as the difference between nominal interest rate (measured as the Central Bank's rate) and inflation. We measure volatility as a percentage standard deviation of each variable. Aside from considering the entire sample period of 1994Q1-2012Q4, we also study two sub-periods: before and after 1999Q4. This allows us to document any the changes in the macroeconomic volatility over time.

Several observations stand out from Table 2. First, in the time span considered agricultural GDP is over 40 percent more volatile than non-agricultural GDP and aggregate GDP. Second, investment, government consumption and private consumption are all more volatile than aggregate GDP, with investment being the most volatile of the lot. Third, the volatility of all variables has increased over time. The rise in the volatility is especially pronounced for agricultural GDP. Notice that the volatility of agricultural GDP before 1999Q4 was comparable to the volatility of non-agricultural and aggregate GDP, but it has more than doubled since then. Paraguayan terms of trade (TOT) have also exhibited a pronounced increase in volatility with the percentage std dev for TOT rising from 11.61 percent to 15.70 percent. We also find that the volatility of government consumption increased dramatically over time. Thus, the rise in volatility in Paraguay seems to be an all-encompassing phenomenon.

Our objective is to investigate the sources of aggregate GDP volatility, and its sectoral components. We consider both domestic and external factors. Figure 1.2 plots GDP in Paraguay together with various domestic and external macroeconomic aggregates, while Table 3 reports unconditional correlations across these variables.

One of the important features of Paraguayan economy is that agriculture has been a substantial and increasing component of its GDP. Figure 1.2(a) shows the dynamics of quarterly real GDP in Paraguay during 1994Q1-2012Q4 period, as well as its agricultural and non-agricultural components. Agricultural GDP remains a significant component of Paraguayan economy, comprising about 15 percent of aggregate GDP, on average. It is also significantly more volatile than the aggregate, while non-agricultural GDP is about as volatile as the aggregate. Importantly, the share of agricultural GDP in total GDP has increased secularly from about 12 percent in the second half of the 1990s to over 18 percent in 2011, contributing to a rise in aggregate GDP volatility that we documented earlier.

Table 1.2: Volatility of Key Variables

Variable	1994Q1-2012Q4	1994Q1-1999Q4	2000Q1-2012Q4
gdp	5.54	3.20	5.50
gdp agri	8.36	3.52	9.74
gdp non-agri	5.97	3.32	5.97
investment	18.19	13.50	17.65
int rate	7.25	5.41	6.82
terms of trade	15.10	11.61	15.70
gov cons	13.73	3.25	14.79
priv cons	7.00	5.24	6.90

Source: Authors.

Among domestic factors influencing business cycle fluctuations we consider domestic investment, trade balance and variables that capture the stance of policy in Paraguay. In terms of the latter, we focus on two key variables: domestic real interest rate and government consumption. Our interest in policy variables reflects the well-known fact that government policies in developing countries tend to exacerbate rather than smooth out business cycle fluctuations.

Recent work shows that real interest rates tend to be counter-cyclical in developing countries, while they tend to be pro-cyclical in developed economies (see, for instance, Neumeyer and Perri (2005), Uribe and Yue (2005)). One of the prominent explanations behind this fact is distortions in factor markets (for instance, the requirement that firms have to pay for part of the factors of production before production takes place, creating a need for working capital). This is also the case for Paraguay, where GDP and real interest rate are negatively correlated, with unconditional correlation equal to -0.17 (see Figure 1.2(b)). This correlation, however, is somewhat smaller (in absolute terms) than the corresponding number in the other Latin American countries, where it is equal to -0.63 in Argentina, -0.49 in Mexico, -0.38 in Brazil (see Neumeyer and Perri (2005)).

In the same spirit, a number of studies have shown that fiscal policy tends to be pro-cyclical in developing countries as well. The procyclicality is defined as a positive response of government spending to an exogenous expansionary business cycle shock. Gavin and Perotti (1997) showed that this is the case in Latin America. Talvi and Végh (2005) then claimed that procyclical fiscal policy is not only a Latin-American phenomenon, but instead characterizes the entire developing world. In a recent study, Ilzetzki and Vegh (2008) revisit the evidence using a sample of 49 countries while allowing for a reverse causality running from fiscal policy to GDP. They show that fiscal policy is indeed procyclical in developing countries.

There are several explanations for this finding: one is that frictions in international credit markets prevent developing countries from borrowing in bad times ((Gavin and Perotti (1997), Caballero and Krishnamurthy (2004), Mendoza and Oviedo (2006), and others); the second is a political economy explanation that good times encourage fiscal profligacy ((Tornell and Lane (1998), Talvi and Végh (2005), and others); and the third is the delays in the implementation and execution of fiscal policies in developing economies.

We find that Paraguay follows the same practice. We measure fiscal policy in Paraguay by considering two key policy instruments: government consumption and government investment. Tax rates are another important fiscal policy instrument; however, data for Paraguay is not available. From Figure 1.2(c) it is easy to see that government consumption is strongly procyclical during 1994-2012 period, with the unconditional correlation equal to 0.85. Figure 1.2(d) plots public investment against GDP. It is easy to see that its dynamics differ significantly from those of public consumption. However, we still find that government investment is procyclical, although its correlation with GDP is much lower at 0.10. It is also interesting to note that the co-movement of public investment with sectoral output is quite distinct from the corresponding co-movements of government consumption. While the latter is positively correlated with both agricultural and non-agricultural output, government investment exhibits a negative correlation with agricultural output (equal to -0.18), but a positive correlation with non-agricultural output (equal to 0.16).

Overall, the results above suggest to us that both monetary and fiscal policies tend to be procyclical in Paraguay and, therefore, may be important drivers of its business cycles.

Among external factors, fluctuations in terms of trade have been viewed as an important source of business cycle volatility in developing countries. In developed economies terms of trade tend to permeate the economy mainly through oil price movements. In developing countries, these effects are exacerbated by two facts: one is that these economies tend to be heavily specialized in a few commodities making them particularly sensitive to commodity price fluctuations; and two is that they are often dependent on imports of intermediate inputs and capital goods. Mendoza (1995) shows in a three-sector intertemporal model that terms of trade shocks account for nearly 50 percent of GDP volatility in developed and developing countries. Kose and Riezman (2001) also show that fluctuations in international relative prices explain 44 percent of the output volatility in Africa. Kose (2002) breaks the import prices into the price of imported capital and the price of imported inputs and finds that the world price shocks are responsible for more than 80 percent of output fluctuations in a representative developing economy. Using data for 3 developed economies (Australia, Canada, New Zealand) and 2 developing countries (Chile and Mexico), Lubik and Teo (2005) report a smaller contribution of terms of trade shocks to business cycles fluctuation.

Figure 1.2(e) shows terms of trade and GDP series in Paraguay and suggests a negative correlation between them, equal to -0.56. This negative correlation is even stronger for non-agricultural GDP at -0.63, while it is positive for agricultural GDP at 0.08, in line with the arguments above.

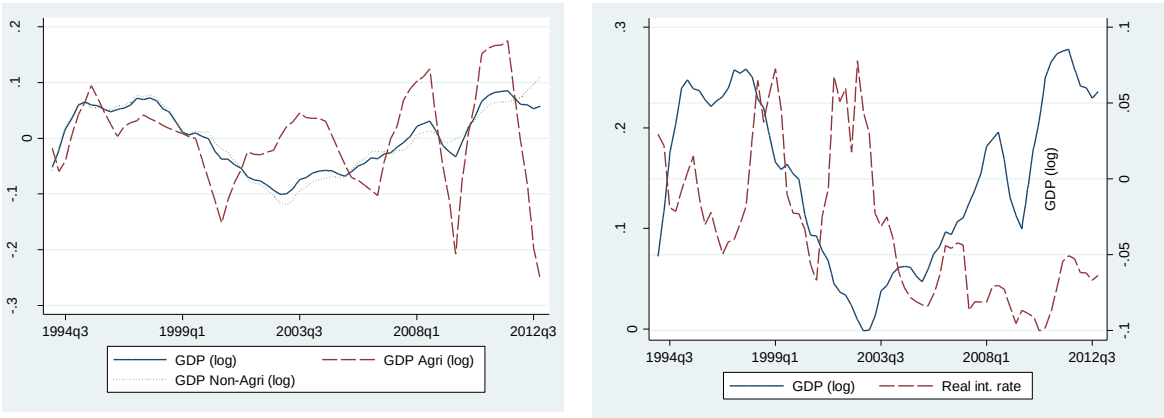
To capture foreign demand conditions for Paraguayan exports we consider GDP in four main trade partners of Paraguay. More precisely, we construct a weighted foreign GDP using GDP data for Argentina, Brazil, Chile and Uruguay, where their export shares in Paraguayan exports are used as weights. The remaining export share is allocated to the US and its GDP in the construction of this aggregate foreign demand measure. The dynamics of this measure during our sample period together with Paraguayan GDP are shown in Figure 1.2(f). The strong positive correlation between the two clearly stands out from that figure. Indeed, the unconditional

correlation of aggregate GDP with the foreign demand is 0.82. It is particularly high for non-agricultural GDP, at 0.80, but falls for agricultural GDP to 0.30.

Another external variable that is important for understanding business cycle fluctuations in developing countries is the world interest rate. Thus, Calvo, Leiderman and Reinhart (1993) show that lower international interest rates have led to an increase in international capital inflows into Latin American countries as investors sought higher returns. Such inflows have contributed to domestic expansions in these countries. A very large literature tried to quantify to what extent the world interest rate can explain fluctuations in small open economies using various methodologies. Lubik and Teo (2005), by using an estimated dynamic stochastic general equilibrium (DSGE) model for Australia, Canada, New Zealand, Chile and Mexico show that world interest rate shocks have substantial explanatory power for business cycle fluctuations in these countries, with their contribution ranging from 40 percent to 75 percent. Neumeyer and Perri (2005) parameterize a dynamic stochastic model of a small open economy, including various stochastic processes, one of which is the process for the world real interest rate. Using their simulations results of the model, one can quantify the contribution of the world interest rate shocks to the output fluctuations to be around 30 percent in a representative emerging economy. In a panel of emerging countries Uribe and Yue (2005) find a similar number. They show that innovations in the US interest rate account for about 20 percent of movements in aggregate activity of those countries. Blankenau, Kose and Yi (2001) using a different methodology find that world interest rate shocks can explain about one-third of the fluctuations in output of Canada.

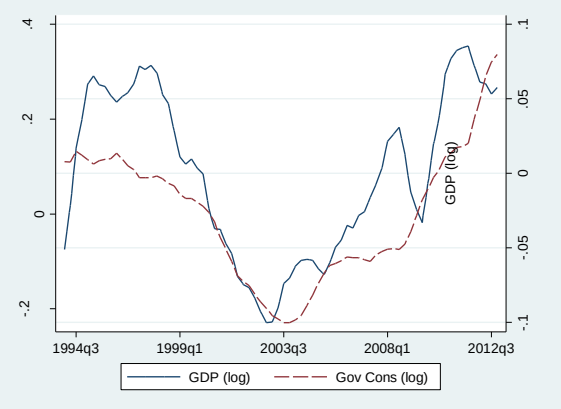
We, therefore, consider world interest rate in our evaluation. Figure 1.2(g) shows domestic GDP plotted together with the world real interest rate measured by the real 3-month US T-bill rate. We find a weak positive correlation with aggregate output, but negative correlation with agricultural output. Since it is possible that changes in the U.S. T-bill rate may also be associated with fluctuations in liquidity in the world markets, we also consider an alternative measure of the world interest rate as the real return on the S&P500.[6] Figure 1.2(h) plots that return together with GDP in Paraguay. The correlation between the two variables is positive, but somewhat weak, equal to 0.19.

Figure 1.2: Business Cycle Fluctuations in Paraguay



[6] Data is from the Global Financial Database.

(a)



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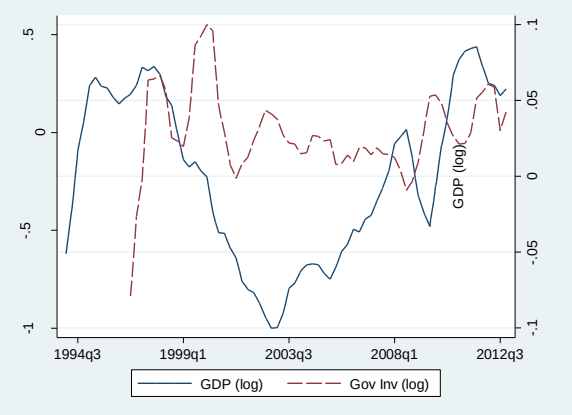

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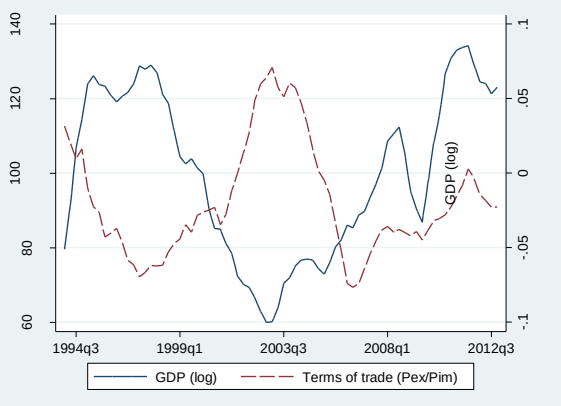

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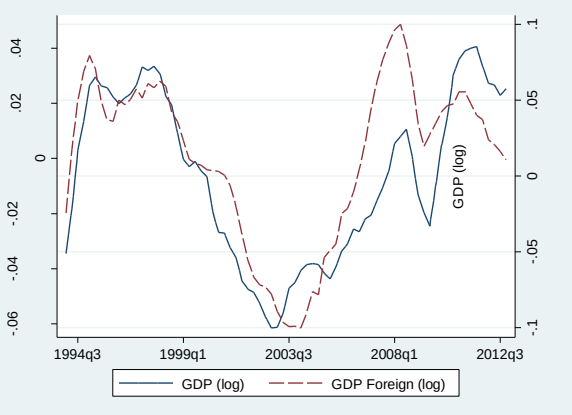
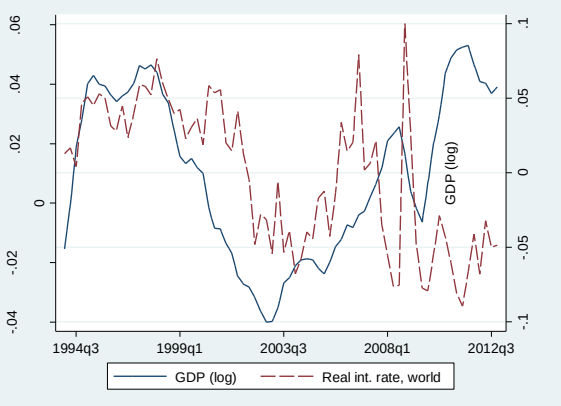
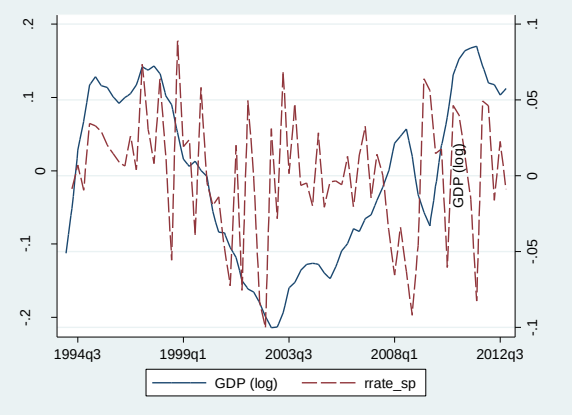


(e)



(f)



(g)

(h)

Source: authors.

Table 1.3: Co-movements Across Variables

	gdp	gdp agri	gdp non-agri	inv	int rate	int rate US	gdp foreign	tot	gov cons	gov inv
gdp	1									
gdp agri	0.39	1								
gdp non-agri	0.97	0.17	1							
inv	0.89	0.33	0.87	1						
int rate	-0.17	0.00	-0.18	-0.23	1					
int rate us	0.13	-0.15	0.18	0.00	0.41	1				
gdp foreign	0.82	0.30	0.80	0.74	-0.23	0.24	1			
tot	-0.56	0.08	-0.63	-0.35	0.25	-0.44	-0.74	1		
gov cons	0.85	0.01	0.91	0.86	-0.09	0.09	0.65	-0.42	1	
gov inv	0.10	-0.18	0.16	0.02	0.14	0.02	-0.03	0.07	0.26	1

Source: Authors.

Overall, several findings from the unconditional moments of Paraguayan data are worth emphasizing:

- Real GDP is less volatile than investment, private and government consumption, with investment being the most volatile variable among them. Agricultural GDP is over 40 percent more volatile than aggregate GDP.
- Terms of trade and real interest rate are more volatile than aggregate GDP.
- Aggregate investment and government consumption are strongly pro-cyclical, while terms of trade and the real interest rate are countercyclical. Public investment is weakly positively correlated with GDP, which implies that the strong procyclicality of aggregate investment is driven by private and not by public component of investment.

Structural vector autoregression analysis

While unconditional correlations are useful to summarize the relationship between various variables, they do not allow us to discern the effects of various shocks on domestic output. Therefore, next, we turn to vector autoregression (VAR) analysis to gain a better understanding of the dynamic relationships between various domestic and external variables over the business cycle in Paraguay. Since we are interested in a causal interpretation of these relationships, we will use a structural VAR guided by economic theory.

We are interested in identifying and quantifying the effects of both domestic and external shocks on Paraguayan output. Our empirical model has the following form:

$$Aw_t = Bw_{t-1} + \varepsilon_t$$

where w_t is a vector of domestic and external variables; and A and B are parameters matrices. We are using a first-order SVAR since this is the order chosen by the Schwarz's Bayesian information criterion (BIC) for selecting the lag length. The vector w_t consists of two blocks of variables. A foreign block is $[\,tot_t,\ r_t^{us}, y_t^f\,]'$, while the domestic block is composed of $[g_t, i_t, tby_t, r_t, y_t]'$. Here *tot* is the terms of trade, r^{us} is the real (3-month) T-bill rate in the US,

and y^f if the (log) export-weighted real GDP in major trade partners of Paraguay. Domestic variables are g – (log) real government consumption, i – (log) real investment, tby – real trade balance to GDP ratio, r is the real domestic short-term interest rate, and y is (log) real GDP. The variables to be included in the SVAR are chosen to capture the factors identified in the literature as important determinants of business cycles in developing countries, as discussed above. All variables, except domestic and world interest rates, are expressed in first-differences.

In order to identify the structural parameters of the model, we must specify restrictions on matrices A and B above. First, we require that the matrix A is lower triangular with unit diagonal elements. Since external variables in the SVAR system appear before domestic variables, our identification strategy assumes that external variables affect domestic conditions contemporaneously. Similarly, among domestic variables, those that appear higher up in the vector exert a contemporaneous effect on the variables that are at the bottom of the vector, while the latter variables percolate back into the system with a one period lag. The second set of restrictions is motivated by the fact that Paraguay is a small economy relative to the rest of the world. As a result, external variables are very unlikely to be affected by the domestic conditions in Paraguay, either contemporaneously or with a lag. By imposing these restrictions we are effectively using a block recursive structure in our SVAR (see Zha (1999) for theory and application for Canada, and Canova (2005), Uribe and Yue (2006) for applications to emerging economies). Hence, in our model external variables are determined independently of domestic variables, both contemporaneously and in lags.

We are interested in answering several questions with our estimated SVAR. First, how do external variables affect domestic economic conditions in Paraguay, especially its output? Which of the external variables are the most important for understanding business cycle fluctuations? Second, how do government policy shocks affect domestic economic activity in Paraguay? How important are these shocks in business cycles? Third, how important are external versus domestic factors in explaining movements in aggregate economic activity in Paraguay? We answer these questions by means of impulse responses and variance decompositions.

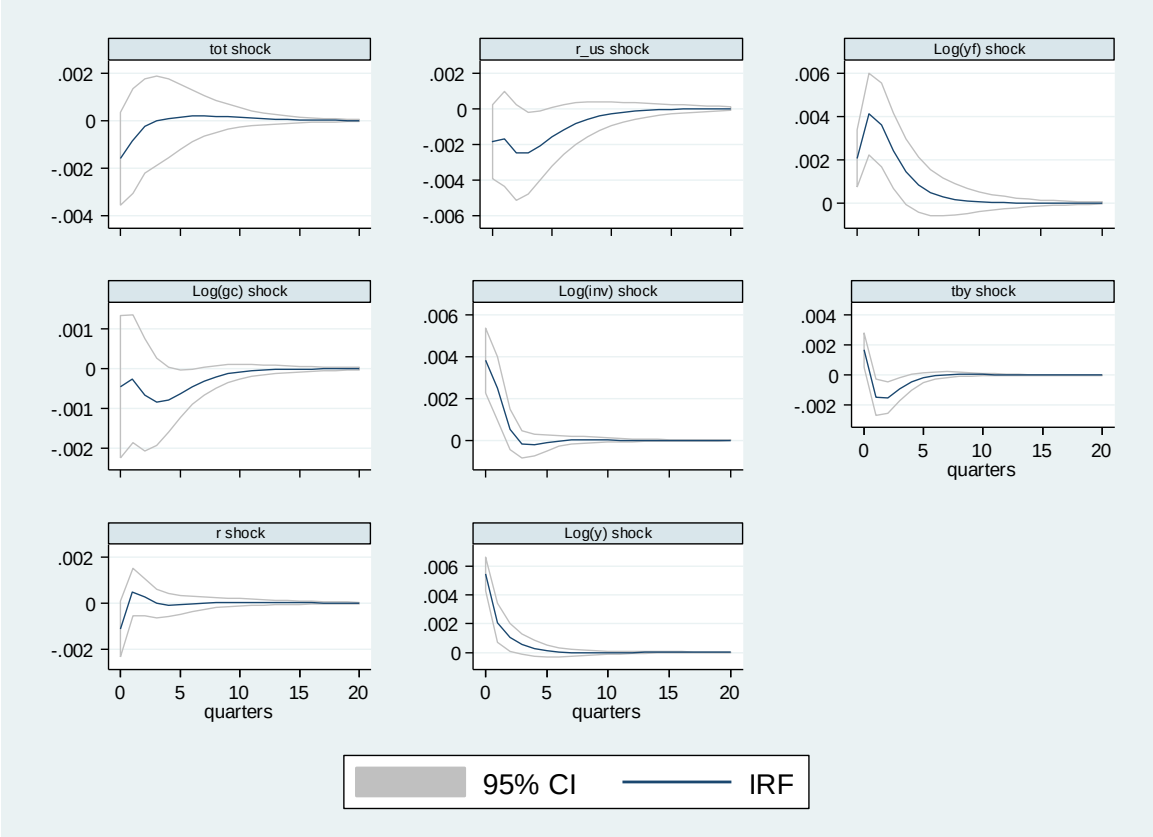
1.2 Impulse response functions

Figure 1.3 presents impulse responses of real output implied by our structural VAR to various shocks, together with 2 standard error bands. Consider shocks to external variables first. In response to a unit unanticipated innovation in the world interest rate, Paraguayan output declines, suggesting that external financial conditions indeed spill over onto the domestic performance. There are several possible explanations for this negative effect.

The first is a direct effect through portfolio reallocation by foreign investors who shift out of Paraguayan assets when world interest rate rises. Such reductions in the rate of inflow can be strongly contractionary, at least in the short run, as shown in Calvo, Leiderman and Reinhart (1993), Gavin, Hausmann and Leiderman (1995). We attempt to test this hypothesis by studying the co-movement between world interest rate and financial flows in Paraguay, in the spirit of Calvo, Leiderman and Reinhart (1993) study of Latin American countries. Since reliable quarterly data on financial flows in Paraguay spanning the duration of our sample is not available we proxy net financial flows with the trade balance. The two are closely related through the balance of payments identity: absent international financial flows, trade has to be balanced every

period. Conversely, if no goods are tradable across borders, there is no need for intertemporal borrowing and lending. Then, if higher world interest rate leads to a fall in financial inflows into Paraguay, we should see that such interest rate increases are associated with improvements in the current account (proxied by trade balance here).

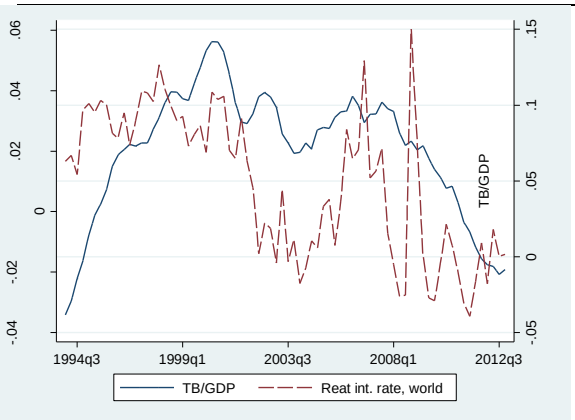
Figure 1.3: Impulse Responses of Output to Various Shocks



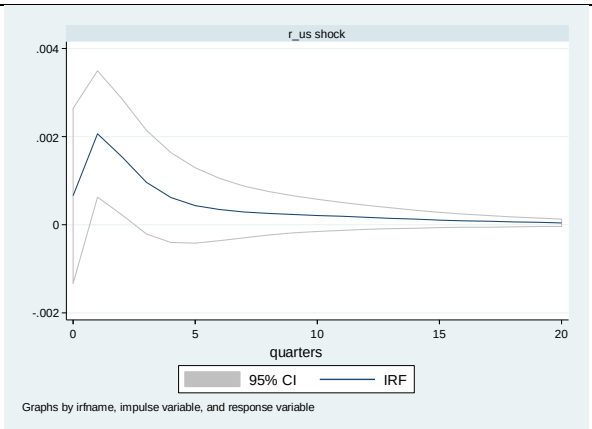
Source: authors.

Figure 1.4(a) plots the trade balance to GDP ratio in Paraguay together with the U.S. real interest rate. The correlation between the two variables is positive equal to 0.30. Of course, this unconditional correlation, while supportive of our hypothesis, may be the result of shocks other than the world interest rate shocks. SVAR allows us to control for those. Figure 1.4(b) plots the response of trade balance to GDP ratio following a positive unanticipated shock to the world interest rate. It is easy to see that trade balance improves on impact, supporting the idea that world interest rate lead to some portfolio rebalancing by foreign investors.

Figure 1.4: World Interest Rate Shocks and Capital Flows



(a)



(b) response of TB/GDP to world int rate shock

Source: authors.

Second, it is likely that the world interest rate shocks affect the Paraguayan economy through their influence on world commodity prices. Several recent studies have emphasized the existence of a theoretical link between world real interest rates and commodity prices. For instance, Frankel (2008) argues that higher world real interest rate will reduce speculative demand for commodities and lead to lower prices for them. Higher interest rates also can make holding commodity inventories more costly inducing a further fall in their prices. Indeed, he finds that real interest rates are important determinants of the prices of agricultural and mineral commodities. In the same spirit, Calvo (2008) argues that low interest rates, by inducing portfolio reallocation away from liquid assets by the sovereign wealth funds, can drive up commodity prices.

On the other hand, since changes in commodity prices will pass-through into domestic price inflation or affect inflationary expectations (even in the longer term) (see Celasun, Ratnovski and Mihet (2012) for evidence on this in the U.S.), the reverse effect from commodity prices to world interest rates is likely to be present as well.[7] The above discussion makes it clear that there exists a complex interaction between world interest rate and commodity prices.

We attempted to capture this relationship between world interest rates and commodity prices by including the terms of trade variable and the U.S. real T-bill rate in our SVAR model. However, our recursive identification scheme does not allow for a contemporaneous correlation between the two variables.[8] Thus it is possible that some of the effects of commodity price changes on Paraguayan economy are subsumed in the world interest rate shocks.

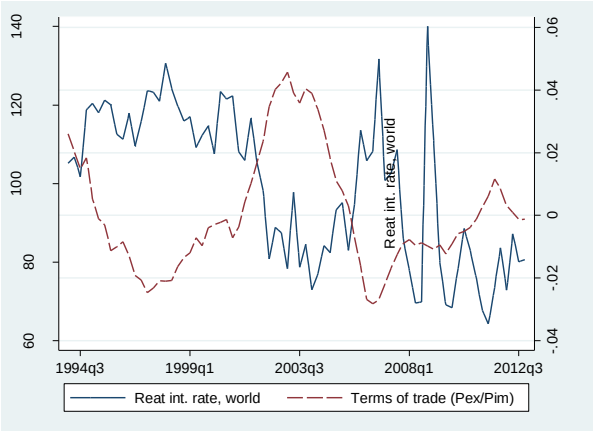
To illustrate the interrelation between the two variables, consider Figure 1.5 which plots the U.S. real T-bill rate together with the terms of trade variable. It is easy to see the negative relationship between the two. Indeed, the correlation is equal to -0.44 during our sample period. These results highlight the fact that even a country that is not deeply integrated in the world capital markets

[7] For further empirical analysis of the relationship between international interest and commodity prices see Byrne, Fazio, and Fiess (2012) and Frankel and Rose (2010).

[8] Note that changing the order of the two variables in the SVAR will not resolve the simultaneity problem. In fact, the results remain robust to a change in the ordering of the two variables.

may be exposed to world shocks (including the world interest rate shocks) as long as it remains dependent on commodity production and exports.

Figure 1.5: World Interest Rate and Commodity Prices



Source: authors.

Third, the higher world interest rate may also affect Paraguayan economy indirectly by weakening economic conditions in its major trade partners – Brazil, Argentina, Chile, Uruguay – who are significantly exposed to the world financial markets through sovereign borrowing. These conditions would spill over into Paraguayan economy through these countries' lower demand for Paraguayan exports. Higher world interest rates may affect consumption demand by these countries through a number of channels: (i) through intertemporal substitution, by encouraging higher savings by households; (ii) through negative wealth effects to indebted households; (iii) through portfolio reallocation effects. Higher world interest rates may also negatively affect investment by firms by raising their cost of borrowing.

While we tried to control for the effects of foreign demand conditions on Paraguayan economy by using a trade-weighted output of the Paraguay's major trade partners, that measure may not fully capture such demand shocks if there are nominal rigidities in the goods or factor markets, or if there exists a significant informal sector, or if supply and demand shocks are correlated in these economies. The world interest rate will again subsume some of these foreign demand effects.

The fourth potential effect of higher world interest rates is a reduction in remittances to Paraguayan households from abroad, which would negatively affect domestic demand. While remittance inflows have increased significantly in Paraguay in recent years from 0.67 percent of GDP in 1991 to over 2 percent of GDP in 2011, lack of quarterly data does not allows us to explore this hypothesis in details.[9] We find that the effects of the world interest rate shock tend to be quite long-lived as Paraguayan GDP shows a persistent decline, lasting about 10 quarters after the shock. While we propose several channels through which world interest rate shocks may spill over into Paraguayan economy, a detailed investigation of them is left for the future work.

[9] These numbers are computed using annual Balance of Payments data from the Banco Central del Paraguay.

Next, we turn to terms of trade. Positive innovations to terms of trade (measured as price of exports to price of imports) lead to a fall in GDP on impact but the effect is not statistically significant. The next external shock is unanticipated innovation to the foreign GDP which we use to capture foreign demand for Paraguayan exports. A positive shock to foreign output leads to an increase in Paraguayan output, and this effect is both economically and statistically significant. Furthermore, the effects of this shock become larger in the first few quarters after the impact and last for several years.

Lastly, we study the effects of domestic shocks on Paraguayan GDP. In response to an unanticipated domestic output shock, GDP itself increases and then gradually returns toward its steady-state level. Shocks to investment and trade balance both lead to higher output. An unanticipated positive innovation to government consumption leads to a fall in real GDP on impact, but GDP recovers after about 10 quarters. Lastly, an increase in domestic real interest rate leads to a contraction in GDP but the effect is short-lived.

1.3 Variance decompositions

To quantify the contribution of various shocks to GDP volatility in Paraguay, we perform a variance decomposition based on our estimated SVAR system at different horizons. Variance decomposition allows us to quantify the contribution of each shock to the variance of forecasting error for output. The results are presented in Table 4.

Table 1.4: Variance Decomposition of GDP Volatility

quarters	tot	r_us	Log(yf)	Log(gc)	Log(inv)	Tby	r	Log(y)	External	Domestic
1	0.043	0.058	0.071	0.004	0.248	0.047	0.022	0.506	0.173	0.827
4	0.026	0.143	0.308	0.011	0.163	0.062	0.012	0.274	0.477	0.523
8	0.024	0.191	0.300	0.019	0.148	0.058	0.011	0.248	0.515	0.485
12	0.025	0.195	0.299	0.020	0.147	0.058	0.011	0.247	0.518	0.482
16	0.025	0.195	0.299	0.020	0.147	0.058	0.011	0.247	0.518	0.482
20	0.025	0.195	0.299	0.020	0.147	0.058	0.011	0.247	0.518	0.482

Source: authors.

We focus on the variance decomposition at 12 quarters which is where the percentages for all cases stabilize. Researchers typically define business cycles as movements at frequencies between 6 and 32 quarters (see Baxter and King (1999)). The 12-quarter horizon that we focus on is in the midpoint of this range.

Our estimates show that external shocks account for a large part of output volatility in Paraguay during 1994-2012 period. More precisely, about 52 percent of GDP volatility is driven by shocks to the terms of trade, world interest rate, and foreign demand for Paraguayan output. Among the three external factors, shocks to foreign output represent an important driving force, accounting for about 30 percent of GDP volatility, followed by shocks to the world interest rate which were

responsible for about 20 percent of GDP volatility, and by the terms of trade shocks which contributed another 3 percent to GDP volatility.[10]

Shocks to domestic variables account for the remaining 48 percent of GDP volatility. The majority of it is due to shocks to real GDP (25 percent) and shocks to investment (15 percent), while policy shocks account for about 3 percent of total GDP volatility. The contribution of shocks to the trade balance to GDP ratio is about 6 percent.

We also examine the sensitivity of our results with respect to several aspects of our specification. First, we consider an alternative proxy for the world interest rate given by the real return on the S&P500. We find minimal changes compared to our earlier results. World interest rate shocks remain an important contributor to the output fluctuations in Paraguay, accounting for over 7 percent of GDP volatility at 12 quarters horizon. At the same time, the contribution of shocks to foreign output rises to 35 percent, while the contribution of terms of trade shocks remains at 3 percent. The share of output fluctuations accounted for the domestic shocks increases slightly to 55 percent. Second, given the high dependence of Paraguayan exports on a few commodities we use exports concentration variable instead of trade balance to GDP ratio. Export concentration is obtained as the share of two principal goods exports in total exports of the country. We find that results remain robust to this change as well.

1.4 The sources of agricultural and non-agricultural GDP volatility

Our comparison of sectoral GDP volatility in Figure 1.2(a) revealed that agricultural GDP is significantly more volatile than aggregate GDP. We next analyze the contribution of the sectoral composition of Paraguayan economy to the aggregate GDP volatility. We are also interested in understanding whether agricultural and non-agricultural GDP volatility are driven by different shocks.

To evaluate the contribution of agricultural and non-agricultural output volatility to the aggregate GDP volatility we compute a simple variance decomposition as follows. Using the identity $y = y^a + y^{na}$, we can write

$$Var(y) = Cov(y^a, y) + Cov(y^{na}, y),$$

where *Var* denotes unconditional variance, while *Cov* is unconditional covariance. Then the variance of aggregate GDP can be decomposed as

$$1 = \frac{Cov(y^a, y)}{Var(y)} + \frac{Cov(y^{na}, y)}{Var(y)}.$$

[10] Kose, Otrok, and Prasad (2012) and Kose, Otrok, and Whiteman (2008) find a stronger role of domestic factors. This difference appears to mainly stem from a sample period that only goes up until 2005 only. Raddatz (2007) also finds a predominant role of external variables in a paper that examines whether the differences in output volatility between Latin America and other regions result from volatility of external shocks or from a more pronounced response to these. Podpiera and Tulin (2012), focusing on the role of financial external variables find a relevant role of external factors.

Notice that $\frac{Cov(y^a,y)}{Var(y)}$ term is the slope regression coefficient in a simple OLS regression of y^a on y and a constant; similarly, $\frac{Cov(y^{na},y)}{Var(y)}$ is the slope regression coefficient in an OLS regression of y^{na} on y and a constant. We find that variations in non-agricultural output contribute the most to the aggregate GDP volatility. Specifically, a 1 percent increase in aggregate GDP is accompanied by a 0.25 percent increase in agricultural GDP and 0.75 percent increase in non-agricultural GDP.

Next, we study the volatility of agricultural and non-agricultural GDP and factors underlying them in more detail. Specifically, we extend our SVAR specification to include agricultural and non-agricultural GDP instead of the aggregate GDP. Our identifying assumption is that shocks to agricultural GDP can have a contemporaneous effect on non-agricultural GDP, while the latter feedbacks into agricultural GDP only with a lag. This assumption is motivated by the results in Bravo-Ortega and Lederman (2005) who find that developing countries tend to experience positive effects running from agriculture to the rest of the economy. They also show that this effect is stronger in Latin American countries than in other developing economies. The rest of the variables, their ordering and parameter restrictions in the SVAR remain unchanged.

We begin by analyzing the effects of various shocks on agricultural GDP using impulse response functions. Figure 1.6 presents our findings. Focusing first on external factors, our results suggest that world interest rate shocks and foreign output shocks have the same qualitative effect on agricultural GDP as on aggregate GDP. Quantitatively, the effects of these shocks on agricultural GDP are significantly larger than for the aggregate GDP. For instance, a positive shock to the foreign real output leads to a 1 percent increase in agricultural real GDP, while it leads to about 0.4 percent increase in aggregate real GDP. Similarly, unanticipated shocks to the world interest rate lead to a reduction in Paraguayan agricultural GDP and the effects of these shocks are significantly larger than on aggregate GDP. These findings are supportive of the idea that the effects of world interest rate shocks on Paraguayan economy are primarily transmitted through the agricultural sector – i.e. through the effects of these shocks on commodity prices and/or foreign demand for Paraguayan exports, which are predominantly agricultural.

The shocks to terms of trade, in contrast, have contrasting effects on agricultural GDP and on aggregate GDP. While the terms of trade shocks lead to a fall in aggregate output, they benefit the agricultural sector and lead to an increase in agricultural output. This effect is quite large and significant.

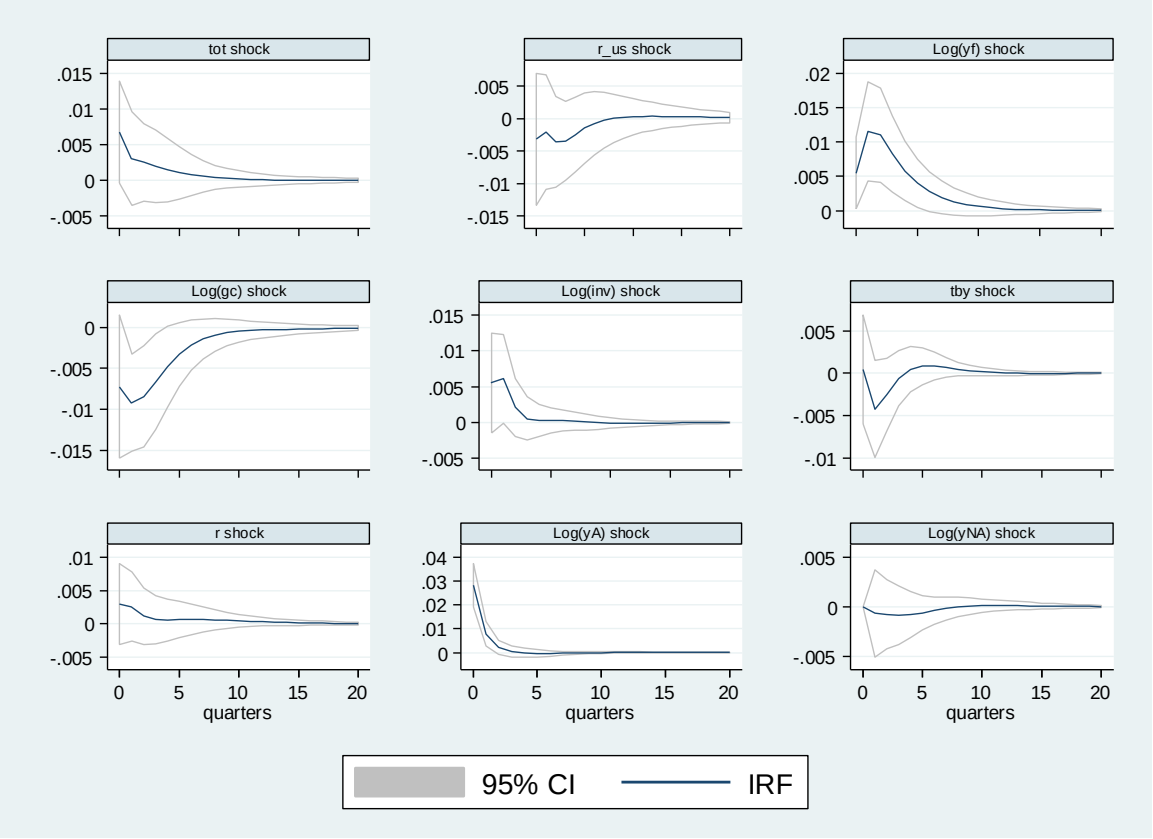
In terms of the domestic shocks, a positive unanticipated unit innovation to agricultural output leads to a significant increase in agricultural GDP on impact, followed by a gradual decline back to the steady state. The rest of the domestic shocks have similar effects to those for the aggregate GDP, except that these effects are somewhat larger. For instance, consider a unit shock (1 percent) to government consumption. It leads to a 1 percent decline in agricultural GDP, confirming the idea that procyclical fiscal policy may have detrimental effect on domestic conditions, especially in agriculture. Shocks to non-agricultural GDP do not affect agricultural GDP on impact, given out identification assumption, but lead to a small decline in agricultural GDP in the year following the shock.

Impulse response functions for the effects of various shocks on non-agricultural GDP are presented in Figure 8. These results show that the effects of the external shocks on non-agricultural output are very much in line with our findings for the aggregate GDP. Specifically, shocks to the world interest rate and terms of trade tend to reduce non-agricultural output, while the shocks to foreign demand lead to an increase in non-agricultural output. The main difference is that the effects of these shocks on non-agricultural output are somewhat larger than on the aggregate output, especially for the terms of trade shocks.

When it comes to domestic variables, several results are worth noting. First, shocks to government consumption show an interesting contrast in their effect on agricultural and non-agricultural GDP. Namely, these shocks lead to a reduction in agricultural GDP, but they tend to increase non-agricultural GDP. One potential explanation for this result is the negative wealth effects that would arise if the majority of government consumption is allocated towards non-agricultural goods. Increases in government consumption, is such case, will raise the relative price of non-agricultural goods, leading to a negative wealth effects for agricultural workers and thus having contractionary effects on that sector.

Shocks to domestic interest rate have almost no effect on agricultural GDP, but significantly reduce non-agricultural GDP. This may be not surprising if higher interest rates reduce investment demand and non-agricultural sector is more capital intensive. Shocks to investment have large positive effects on output in both sectors.

Figure 1. 6: Impulse Responses of Agricultural Output to Various Shocks



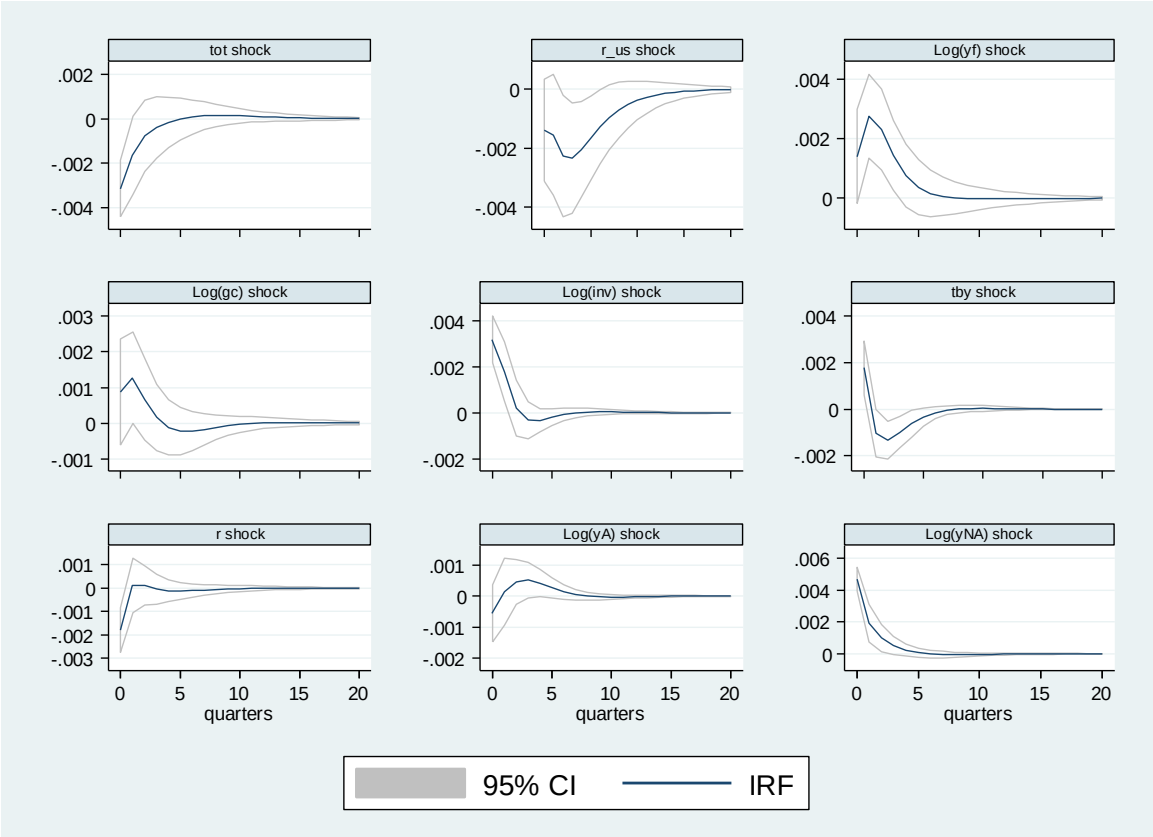
Source: authors.

Table 1.5: Variance Decomposition of Agri and Non-Agri GDP Volatility

Agri											
quarters	**tot**	**r_us**	**Log(yf)**	**Log(gc)**	**Log(inv)**	**tby**	**r**	**Log(yA)**	**Log(yNA)**	**External**	**Domestic**
1	0.047	0.010	0.031	0.053	0.031	0.000	0.009	0.819	0.000	0.088	0.912
4	0.038	0.023	0.208	0.149	0.042	0.015	0.010	0.513	0.001	0.270	0.730
8	0.038	0.026	0.228	0.162	0.040	0.015	0.010	0.479	0.002	0.292	0.708
12	0.038	0.026	0.229	0.162	0.040	0.015	0.011	0.477	0.002	0.293	0.707
16	0.038	0.027	0.229	0.162	0.040	0.015	0.011	0.477	0.002	0.293	0.707
20	0.038	0.027	0.228	0.162	0.040	0.015	0.011	0.477	0.002	0.293	0.707
Non-Agri											
quarters	**tot**	**r_us**	**Log(yf)**	**Log(gc)**	**Log(inv)**	**tby**	**r**	**Log(yA)**	**Log(yNA)**	**External**	**Domestic**
1	0.185	0.037	0.036	0.014	0.191	0.059	0.061	0.006	0.412	0.258	0.742
4	0.134	0.151	0.170	0.028	0.136	0.070	0.033	0.008	0.270	0.454	0.546
8	0.120	0.221	0.159	0.027	0.124	0.068	0.030	0.010	0.243	0.500	0.500
12	0.120	0.227	0.157	0.027	0.122	0.067	0.030	0.010	0.241	0.504	0.496
16	0.120	0.228	0.157	0.027	0.122	0.067	0.030	0.010	0.240	0.505	0.495
20	0.120	0.228	0.157	0.027	0.122	0.067	0.030	0.010	0.240	0.505	0.495

Source: authors.

Figure 1.7: Impulse Responses of Non-Agricultural Output to Various Shocks



Source: authors.

Table 5 presents variance decomposition results for agricultural and non-agricultural GDP volatility. We find that while external shocks were responsible for over 50 percent of non-agricultural GDP volatility (in line with our results for aggregate GDP), these shocks accounted for only 1/3 of agricultural GDP volatility.[11] Domestic shocks were significantly more important for agricultural volatility, with shocks to agricultural output itself accounting for more than a half.

What are these unanticipated shocks to agricultural output? We conjecture that agricultural productivity shocks, driven to a large extent by weather conditions, may be important to understand agricultural GDP volatility. To investigate this conjecture we back out the structural shocks to agricultural output from our SVAR estimates and study their co-movement with a proxy for weather conditions given by rainfall measure (in millimeters).[12] We find a positive correlation between structural shocks to agricultural output and rainfall, equal to 0.36. Importantly, we also find that this correlation has become more pronounced over time. Before 1999Q4 the correlation was very small, equal to -0.10, but increased dramatically since 2000 to 0.58. This occurred at the same time as the volatility of rainfall has declined from 21.80 percent before 1999Q4 to 13.98 percent since 2000Q1. This suggests to us that while weather shocks have become less volatile in the analyzed sub-periods, Paraguayan agricultural sector has become more sensitive to them. This could be the result of a growing concentration of Paraguayan agricultural production in few commodities, such as soy beans and livestock.[13] Less diversified production structure makes agricultural sector more susceptible to weather shocks. Other factors driving the unanticipated shocks to agricultural output may include changes in mechanization and fertilizer usage, other weather shocks not captured by rainfall, such as temperature fluctuations, as well as natural disasters, etc. Due to lack of data on these measures we do not investigate their role in this study.

Shocks to government consumption, investment, and trade balance played much smaller role and together accounted for the other half of agricultural GDP volatility driven by domestic shocks.

Non-agricultural GDP, in contrast, is highly sensitive to external shocks – it is in roughly equal proportion driven by the shocks to terms of trade, world interest rate and foreign output. Among domestic factors, shocks to non-agricultural GDP (i.e. non-agricultural productivity shocks) are the most important, accounting for about 24 percent of the overall non-agricultural GDP volatility. Shocks to investment and trade balance also play an important role, contributing another 19 percent to the volatility of non-agricultural GDP.

1.5 Model-based business cycle accounting

Next we turn to a model-based examination of the sources of business cycle volatility in Paraguay. More precisely, we employ the business cycle accounting methodology of Chari,

[11] As before, we mainly focus on the variance decomposition results at the 12 quarters horizon.
[12] To eliminate seasonal fluctuations in the rainfall measure we apply seasonal adjustment using the moving average filter, and de-trend the resulting series by computing their log deviations from a log-linear trend.
[13] For instance the share of soy beans in exports rose from 27 percent, on average, of total exports before 1999Q4 to 32 percent since 2000Q1; similarly, the share of meat in exports more than doubled during the same period from 6 percent of total exports, on average, before 1999Q4 to over 13 percent since then.

Kehoe and McGrattan (2007) by introducing time-varying wedges into a standard frictionless neoclassical growth model. These wedges represent frictions and distortions in labor and capital markets, and shocks to efficiency, government spending, and trade balance. We will quantify these wedges and evaluate their contribution to GDP volatility in Paraguay.

The purpose of this exercise is two-fold. First, such analysis will allow us to provide structural interpretations to the SVAR results reported in the previous section. Second, it will allow us to identify the parts of the economy where the wedges (and therefore distortions and/or shocks) are the highest and focus the policy discussion in these sectors.

We start by outlining a model of a small open economy that replicates the key features of the Paraguayan economy. The economy is populated by a representative household optimizing her lifetime utility over leisure $(1 - l_t)$ and consumption (c_t). The problem of the household can be summarized as

$$\max \sum_{t=0}^{\infty} \beta^t u(c_t, 1 - l_t)\, N_t \qquad subject\ to$$

$$\left(1 - \tau_{k,t}\right) r_t k_t + \left(1 - \tau_{l,t}\right) w_t l_t = c_t + x_t,$$

$$N_{t+1} k_{t+1} = [(1 - \delta) k_t + x_t] N_t,$$

$$c_t \geq 0 \quad for\ all\ t\ and\ in\ all\ states$$

Here l_t denotes labor input, k_t is capital stock, x_t is investment; $r_t\ and\ w_t$ are rental rate of capital and wage rate, respectively; and N_t is working age population. Thus, we use lower-case letters denote variables in per-capita terms, while upper-case letter denote aggregate variables.[14] $1 - \tau_{k,t}\ and\ 1 - \tau_{l,t}$ are time-varying capital wedge and labor wedge, respectively. Capital wedge acts as a tax on rental payments to capital and thus interferes in the inter-temporal consumption-saving decision of the household. Labor wedge acts as a tax on labor income payments and thus distorts the intra-temporal consumption-leisure decision of the household.

The production side of the economy consists of two intermediate goods sectors – agriculture (*a*) and non-agriculture (*na*) -- and a final good sector whose output is non-tradable. We assume that there is a representative firm in each sector. Labor and capital are fully mobile across sectors. Note that this assumption only applies in the frictionless benchmark model. Clearly, it is unrealistic in the economy such as Paraguay. By comparing the actual allocations of factors across sectors in Paraguay with those implied by the frictionless benchmark we will be able to quantify the extent of the restrictions on sectoral factor mobility in the Paraguayan economy.

Output produced in each intermediate goods sector is given by the following technology:

$$Y_a = K_a^v (z_a L_a)^\mu$$

[14] We use total population numbers since working-age population data is not easily available.

$$Y_{na} = K_{na}^{\alpha}(z_{na}L_{na})^{1-\alpha}$$

where K_j *and* L_j are capital and labor employed in sector j=a, na. z_j is the level of the labor augmenting productivity in sector j=a, na.[15] The final good is produced by combining two intermediate goods:

$$Y = \left(\widehat{Y_a}\right)^{\varphi}\left(\widehat{Y_{na}}\right)^{1-\varphi}$$

where $\widehat{Y_a}$ and $\widehat{Y_{na}}$ denote the amounts of agricultural and non-agricultural goods used in the production of the final good. We assume that the final good is the numeraire good so that all prices are expressed in units of the final good.

Firms in each sector are perfectly competitive and each period, taking prices as given, maximize their profits given by:

$$\Pi_t^a = p_{a,t}Y_{a,t} - w_tL_{a,t} - r_tK_{a,t}$$

$$\Pi_t^{na} = p_{na,t}Y_{na,t} - w_tL_{na,t} - r_tK_{na,t}$$

$$\Pi_t = Y_t - p_{a,t}\widehat{Y_{a,t}} - p_{na,t}\widehat{Y_{na,t}}$$

Finally, in equilibrium, all final goods that are produced must be either consumed by households, government or foreigners, or invested:

$N_t(c_t + x_t) + G_t = Y_t$.

Here G_t is a government spending and net exports wedge. Also, labor and capital used by the firms in all sectors must be equal to capital and labor supplied by households:

$$N_tk_t = K_{a,t} + K_{na,t}$$

$$N_tl_t = L_{a,t} + L_{na,t}$$

We assume the following functional form for the utility function:

$$u(c, 1-l) = \ln(c) + \psi\ln(1-l),$$

where ψ is the relative weight of leisure in the utility function.

[15] Note that the production function for agricultural good is functionally equivalent to $Y_a = AK_a^{v}{L_a}^{\mu}$, where $A = z_a^{\mu}$. A similar rewriting applies to the production function in non-agriculture.

Wedges

Wedges can be computed from the optimality conditions of firms and households in our model. Each wedge provides a measure of how much each condition deviates from the optimum. In particular, we define the following wedges:

1. Labor wedge: $\left(1-\tau_{l,t}\right)=\frac{\psi\tilde{c}_t}{(1-l_t)w_t}$ (1)

2. Capital wedge: $\left(1-\tau_{k,t}\right)=\left[\frac{\tilde{c}_{t+1}}{\beta\tilde{c}_t}-(1-\delta)\right]\frac{1}{r_t}$ (2)

3. Government spending and trade balance wedge: $\tilde{g}_t=\tilde{y}_t-\tilde{c}_t-(1+\gamma_n)(1+\gamma_z)\tilde{k}_{t+1}+(1-\delta)\tilde{k}_t$ (3)

4. Efficiency wedge in agriculture: $z_{a,t}=\left[\frac{\tilde{Y}_{a,t}}{\tilde{K}_{a,t}^{v}L_{a,t}^{\mu}}\right]^{1/\mu}$ (4a)

   Efficiency wedge in non-agriculture: $z_{a,t}=\left[\frac{\tilde{Y}_{na,t}}{\tilde{K}_{na,t}^{\alpha}L_{na,t}^{1-\alpha}}\right]^{1/(1-\alpha)}$ (4b)

5. Sectoral capital allocation wedge: $\tau_{w,t}=\frac{VMPL_{a,t}}{VMPL_{na,t}}=\frac{p_{a,t}}{p_{na,t}}\frac{\mu\tilde{Y}_{a,t}/L_{a,t}}{(1-\alpha)\tilde{Y}_{na,t}/L_{na,t}}$ (5a)

   Sectoral labor allocation wedge: $\tau_{r,t}=\frac{VMPK_{a,t}}{VMPK_{na,t}}=\frac{p_{a,t}}{p_{na,t}}\frac{v\tilde{Y}_{a,t}/\tilde{K}_{a,t}}{\alpha\tilde{Y}_{na,t}/\tilde{K}_{na,t}}$ (5b)

We used γ_n to denote population growth and γ_z to denote trend growth in average labor efficiency. A "~" over a variable is used to denote de-trended per-capita variables:

$$\tilde{q}_t=\frac{Q_t}{N_t z_0(1+\gamma_z)^t}$$

Equations (5a)-(5b) give the sectoral capital and labor allocation wedges, respectively. These wedges measure the gap in value marginal products of labor and capital (VMPL and VMPK) between agriculture and non-agriculture.

To derive all these wedges for Paraguayan economy we need data on output, capital and employment in agriculture and non-agriculture, relative price of agricultural to non-agricultural output, and private consumption. Our sample uses annual data and spans 1991-2010 period. All variables are in per capita terms and all (except labor) are linearly de-trended using the average productivity growth. Note that we do not have data for real rental rates and wages in Paraguay. Therefore we substitute wages and rental rates by the value marginal products of labor and capital, respectively.

We also need to assign values to the parameters in the production functions and utility function. We calibrate them such that we can match certain long-term facts about Paraguay. Their values are summarized in Table 6.

Table 1.6: Model Parameters

	parameter	value
ψ	weight of leisure in utility	3.36
β	subjective discount factor	0.99
δ	depreciation rate	0.08
γ_n	population growth rate	2.1%
γ_z	productivity growth rate	-1.0%
α	capital share in non-agriculture	0.35
v	capital share in agriculture	0.25
μ	labor share in agriculture	0.45

Source: authors.

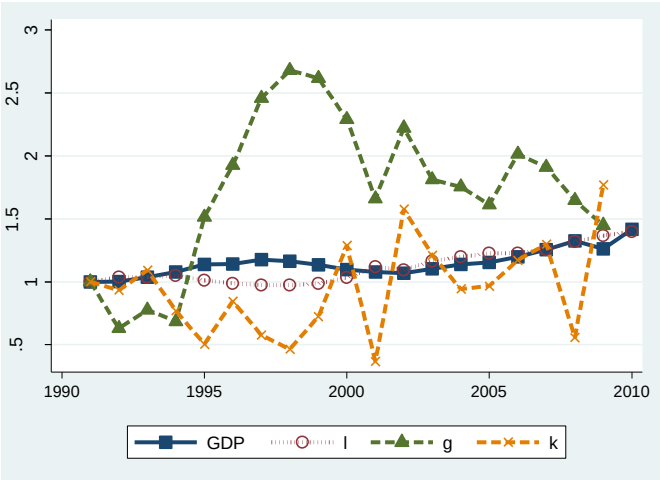
Most of the parameter values are standard and have been extensively used in the literature. These are the weight of leisure in utility, equal to 3.36; subjective discount rate equal to 0.99 and annual depreciation rate equal to 8 percent.[16] We estimate average annual population growth to be equal to 2.1 percent during 1991-2010 period in Paraguay, while the average productivity growth during the same period is negative equal to -1 percent. We also find that this average aggregate productivity growth conceals some important sectoral differences in productivity. Specifically, we find that during the same period, agricultural productivity was growing at about 3 percent per annum, while productivity in non-agriculture was falling at about 1.6 percent per annum. Given the larger size of non-agricultural sector in Paraguayan GDP, the aggregate productivity growth was negative.

Parameters governing production technology are calibrated as follows. We assume that the labor share in non-agriculture is equal to 0.65, while the capital share in non-agriculture is equal to 0.35. These numbers are standard in developed countries and are close to the estimates for Ecuador (labor share = 0.57) and Bolivia (labor share = 0.63) computed by Gollin (2002) after accounting for self-employed and assuming that labor and capital shares for self-employed are approximately the same as in private unincorporated enterprises. For the agricultural sector, we use labor and capital share estimates from Abler, Tolley, and Kripalani (1994) computed for India. They estimate that labor share is equal to 0.45, while capital share is equal to 0.25 in agriculture.[17] The rest is returns to a fixed factor such as land.

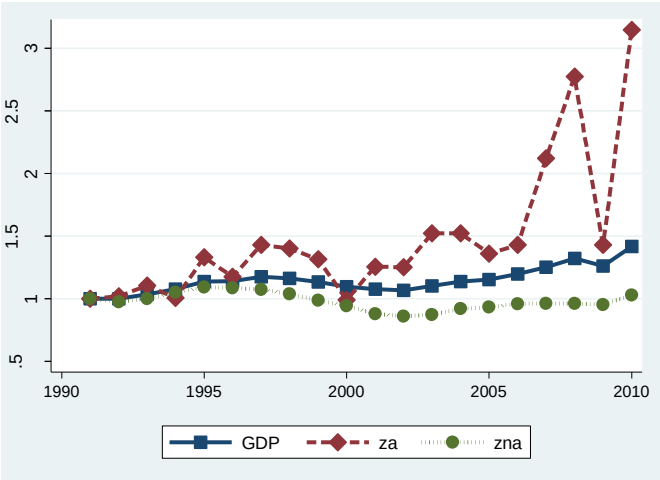
Our estimated wedges are plotted in Figure 1.8. Panel (a) presents labor, capital and government wedges, as well as GDP; while panel (b) shows GDP and efficiency wedges in agriculture and non-agriculture. All wedges and GDP are normalized by their initial value in 1991. Since all variables in our calculations are de-trended using the average productivity growth, agriculture and non-agriculture efficiency wedges show the changes in sectoral productivity relative to the aggregate trend. The sectoral labor and capital allocation wedges are presented in Figure 10 below.

[16] The depreciation rate for the capital stock is taken from Acosta-Ormaechea and Dabán Sánchez (2011).
[17] We also analyze how sensitive our results are with respect to the factor share parameters. We find that these parameters affect primarily the average size of the wedges but not their trends or dynamics.

Figure 1.8: Wedges and Aggregate GDP



Panel (a)



Panel (b)

Source: authors.

Let's start by interpreting the labor wedge, given by equation (1). As we argued above, $\tau_{l,t}$ can be broadly interpreted as a time-varying tax on labor income. It can arise due to distortions affecting both the demand and supply sides of the labor market. For instance, the labor wedge may reflect payroll taxes, distortions due to unionization, collective bargaining, hiring and firing costs, or sticky wages. An increase in this tax would lead to a reduction in labor input. Based on this, if we observe that $1 - \tau_{l,t}$ is increasing over time it would mean that $\tau_{l,t}$ is falling and labor market frictions are becoming less important. From panel (a) of Figure 1.8, this is exactly the pattern that characterizes the Paraguayan labor market during 1991-2010 period. The labor wedge $1 - \tau_{l,t}$ has increased over time, especially during the 2000s, reflecting increased employment. This may suggest that structural improvements in the Paraguayan labor market, higher labor force participation, and greater flexibility by firms in adjusting their labor inputs may have taken place during this time.

To gain some insights into the driving forces behind these changes we turn to the "Doing Business" survey by the World Bank, particularly, its "Employing Workers" section. It provides information on the right to collective bargaining, difficulty of hiring workers, the cost of advance notice requirements, severance payments, and penalties due when terminating a worker. It also contains information about minimum monthly wages of apprentice workers. Young workers are especially susceptible to the negative effects of labor market rigidities, since they typically lack experience and on-the-job training. In the presence of firing costs, potential employers are discouraged from hiring such workers.

Unfortunately, the historical data from the survey is available going back only to 2006, thus limiting our ability to explain the entire trend in the labor wedge. Nevertheless it provides us with some hints about the developments in the Paraguayan labor market in the recent years. Interestingly, we find no changes in the indicators of firing costs in Paraguay during 2006-2011 period (see Table A1 in the Appendix). However, we also find that minimum apprentice wages have increased substantially in Paraguay during this time. Their growth at 9.8 percent per year on

average was above 8.8 percent average growth of apprentice wages in the Latin American region during the same period.[18] We conjecture that such rapid growth in young workers' wages could have led to an increased participation of these workers in Paraguayan labor market, thus increasing the labor wedge.

Capital wedge summarized in equation (2) can be interpreted in a similar manner. Higher $1-\tau_{k,t}$ would imply a lower effective tax on capital, $\tau_{k,t}$, resulting in higher investment and thus benefiting GDP growth in Paraguay. This wedge, therefore, captures financing constraints affecting firms' investment decisions. In our benchmark economy capital is the only asset available for saving. Therefore, equation (2) also characterizes the optimal consumers' intertemporal consumption-savings decision. Thus, the capital wedge $1-\tau_{k,t}$ also captures the liquidity constraints affecting these decisions. In effect, we can think of the capital wedge as reflecting the relative importance of the two types of constraints.

As we discussed above, an increase in $1-\tau_{k,t}$, interpreted as a lower effective tax on capital, $(\tau_{k,t})$, will be associated with a fall in financing frictions facing firms. On the other hand, an increase in $1-\tau_{k,t}$ can be interpreted as a lower effective return on savings to households and thus will be associated with an increase in liquidity constraints facing them.

We find that the capital wedge shows some secular increase over time, although this increase is accompanied by a significant volatility around the trend. The fact that the wedge is secularly increasing is indicative of the improved access to financing faced by firms, relative to consumers. Furthermore, we find that a substantial part of volatility in the capital wedge is driven by the consumer (consumption growth) side, suggesting that financing constraints facing households remain pronounced and time-varying.

One way to evaluate this result is to look at the dynamics of private credit to businesses and households. Unfortunately, we only have data available for aggregate credit to the private sector. We find that during 1994-2011 period its stock (as a ratio of GDP) has expanded by 35 percent, suggesting an improvement in credit market conditions in Paraguay during this period.

Table 7 provides additional evidence on the improvements in credit conditions in Paraguay during 2004-2012 period. It reports the number of individuals and firms listed in a public credit registry or private credit bureau with information on their borrowing history from the past 5 years. The number is expressed as a percentage of the adult population (the population age 15 and above according to the World Bank's World Development Indicators). We also include the recovery rate measured as cents on the dollar recouped by creditors through reorganization, liquidation or debt enforcement (foreclosure) proceedings.

[18] These numbers are for wages measured in US dollars.

Table 1.7: Ease of Getting Credit, Doing Business, World Bank

Year	Public registry coverage (% of adults)	Private bureau coverage (% of adults)	Recovery rate in case of insolvency (cents on the dollar)
DB2004	--	--	7.1
DB2005	9	--	8.5
DB2006	8.7	52.2	13.3
DB2007	10.6	52.2	15.4
DB2008	11	48.7	14.6
DB2009	9.7	48.6	20.7
DB2010	10.9	47.4	20.7
DB2011	13.9	50.5	16.1
DB2012	15.7	48.5	16.6
DB2013	16.7	47.5	15.3

Source: authors.

We see that private credit bureau coverage, although declined somewhat since 2006, has been well above 33.8 percent average coverage in the Latin America and Caribbean region. At the same time, the public registry has picked up the slack by increasing its coverage from 9 percent in 2005 to 16.7 percent in 2013. This number now stands well above the 11 percent public registry coverage in the Latin America and Caribbean.

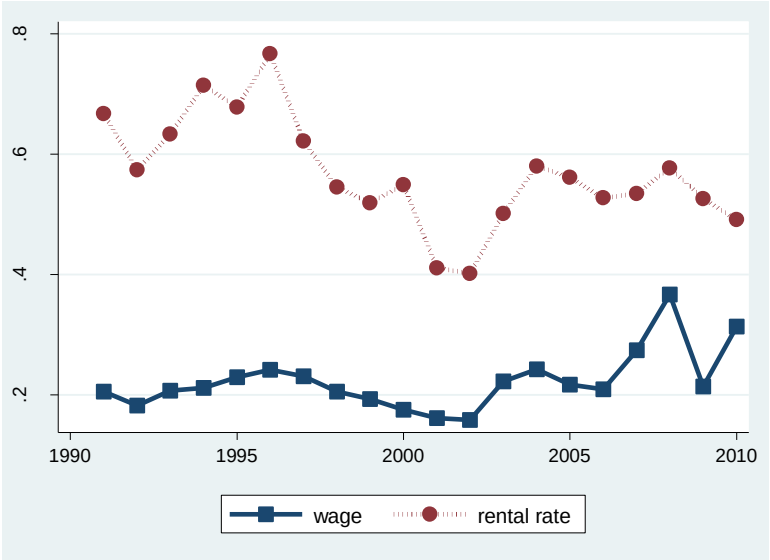
Government spending and trade balance wedge computed from equation (3) shows little change through the early 1990s, but increases in the late 1990s and remains well above 1 throughout the 2000s. The increase reflects mainly the improvement in the Paraguayan net exports starting mid-1990s. Namely, in the 1990s net export was at about 5 percent of GDP, but almost doubled reaching 8.8 percent of GDP in the 2000s. Its peak was at 14 percent of GDP in year 2000. During the same period, government consumption did not show much change, and in fact declined somewhat from 8.5 percent of GDP to 7.5 percent of GDP. Thus, our government consumption and net exports wedge reflects mainly the changes in net exports over the period.

Turning to the sectoral efficiency wedges given by equations (4a)-(4b) and plotted in Figure 1.8(b), we find that there are substantial differences in the dynamics of agricultural and non-agricultural wedges. During 1991-2010 period agricultural efficiency wedge is increasing a lot, while non-agricultural efficiency wedge is declining. These trends just reflects the fact that the measured agricultural productivity has been improving during this period, averaging 3 percent per year; while the measured non-agricultural productivity has been falling, averaging -1.5 percent annually. Of course, we must note that this productivity measure reflects not only total factor productivity (TFP) but also all other factors that are not captured directly by our measures of capital and labor. These include human capital, weather conditions, omitted inputs, misallocation of resources, institutional factors, and in fact everything that may lead to inefficient human and physical capital stocks in each sector.

Lastly, we discuss inter-sectoral labor and capital allocation wedges derived in equation (5a)-(5b) and presented in Figure 1.9. Recall that the two wedges compare the value marginal products of labor and capital between agriculture and non-agriculture. Both wedges are less than

1 suggesting that returns to labor and capital are lower in agriculture than in non-agriculture. Labor allocation wedge starts at around 0.2 suggesting a 5-fold relative gap in favor of non-agricultural labor returns. This is a well-known characteristic of developing countries – low value marginal product in agriculture (see recent work by Restuccia, Yang and Zhu, 2008; Gollin, Lagakos and Waugh, 2012; and others). Interestingly, the gap remained relatively stable throughout our sample, showing a small increase only after 2005. This suggests some recent improvements in workers' returns in agriculture, but the gap relative to non-agricultural workers remains significant.

Figure 1.9: Sectoral Allocation Wedges Between Agri and Non-Agri



Source: authors.

The wedge in the sectoral capital allocation shows more variability than the sectoral labor allocation wedge. It is around 0.6 in the early 1990s, increases to about 0.8 in the first half of the 1990s, but then shows a secular decline through the second half of the 1990s and early 2000s. During the 2004-2010 period the gap stabilizes at around 0.55 on average. This implies that, while volatile, the gap in average returns to capital remained in favor of non-agricultural sector.

Overall our results on sectoral labor and capital allocation wedges suggest that factor mobility remains limited in Paraguay, preventing the equalization of value marginal products across sectors. These frictions reduce efficiency and thus may contribute negatively to the performance of Paraguayan economy.

1.6 Conclusions

In this paper we document and analyze the sources of macroeconomic volatility in Paraguay during 1991-2012 period. We employ two approaches in our study. The first is a structural vector autoregression (SVAR) approach which allows us to assess the role played by both external factors and domestic shocks in driving GDP fluctuations in Paraguay using impulse response functions and variance decompositions. We find that external shocks, including shocks to terms

of trade, world interest rate and foreign output, account for over 50 percent of aggregate GDP volatility in Paraguay, while domestic shocks which include shocks to government consumption, real interest rate, investment, trade balance and aggregate output are responsible for the rest. To shed some light on the volatility of sectoral GDP we split the aggregate GDP into its agricultural and non-agricultural components. We find a similar quantitative contribution of domestic and external shocks to non-agricultural output volatility. Agricultural GDP, in contrast, is driven predominantly by domestic factors, which account for 71 percent of its volatility, while external factors account for the remaining 29 percent.

Our second approach is a model-based business cycle accounting exercise. It allows us to quantify frictions and distortions associated with various sectors and aspects of the economy and their contribution to business cycles in Paraguay. We find signs of improvement in various aspects of Paraguayan economy: with labor market distortions declining, firms' assess to credit improving and agricultural efficiency rising over time. Nevertheless significant distortions remain when it comes to gaps in labor and capital returns between agriculture and non-agriculture, efficiency in non-agricultural sector, and households' access to finance.

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Appendix 1.1: Table 1.

	Difficulty of hiring		Rigidity of hours					Redundancy rules								Redundancy cost		
year	Are fixed-term contracts prohibited for permanent tasks?	What is the maximum cumulative duration of a fixed-term employment relationship (in months), including all renewals?	Can the workweek for a single worker extend to 50 hours per week (including overtime) for 2 months each year to respond to a seasonal increase in production?	Are there restrictions on night work?	Are there restrictions on "weekly holiday" work?	What is the maximum number of working days per week?	Mandatory working days of annual leave (i.e. vacation) with pay in manufacturing after 20 years of continuous employment?	Is it legal for an employer to terminate the employment contract of a worker on the basis of redundancy?	Must the employer notify a third party before dismissing one redundant worker?	Does the employer need the approval of a third party in order to dismiss one redundant worker?	Must the employer notify or consult a third party prior to a collective dismissal?	Must the employer obtain prior approval from a third party before a collective dismissal?	Is there a retraining or reassignment obligation before an employer can make a worker redundant?	Are there priority rules that apply to redundancy dismissals or lay-offs?	Are there priority rules applying to re-employment?	notice period for redundancy dismissal after 20 years of continuous employment	severance pay for redundancy dismissal after 20 years of continuous employment	penalty for redundancy dismissal after 20 years of continuous employment
2006	Yes	No Limit	Yes	Yes	No	6	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	15	85.7142857	0
2007	Yes	No Limit	Yes	Yes	No	6	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	15	85.7142857	0
2008	Yes	No Limit	Yes	Yes	No	6	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	15	85.7142857	0
2009	Yes	No Limit	Yes	Yes	No	6	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	15	85.7142857	0

	Difficulty of hiring		Rigidity of hours							Redundancy rules								Redundancy cost						
year	Are fixed-term contracts prohibited for permanent tasks?	What is the maximum cumulative duration of a fixed-term employment relationship (in months), including all renewals?	Can the workweek for a single worker extend to 50 hours per week (including overtime) for 2 months each year to respond to a seasonal	Are there restrictions on night work?	Are there restrictions on "weekly holiday" work?	What is the maximum number of working days per week?	Paid annual leave (working days) - 1 year	Paid annual leave (working days) - 5 years	Paid annual leave (working days) - 10 years	Is it legal for an employer to terminate the employment contract of a worker on the basis of redundancy?	Must the employer notify a third party before dismissing one redundant worker?	Does the employer need the approval of a third party in order to dismiss one redundant worker?	Must the employer notify or consult a third party prior to a collective dismissal (9 employees)?	Must the employer obtain prior approval from a third party before a collective dismissal (9 employees)?	Is there a retraining or reassignment obligation before an employer can make a worker redundant?	Are there priority rules that apply to redundancy dismissals or lay-offs?	Are there priority rules applying to re-employment?	Notice period for redundancy dismissal after 1 year of continuous employment	Notice period for redundancy dismissal after 5 years of continuous employment	Notice period for redundancy dismissal after 10 years of continuous employment	Severance pay for redundancy dismissal after 1 year of continuous employment	Severance pay for redundancy dismissal after 5 years of continuous employment	Severance pay for redundancy dismissal after 10 years of continuous employment	Average penalty for redundancy dismissal after 1, 5 and 10 years of continuous employment
2010	Yes	No Limit	Yes	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	5.0	7.5	10.0	2.1	10.7	42.9	0.0
2011	Yes	No Limit	Yes	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	5.00	7.50	10.00	2.14	10.71	42.86	0
2012	Yes	No Limit	Yes	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	5.00	7.50	10.00	2.14	10.71	42.86	0
2013	Yes	No Limit	Yes	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	No	Yes	5.00	7.50	10.00	2.14	10.71	42.86	0

CHAPTER 2: AGRICULTURAL PERFORMANCE AND MACROECONOMIC OUTCOMES IN PARAGUAY

By

Hakan Berument*

Abstract

This paper investigates the determination of agricultural income and its propagation to other sectors in the Paraguayan economy. Using VAR analysis, determinants as well as propagation of agricultural value added are studied. Our findings indicate that agricultural output is highly susceptible to natural causes and international agricultural price shocks. Both agricultural and non-agricultural productions affect the export performance. In terms of inter-sector linkages, agricultural output contemporaneously triggers higher activity in services. There is a non-significant yet positive feedback from private investments to agriculture, and more importantly, expansion of agricultural activity induces total investments contemporaneously.

JEL Classification:C51 - Model Construction and Estimation; Q11 – Agriculture - Aggregate Supply and Demand Analysis; Prices.

Keywords: Agricultural output, National income, Time series analysis, Paraguay.

2.1 Introduction

This paper investigates the agricultural performance in Paraguay from a macroeconomic point of view. Agriculture is of vital importance to the Paraguayan economy and it is believed to have a high impact on the overall economic outcomes. On one hand, this potential impact is salutary as gains from agriculture will be translated into an increase of social welfare. On the other hand, the ability of agriculture to affect the rest of the economy might be a curse; i.e. undesired or adverse outcomes in the agricultural sector might generate a subsequently adverse impact. So it is essential to have a clear understanding of the performance in the agricultural sector.

In order to understand the Paraguayan agriculture, this paper maintains a two-layer approach. First, the drivers of agricultural GDP are examined. Then the transmission of agricultural value added to other sector is analyzed. These analyses range from a bird's eye view of the relationship between agricultural and non-agricultural sectors to the transmission of agricultural output to lower level components of the GDP. In this way, the study is of an exploratory nature so it tries to depict some basic relationships without employing any priors.

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Throughout the paper, we employ an array of Vector Auto Regression (VAR) models and establish a picture of Paraguayan agriculture by means of Impulse Response Functions (IRF) analysis. Especially in the absence of a comprehensive set of data, the VAR family models allow us to see have a good grasp of the underlying relationships among the variables of interest.

The next section introduces the data and variable definitions. In the third section, results of empirical analysis are provided. Section four elaborates on quantification of VAR findings and dwells on the forecast ability they provide. The last section concludes the paper.

2.2 Data and variables

It is unfortunate that the data on the Paraguayan agriculture did not allow us to obtain a good production function view of what is happening. In many cases the data are missing if not econometrically bogus. Having abandoned the production function family of approaches, we turned our attention to models including at least the rainfall as a variable as the rainfall remains as an important variable for the yields of several agricultural products. In some of our models, the linkages between agricultural value added and rainfall and between agricultural and nonagricultural value added series have simultaneously been addressed. Indeed, these models provided us with a clear grasp of the Paraguayan economic dynamics. The descriptive statistics of data are provided in Appendix 2.1.

One clarification of definitions is essential while working with agricultural data. Agricultural activity is either focused on producing crops, vegetable and fruits, or on animal breeding and its byproducts. Consequently, the direct value added from agriculture can be measured at two levels. The usual practice is to compile both categories together which is sufficient to have a general statistical picture. That certain practice might be adequate for the purposes of daily politics. Nevertheless, separate treatment of crop production and animal breeding becomes inescapable while examining economic relationships for the purposes of policymaking. In doing so, we maintained two definitions of agricultural data. In the first definition, we considered solely the production of crops, vegetable and fruits, i.e. we focused on value added from agricultural land. In the second definition, value added from animal breeding was added on top of the first one. So throughout the paper we used a nomenclature in which the first [second] definition of agricultural output has been referred to as the narrow [broad] definition of agriculture. Such a practice helped us a lot in revealing the economic relationships of interest. Needless to say, the value added out of animal breeding was used in isolation in a subset of our specifications.

As can be seen in the following section, we defined the variables measuring economic activity in growth terms. This preference enabled us to work with stationary variables and to employ stationary VAR specifications.

2.3 Empirical framework

Vector auto-regression (VAR) approach

In the rest of the paper, we basically use the impulse-response functions to describe the relationships that we are seeking within a Vector Auto Regression (VAR) setup.

$$A(L)z(t) = \varepsilon(t) \tag{1}$$

In Equation 1, $z(t)$ is an $m \times 1$ vector of observations, $A(L)$ is an $m \times m$ matrix polynomial in the lag operator L and $\varepsilon(t)$ is an $m \times 1$ vector of structural disturbances. If we consider two subsets of observables ($z_1(t)$ and $z_2(t)$) and maintain the view of an unrestricted VAR, the specification is expressed as in Equation 2 where all $A_{ij}(L)$ are nonzero. Equivalently, each variable of the system receives feedback from the lags of all the remaining variables.
The lag orders of the estimated VARs are taken as suggested by the Schwarz Information Criterion.

$$z(t) = \begin{bmatrix} z_1(t) \\ z_2(t) \end{bmatrix}, \quad A(L) = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix}, \quad \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix} \tag{2}$$

In the next section, we stick to the simplest view of VAR described above, unless otherwise specified. However, we revealed in our preliminary analyses (not reported) that some variables like rainfall does not receive any feedback from the other variables in the system, yet affect the others both contemporaneously and through time lags. Use of a specification based on Equations 1 and 2, then, yields distorted pictures of the economic relationships that we are seeking for. There is a remedy though which is described by Equation (3).

$$z(t) = \begin{bmatrix} z_1(t) \\ z_2(t) \end{bmatrix}, \quad A(L) = \begin{bmatrix} A_{11}(L) & 0 \\ A_{21}(L) & A_{22}(L) \end{bmatrix}, \quad \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix} \tag{3}$$

Equation 3 differs from Equation 2 by setting $A_{12}(L)$ to zero. Explicitly, $z_1(t)$ has a statistical process of its own and receives no feedback from $z_2(t)$. In this way, one is allowed to include one-way feedbacks within a simple VAR framework. The anomalies such as higher economic activity inducing more generous rainfall, or the opposite, are consequently outlawed. The assumptions of Equation 2 are that the coefficient matrix of L^0 in $A(L)$, A_0 is non-singular and $\varepsilon(t)$ is uncorrelated with $z(t-s)$ for $s > 0$.

Note that use of the term “block” does not necessarily imply an obligation to include more than one variable in each block. Provided that each block includes at least one variable and there is no singularity in the system, the associated parameters are estimable. For example, in our cases with rainfall, the first block includes the rainfall variable only whereas the rank of second block is more than one.

As a final point, a short elaboration of VAR orderings might be useful. In the specifications of Section 4 we have employed at most five variables where ordering of variables were guided by plain intuition. Natural factors like rainfall volume were placed first as they are more exogenous and these variables were restricted to be block exogenous. For the ordering of the remaining variables, a value chain based viewpoint was used. For instance, when agricultural output, non-agricultural output and exports are considered together in a model, they are treated in that order as one cannot export packed soybean extract before soybean yield from land and extraction process. This naïve approach practically addresses all our specifications. In VARs including

policy indicators such as public investments, those indicators were placed before other variables owing to their very nature.

A Note on quantification of responses

In the next section, several aspects of the Paraguayan agricultural sector and its interactions with other sectors are explored and presented by means of impulse response functions (IRFs). On one hand simple IRFs can be seen sufficient from a purely academic standpoint. On the other hand, for more practical purposes such as policymaking, one may need to answer questions such as how much (in percentage terms) a variable responds to a change (shock) in another one the size of which is known. However, the standard IRF treatments display solely the response of variables against one standard deviation positive innovations in another one. In other words, some back of the envelope calculations are needed. As we work either with percentage changes or logarithmic levels, the accumulated IRFs provide us with a good starting point for quantification of the impacts measured. In this subsection, we elaborate this quantification problem.

We maintain a simple approach where we scale the values of accumulated impulse response functions against quantification of shocks on the basis of sample information. If the accumulated response of a variable Y to a one standard deviation shock (impulse) in X is known as well as the sample statistics of X then all one needs to do is to find the ratio of response to the standard deviation of X. This way, one can have a better understanding of the impulse response function. In the following subsections, on top of this simple approach, we also report the ratio between the size of the response and the size of the impulse in the form of simple (and approximate) proportions of integers, like 1:7. We named these proportions as response to impulse proportions. Note that, we have restricted our analysis of response to impulse proportions to statistically significant IRFs only.

One must be careful to keep the shocks small enough in everyday assessments. For instance, a response proportion of 1:7 will never imply a 10 percent increase in the responding variable against a 70 percent shock in the impulse variable. After all, the simple econometric analysis we performed is robust provided that we restrict ourselves with some notion of linearity. Definitely, a 70 percent shock must be devastating for the whole economy. So it is crucial to define admissible boundaries for impulse-response analysis.

2.4 Empirical findings

Preliminary models

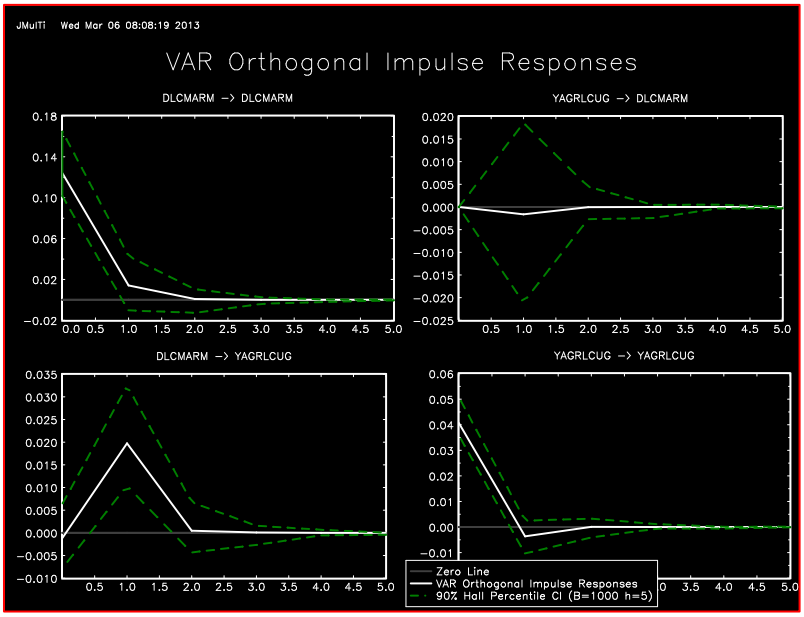
As mentioned before, the Paraguayan economy is a small-open economy and agricultural sectors was said to display price taking behavior. In our opening models hence, we try to verify this. We first investigate the role of agricultural raw material prices in inducing agricultural activity, where our basic motivation is to see whether and how the Paraguayan economy responds to world trends of agricultural prices. The ordering of variables in VAR(1) is {DLCMARM, YAGRLCUG} where DLCMARM is the annual percent change of world agricultural raw material prices – taken as a proxy of gains from agricultural exports and YAGRLCUG is the annual growth of Paraguayan agriculture (LCU, narrow definition – excluding cattle, fisheries,

forestry). The model was estimated using annual data from 1964 to 2011 where the years 2009 and 2010 were controlled for by means of dummy variables.

The IRFs are intuitive (Figure 2.1), i.e. there is no significant feedback from Paraguayan agriculture to world prices, which verifies the price-taking behavior. On the other hand, a positive shock to world prices triggers an increase in Paraguayan agricultural production. This is consistent with our earlier readings about Paraguayan economy. These observations have further been verified within a block-exogenous setup.

As a starting example, we consider (Figure 2.1). Here, the accumulated response of agricultural output to a one standard deviation shock in world agricultural raw material prices has been measured as (DLCMARM → YAGRLCUG) 0.0191. Based on descriptive statistics (1961–2012) of DLCMARM, we know that its average value is 0.03249, range is [-0.18811, 0.47616] and standard deviation is 0.12545. So we may conclude that a 12 percent increase in world agricultural raw material prices induces an approximately 2 percent increase in the Paraguayan agricultural output. Alternatively, one may re-state this as a 1:6 proportion between response and impulse. In what follows, selected IRFs of Section 3 are quantified in a similar manner where sample periods for descriptive statistics in each case strictly follow those in respective VARs.

Figure 2.1:Impulse reponses of agricultural output to world agricultural raw material prices



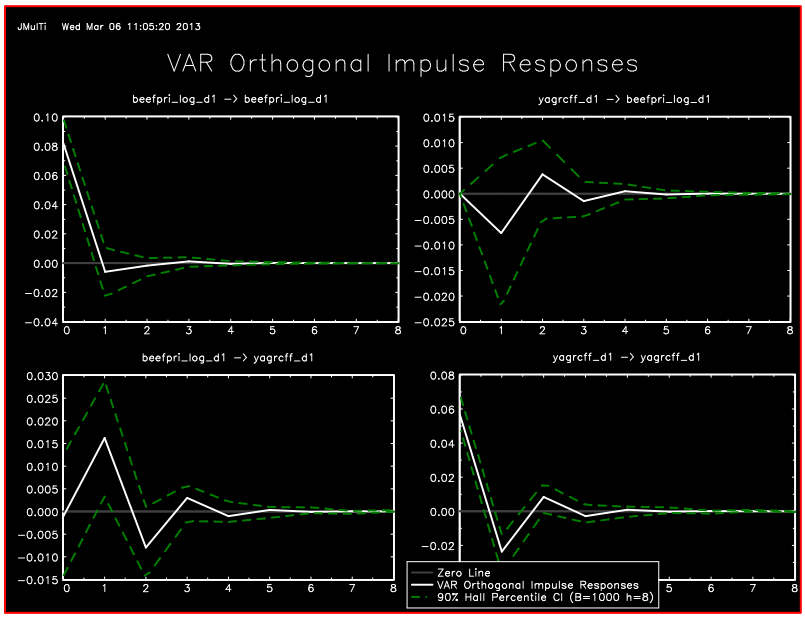
Source: authors.

In a similar manner, we investigated whether the same behavior is valid in the case of cattle, fisheries and forestry (CFF) subsector of agriculture. The ordering in VAR(1) is {BEEFPRI_LOG_D1, YAGRCFF_D1} where BEEFPRI_LOG_D1 is the quarterly percent change of beef prices and YAGRCFF_D1 is the quarterly growth of Paraguayan cattle, fisheries and forestry output. The model was estimated using quarterly data from 1997Q1 to 2011Q4 with seasonally adjusted variables wherever necessary. The impulse response functions suggest that

there is a significantly positive feedback from beef prices to CFF output. The converse relationship, on the other hand, does not have statistical significance (Figure 2.2).

Based on Figure 2.2 (BEEFPRI_LOG_D1 → YAGRCFF_D1), the response of the output of cattle, fisheries and forestry to a one standard deviation increase in beef prices is 0.0095, i.e. approximately 1 percent. Having known the actual value of shock is 0.08046, the proportion of response to impulse can be summarized as 1:8. Similarly, the proportion of response to impulse in Figure 2.3 and Figure 2.8 for (BEEFPRI_LOG_D1 → YAGR2G) is 0.0113:0.08046 or simply 1:8.

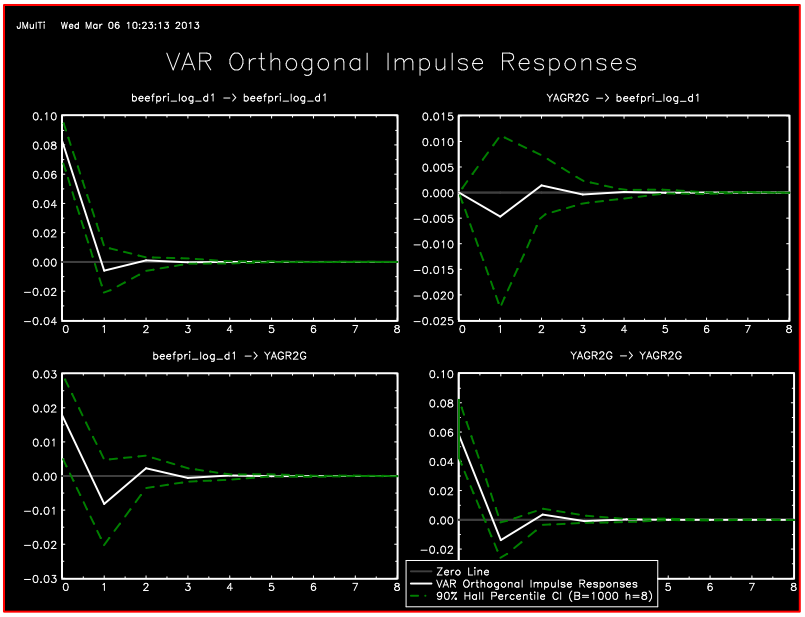
Figure 2.2: Impulse reponses of output of cattle, fishery, and forestry to the beef price



Source: authors.

Figure 2.3 replicates the findings in Figure 2.2 on the basis of a VAR(1) with {BEEFPRI_LOG_D1, YAGR2G} where BEEFPRI_LOG_D1 is the quarterly percent change of beef prices and YAGR2G is the quarterly growth of Paraguayan agriculture (including cattle, fisheries, forestry). The positive first quarter feedback from beef prices to CFF output now change into a contemporaneous one, with its sign and significance unaltered.

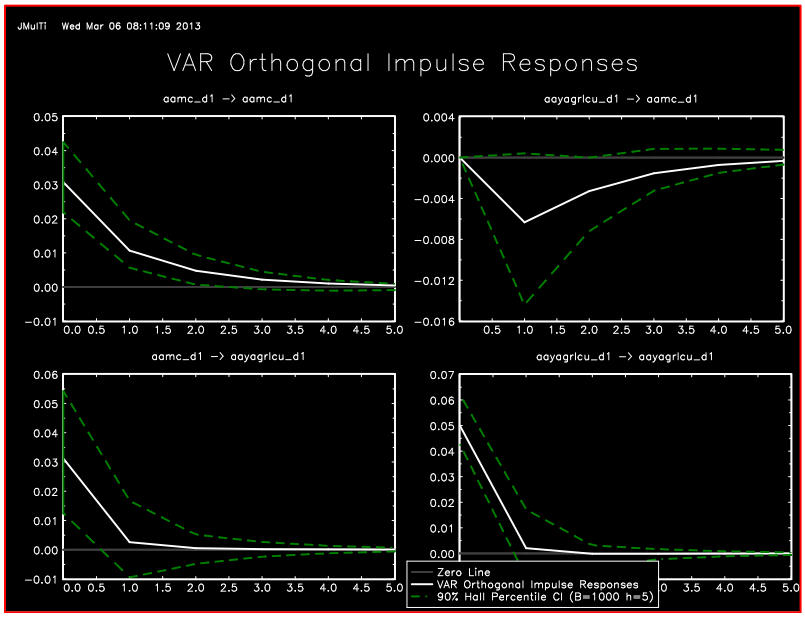
Figure 2.3: Impulse reponses of agriculture output to the beef price



Source: authors.

One may further try to establish a statistical linkage between agricultural output and inputs. For sake of simplicity, we employed machinery input and agricultural output, both measured in relation to agricultural land. The ordering of variables in our VAR(1) is {AAMC_D1, AAYAGRLCU_D1} where AAMC_D1 is the annual change of machinery per land and AAYAGRLCU_D1 is the annual change of agricultural output per land. Once estimated using annual data from 1964 to 2008, the only non-diagonal significant response was observed in the lower left panel, though it documents a contemporaneous feedback only (Figure 2.4). This might be indicating that even the machinery input seems to be quite an exogenous and smooth variable, possibly underlining the existence of Type II error.

Figure 2.4: Impulse reponses of agriculture output per land to the machinery per land



Source: authors.

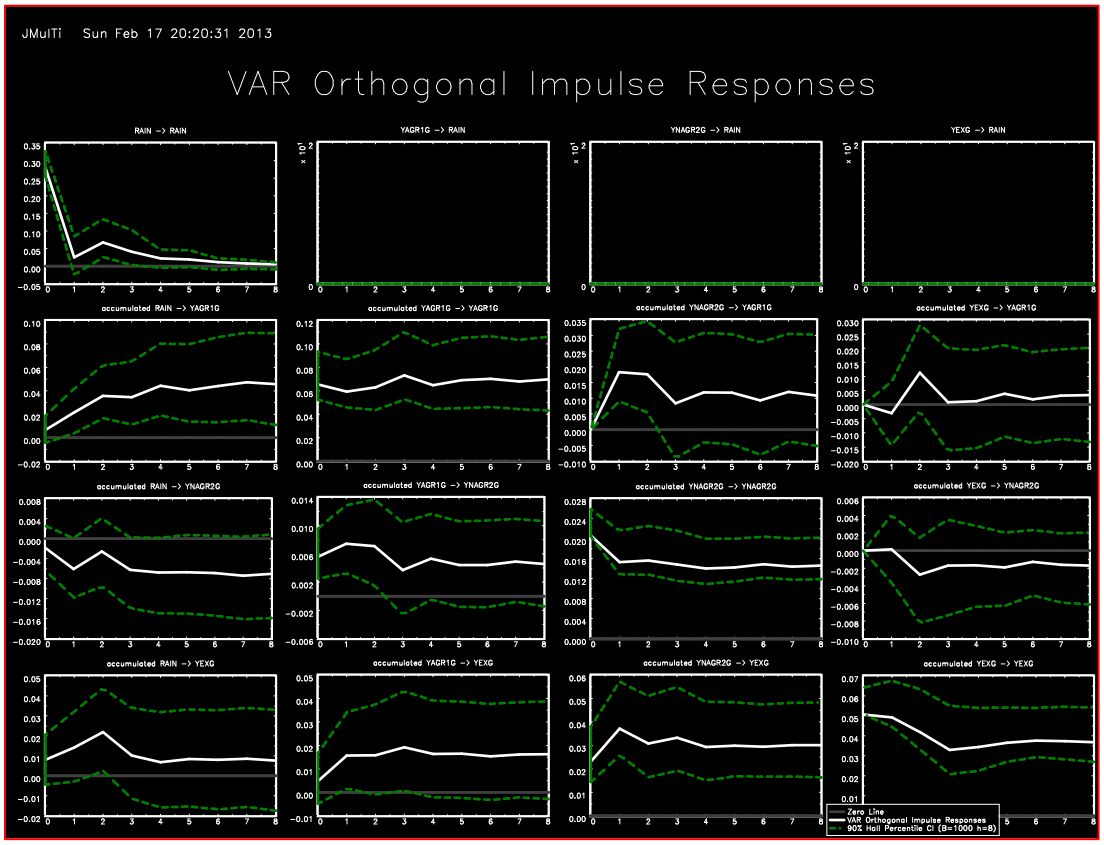
The specifications of the following subsections then elaborate on the first three specifications where we preferred to omit production function strand of analysis.

Interactions of agricultural and non-agricultural GDP

Our baseline quarterly specification tries to fit key activity figures into the same picture. In that, we use rainfall, the narrow definition of Paraguayan agriculture, non-agricultural output and total exports. The ordering of VAR(3) is {RAIN*, YAGR1G, YNAGR2G, YEXG} where RAIN is the volume of rainfall, YAGR1G is the quarterly growth of Paraguayan agriculture (narrow definition – excluding cattle, fisheries, forestry), YNAGR2G is the quarterly growth of Paraguayan non-agricultural output (this time whole agricultural sector –including cattle, fisheries and forestry– has been excluded from the GDP, in a way to solely handle industry and services) and YEXG is the quarterly growth of Paraguayan (total) exports. The model was estimated using quarterly data from 1995Q1 to 2011Q4 with seasonally adjusted variables wherever necessary.

Note that the VAR system is block exogenous with respect to rainfall (RAIN), i.e. RAIN affects the other variables in the system but not vice versa. In our simple notation this was indicated by marking the block exogenous variable (here RAIN) with an asterisk. The same notational preference for agriculture is maintained throughout the paper.

Figure 2.5: Impulse reponses of agriculture output, non-agriculture output, and total exports to rainfall



Source: authors.

Results are sensible and promising, see Figure 2.5. Shocks to rainfall are stabilizing, that is there is no erratic behavior of natural factors. Agricultural output increases in rainfall. Positive agricultural output shocks translate into non-agricultural output increases and both agricultural and non-agricultural production translate into higher exports. These results are robust up to changes in how we define agricultural and non-agricultural output. That is, these are valid even when we consider the wider definition of agricultural output and narrower definition of non-agricultural output.

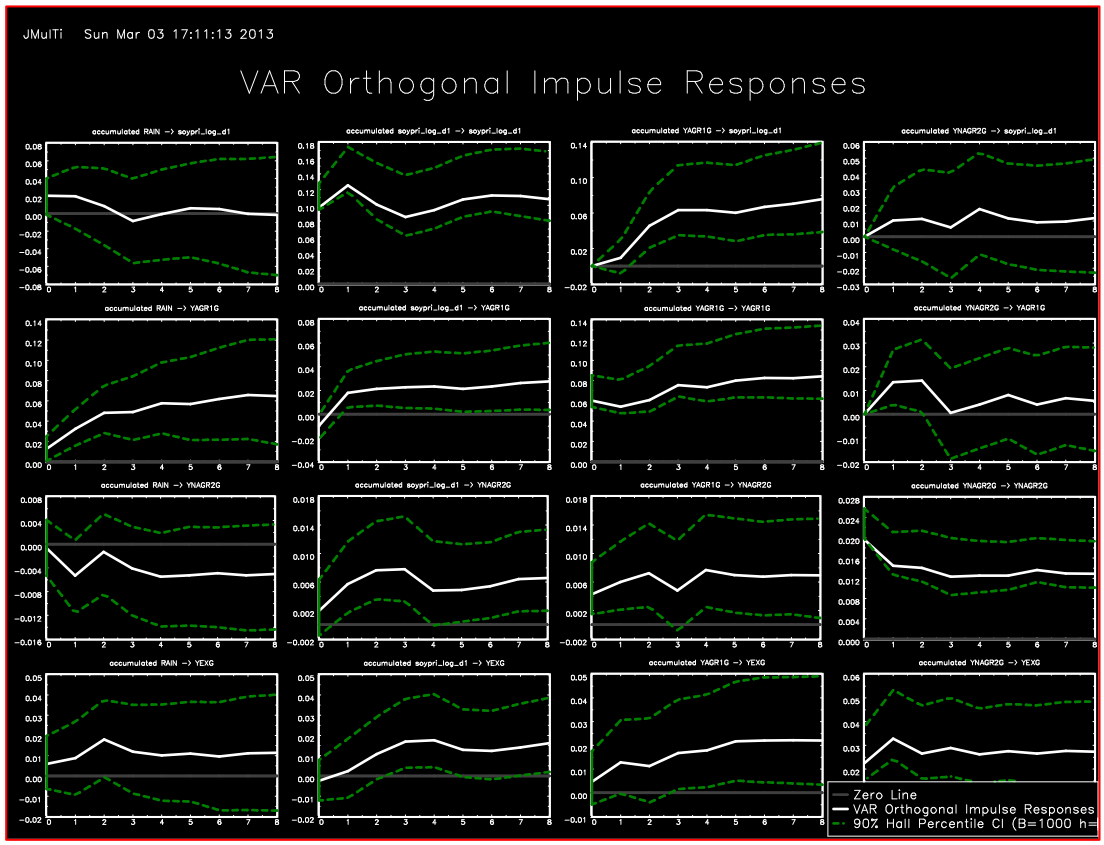
Regarding the effect of the volume of rainfall in Figure 2.5 (RAIN → YAGR1G), the accumulated response of agricultural production to an increase in rainfall is 0.0457:0.28271, or as a simple proportion 1:7. Here it must be noted that 0.28271 practically corresponds to a 30 percent increase in rainfall, which is neither frequent nor continuously possible. One might, hence, may prefer working with smaller and more admissible values of shocks.

Continuing with Figure 2.5 (YAGR1G →YNAGR2G), the accumulated response of non-agricultural output to agricultural output is 0.0046:0.0761 or simply 1:16. For exports (YAGR1G →YEXG), the proportion of the accumulated response of exports to an increase in agricultural activity is 0.0163:0.0761 or 1:5. When (YNAGR2G → YEXG) is considered the proportion becomes 0.0301:0.025 or 1:1.

In an attempt to consider the effects of agricultural prices within this setup, we next included soy prices in our specification. The ordering of VAR(3) is {RAIN*, SOYPRI_LOG_D1, YAGR1G, YNAGR2G, YEXG} where RAIN is the volume of rainfall, SOYPRI_LOG_D1 is the quarterly percent change of soy prices, YAGR1G is the quarterly growth of Paraguayan agriculture (narrow definition – excluding cattle, fisheries, forestry), YNAGR2G is the quarterly growth of Paraguayan non-agricultural output (this time whole agricultural sector –including cattle, fisheries and forestry– has been excluded from the GDP, in a way to solely handle industry and services) and YEXG is the quarterly growth of Paraguayan (total) exports. The model was estimated using quarterly data from 1996Q1 to 2011Q4 with seasonally adjusted variables wherever necessary.

In Figure 2.6, responses to YEXG and responses of RAIN are not shown for better visualization. We observe in Figure 2.6 no significant feedback from rain to soy prices, positive feedback from rain to agricultural output, positive feedback from soy prices to agricultural output, positive feedback from soy prices to non-agricultural output – possibly via industrial value chain, positive feedback from agricultural to non-agricultural output, and positive feedback from both agricultural and non-agricultural output to exports.

Figure 2.6: Impulse reponses of agriculture output, non-agriculture output, and total exports to rainfall and soy price.

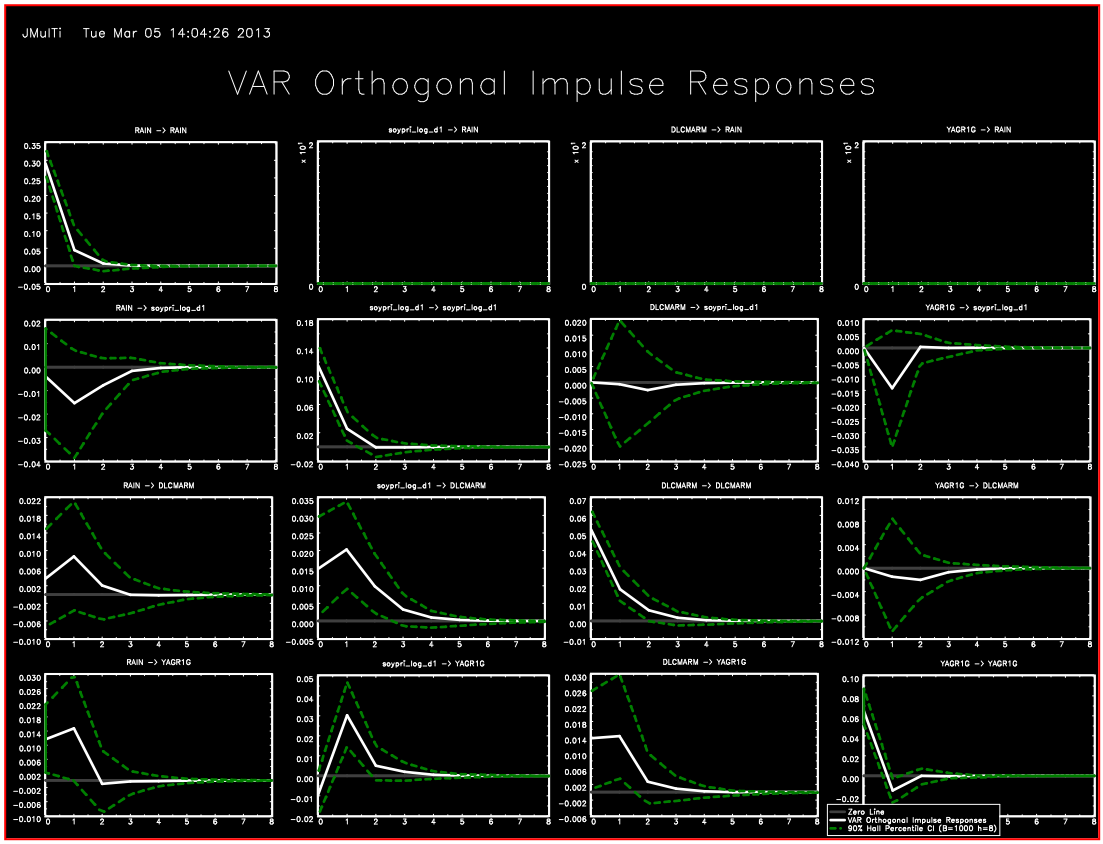


Source: authors.

In the very first model presented in the previous subsection, we investigated the effects of world agricultural raw material prices on the Paraguayan agricultural performance. In the current specification we extend our understanding by including volume of rainfall and soy prices. The ordering of VAR(1) is {RAIN*, SOYPRI_LOG_D1, DLCMARM, YAGR1G} where RAIN is the volume of rainfall, SOYPRI_LOG_D1 is the quarterly percent change of soy prices, DLCMARM is the quarterly percent change of world agricultural raw material prices – taken as a proxy of gains from agricultural exports and YAGR1G is the quarterly growth of Paraguayan agriculture (narrow definition – excluding cattle, fisheries, forestry). The model was estimated using quarterly data from 1995Q3 to 2011Q4 with seasonally adjusted variables wherever necessary. The computed IRFs (Figure 2.7) are intuitive and provide us with a statistically significant story. Rainfall has a significant positive effect on agricultural output. Higher agricultural prices induce higher agricultural income.

Earlier we quantified the response of agricultural production to a shock in world agricultural raw materials. Repeating this exercise with soy prices (Figure 2.7, SOYPRI_LOG_D1 →YAGR1G) one may easily observe that the proportion between response and impulse becomes: 0.0289:0.11871 or 1:4. It should be natural to observe that smaller percentage shocks in soy prices are capable of generating the same effects as larger shocks in world agricultural prices do.

Figure 2.7: Impulse reponses of agriculture output to rainfall, soy prices, and agriculture raw material prices.



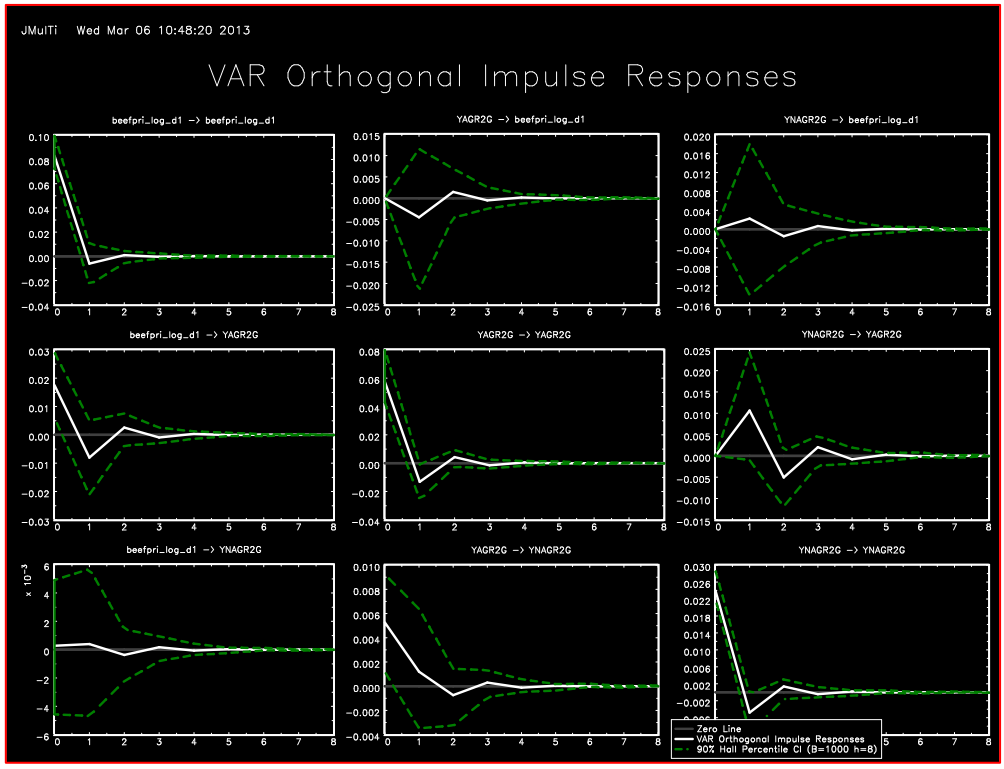
Source: authors.

The relationships that were established between the narrow definition of agricultural sector, non-agricultural sector and export performance provide us with a solid understanding of the Paraguayan economy. Before closing this subsection, we seek for similar relationships regarding the cattle, fisheries and forestry sector. First we consider the broad definition of agricultural output and the narrow definition of non-agricultural output. The ordering of VAR(1) is {BEEFPRI_LOG_D1, YAGR2G, YNAGR2G} where BEEFPRI_LOG_D1 is the quarterly percent change of beef prices, YAGR2G is the quarterly growth of Paraguayan agriculture (including cattle, fisheries, forestry) and YNAGR2G is the quarterly growth of Paraguayan non-agricultural output (i.e., industry and services). The model was estimated using quarterly data from 1997Q1 to 2011Q4 with seasonally adjusted variables wherever necessary.

The impulse response functions displayed in Figure 2.8 suggest that an increase in beef prices induce an increase in broad definition of agricultural output whereas it has no significant impact on the non-agricultural economic activity. More importantly, an increase in agricultural activity triggers an expansion of non-agricultural output. Neither of the agricultural and non-agricultural sector output has a significant impact on beef prices, which is consistent with the price taking behavior.

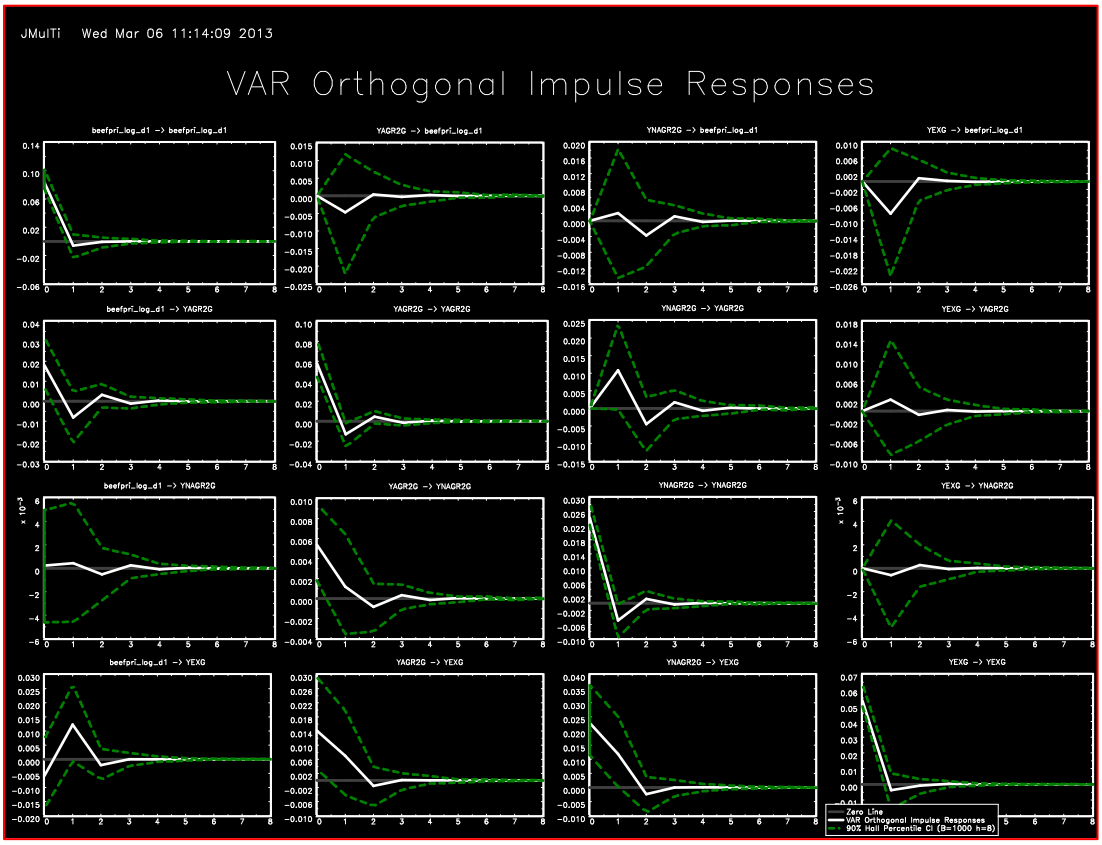
Considering Figure 2.8, one may wonder why beef prices do not have any impact (based on IRFs) on non-agricultural output despite soy prices do. Unfortunately there is no exact answer to such concerns. Still, the positive impacts of beef prices on agricultural output (narrow definition) and of agricultural output on non-agricultural output implies an indirect positive linkage from beef prices to non-agricultural value added.

Figure 2.8: Impulse reponses of agriculture output, non-agriculture output to beef prices.



Source: authors.

Figure 2.9: Impulse reponses of agriculture output, non-agriculture output, and total exports to beef prices.



Source: authors.

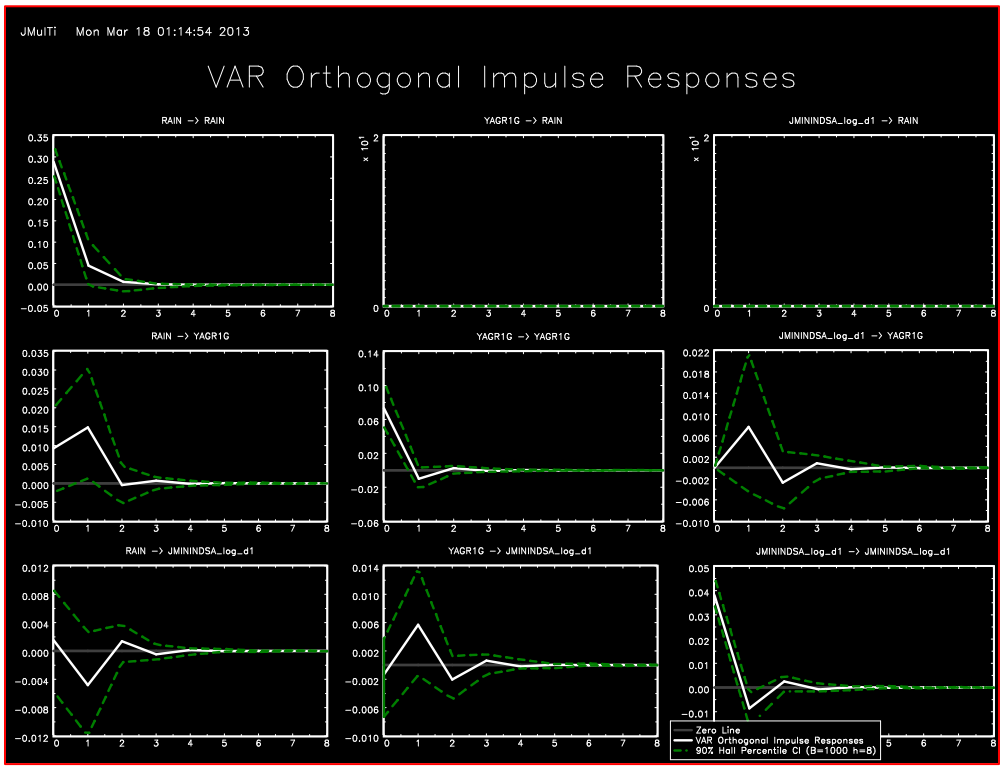
At the end, we add total exports to the current VAR setup and establish a VAR(1) with ordering {BEEFPRI_LOG_D1, YAGR2G, YNAGR2G, YEXG}. Here, BEEFPRI_LOG_D1 is the quarterly percent change of beef prices, YAGR2G is the quarterly growth of Paraguayan agriculture (including cattle, fisheries, forestry), YNAGR2G is the quarterly growth of Paraguayan non-agricultural output (i.e., industry and services) and YEXG is the quarterly growth of Paraguayan (total) exports. The model was estimated using quarterly data from 1997Q1 to 2011Q4 with seasonally adjusted variables wherever necessary. In Figure 9Figure 2.9, upon the findings displayed in Figure 2.8, we observe that both agricultural and non-agricultural output cause an increase in exports. More importantly, positive impact of beef prices on exports, though being near-significant, needs to be highlighted.

Interactions of agricultural and specific non-agricultural sectors

Previously we have documented the feedback from agricultural output to non-agricultural economic activity. In these four specifications, we consider four main non-agricultural sectors in isolation. For each specification we maintain the VAR(1) template {RAIN, YAGR1G, Z} where RAIN is the volume of rainfall and YAGR1G is the quarterly growth of Paraguayan agriculture (narrow definition – excluding cattle, fisheries, forestry). As variable Z, we considered quarterly growth of Paraguayan mining and industry (JMININDSA_LOG_D1), electricity and water (JEWSA_LOG_D1), construction (JCONSA_LOG_D1) and services (JSERSA_LOG_D1)

sector, one at a time. Models were estimated using quarterly data from 1994Q3 to 2011 Q4 with seasonally adjusted variables wherever necessary.

Figure 2.10: Impulse reponses of mining and industry sector to rainfall and agriculture output.

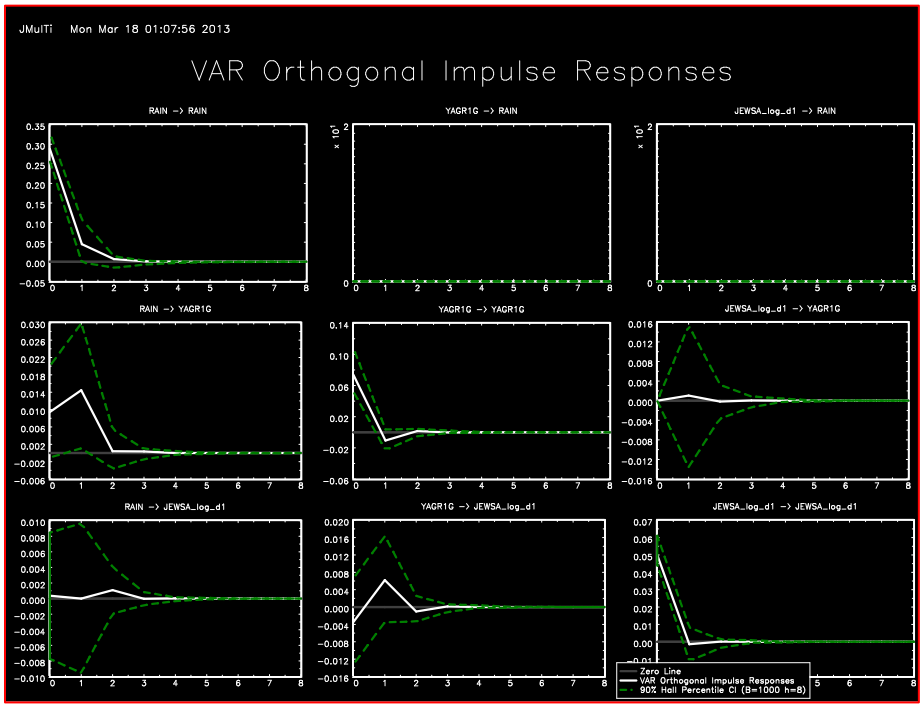


Source: authors.

The impulse response functions suggest positive yet insignificant feedback from agriculture to mining and industry, to electricity and water and to construction sectors. Feedback from agricultural output to services is contemporaneously positive and statistically significant. When this set of estimations are repeated using the broad definition of agricultural output instead of the narrow one, i.e. when YAGR1G is replaced with YAGR2G (quarterly growth of Paraguayan agriculture including cattle, fisheries, forestry), leaving other model attributes unaltered, we observe positive yet insignificant feedback from agriculture to mining and industry, positive and near-significant feedback from agriculture to electricity and water sector after one quarter, and contemporaneously positive and statistically significant feedback from agriculture to construction and services sectors.

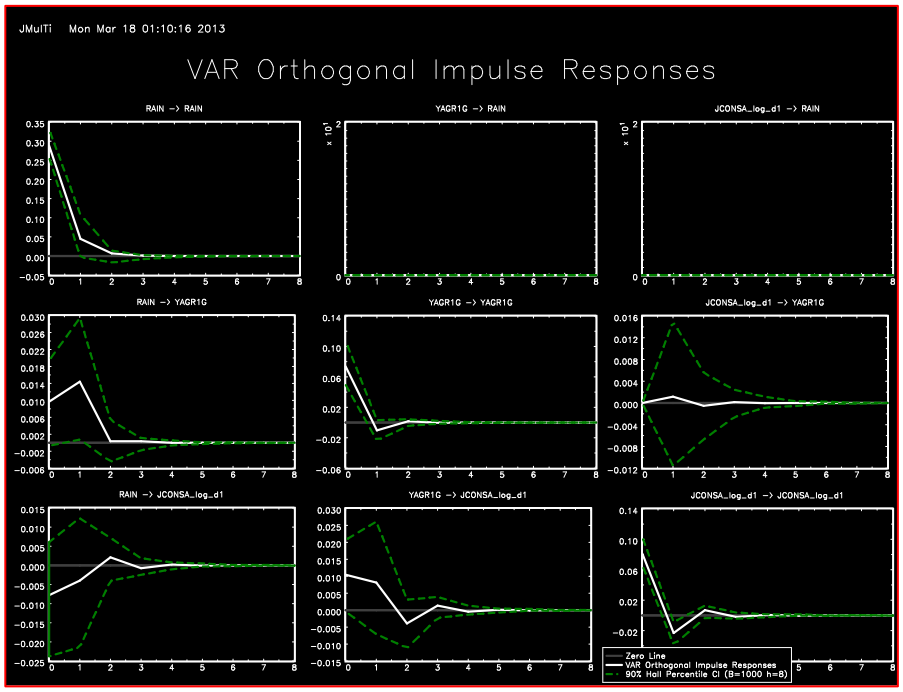
Regarding the inter-sectoral linkages, we use Figure 13 (YAGR1G → JSERSA_LOG_D1) where we have measured the response of services output to an innovation in agricultural output. This time the response proportion is 0.0062:0.0761 or 1:12. In other words, a twelve percent expansion of agricultural activity induces a one percent expansion in the services sector.

Figure 2.11: Impulse reponses of electricity and water sector to rainfall and agriculture output.



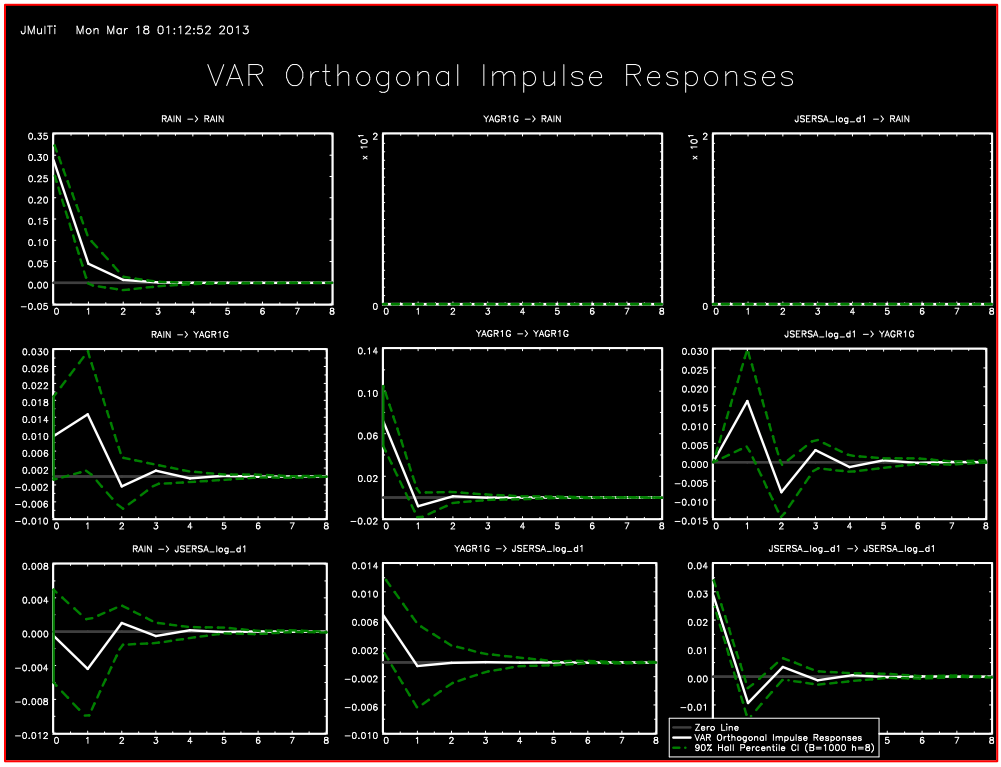
Source: authors.

Figure 2.12: Impulse reponses of construction sector to rainfall and agriculture output.



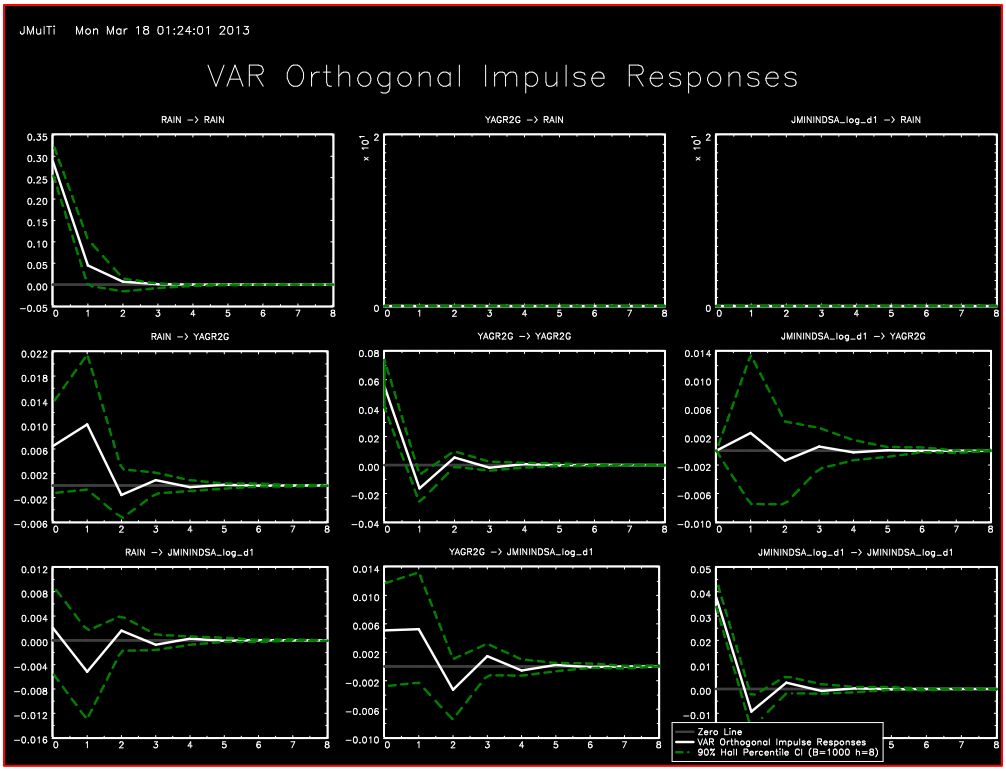
Source: authors.

Figure 2.13: Impulse reponses of services sector to rainfall and agriculture output.



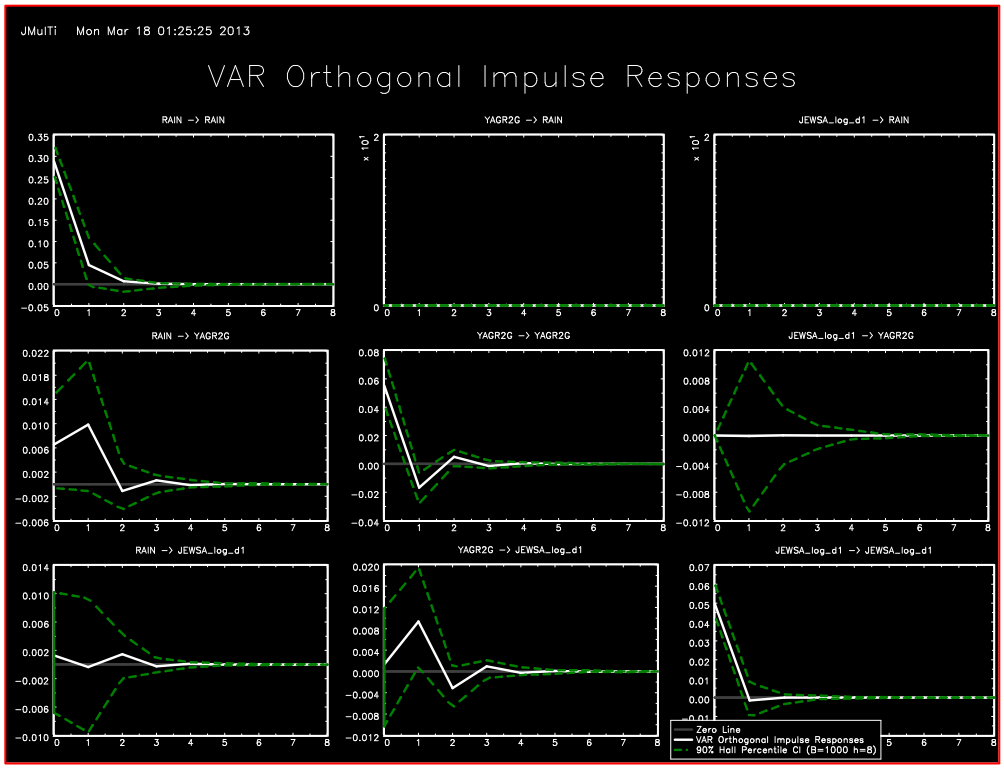
Source: authors.

Figure 2.14: Impulse reponses of mining and industry sector to rainfall and broad agriculture output.



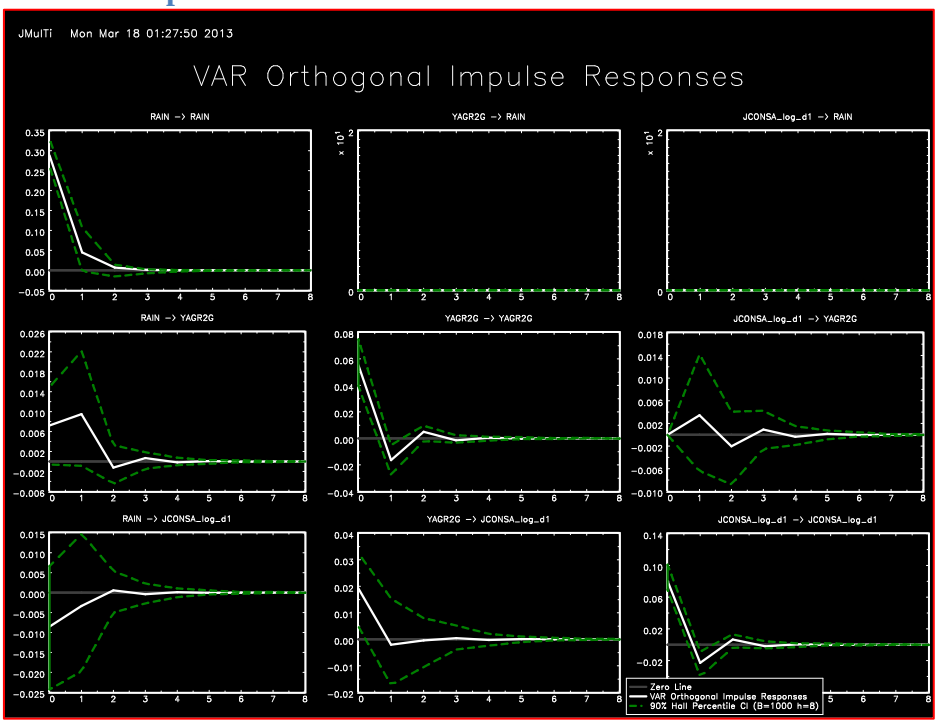
Sources: authors.

Figure 2.15: Impulse reponses of electricity and water sector to rainfall and broad agriculture output.



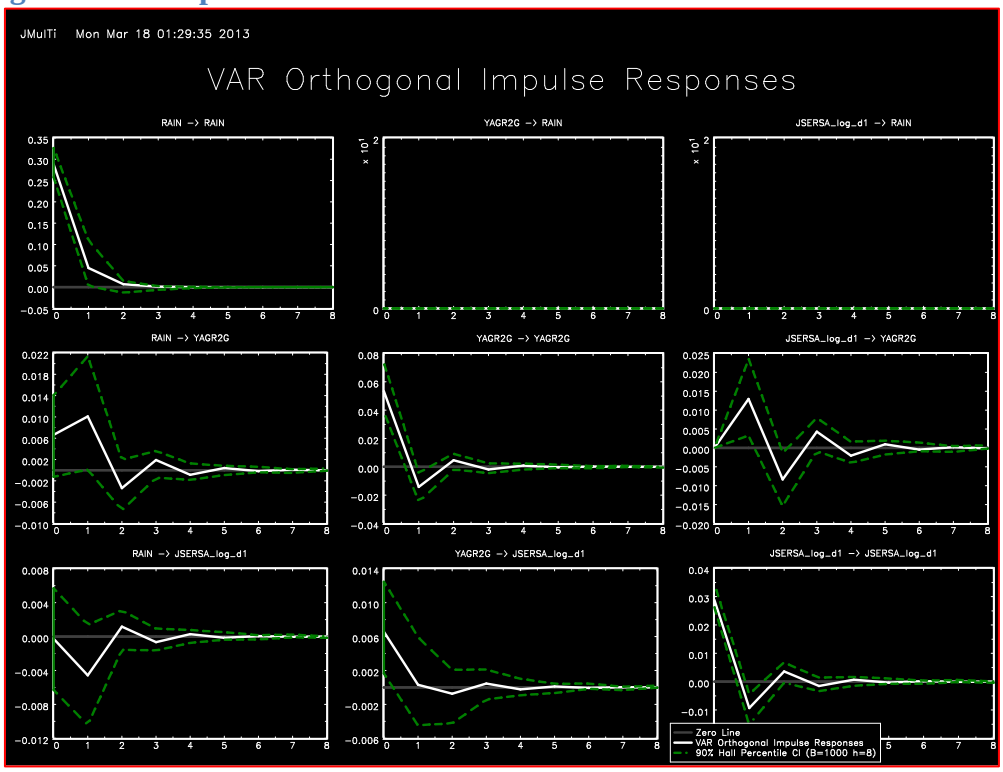
Source: authors.

Figure 2.16: Impulse reponses of construction sector to rainfall and broad agriculture output.



Source: authors.

Figure 2.17: Impulse reponses of services sector to rainfall and broad agriculture output.



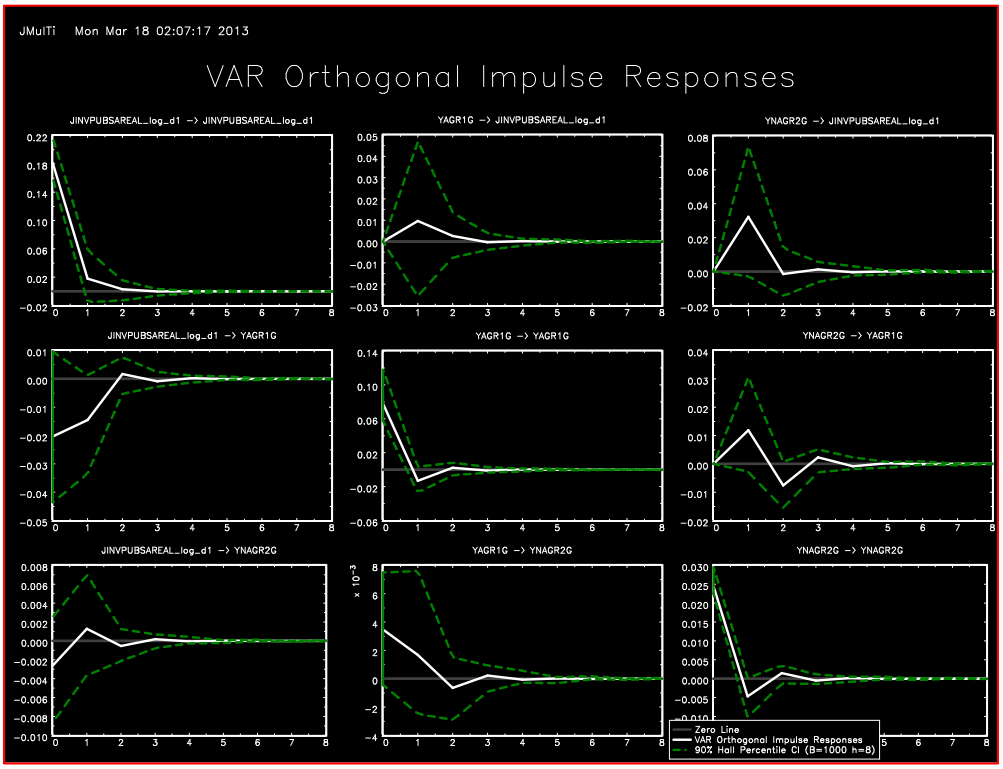
Source: authors.

Investment spending and agriculture

In these series of specifications, we try to see the effects of investments on agricultural and non-agricultural value added. The framework is VAR with no block-exogeneity. In the case of public investments we have placed growth of public investments first in VAR(1), i.e. {JINVPUBSAREAL_LOG_D1, YAGR1G, YNAGR2G}. Private and total investment figures, on the other hand, come last in their respective VAR specifications, i.e. {YAGR1G, YNAGR2G, JINVPRISAREAL_LOG_D1} and {YAGR1G, YNAGR2G, JINVTOTSAREAL_LOG_D1}. Here, YAGR1G is the quarterly growth of Paraguayan agriculture (narrow definition – excluding cattle, fisheries, forestry), YNAGR2G is the quarterly growth of Paraguayan non-agricultural output (whole agricultural sector –including cattle, fisheries and forestry– has been excluded from the GDP), JINVPUBSAREAL_LOG_D1 is the quarterly growth of public investments at constant prices, JINVPRISAREAL_LOG_D1 is the quarterly growth of private investments at constant prices and JINVTOTSAREAL_LOG_D1 is the quarterly growth of total investments at constant prices. Each model was estimated using quarterly data from 1997Q3 to 2011 Q4 with seasonally adjusted variables wherever necessary.

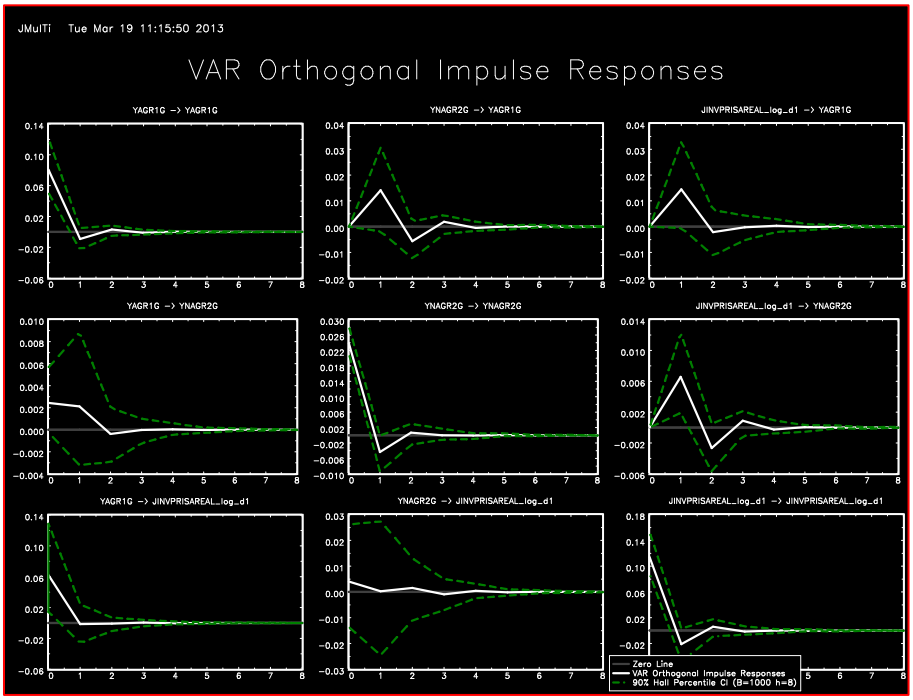
The impulse response functions in Figure 18 show a negative feedback from public investments to output, regardless of being agricultural and nonagricultural. Despite both responses are statistically insignificant, they might be indicative of some degree of crowding out. We may further note that the positive feedback from agricultural to nonagricultural output does not display statistical significance.

Figure 2.18: Impulse reponses of agriculture and non agriculture output to public investment



Source: authors.

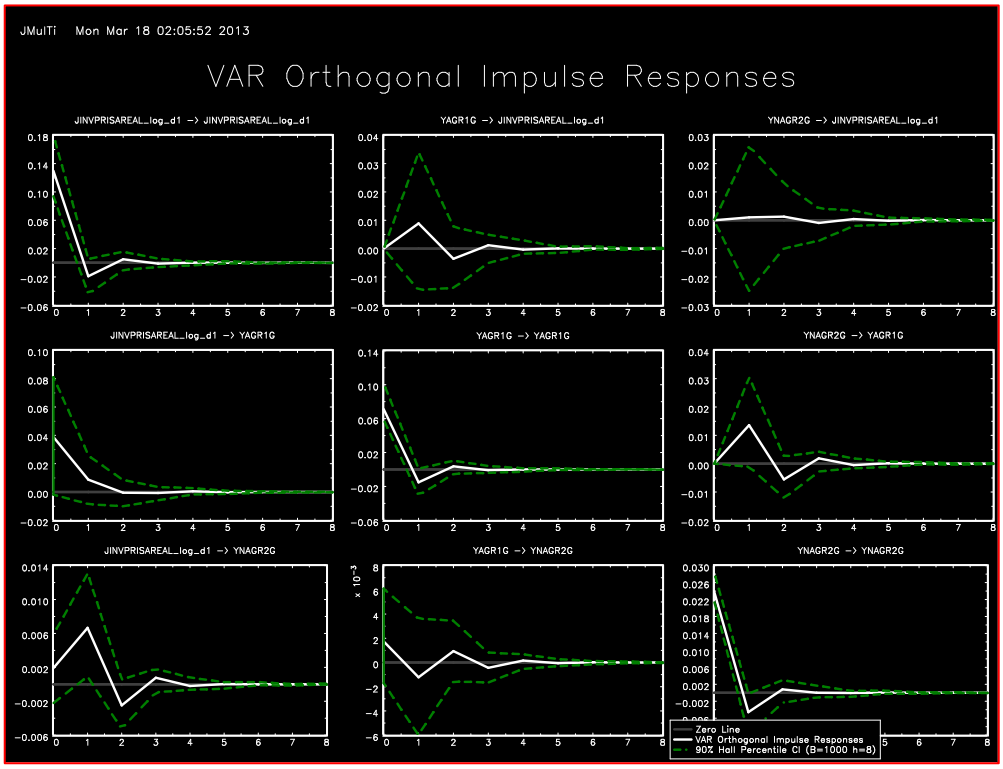
Figure 2.19: Impulse reponses of agriculture and non agriculture output to private investment.



Source: authors.

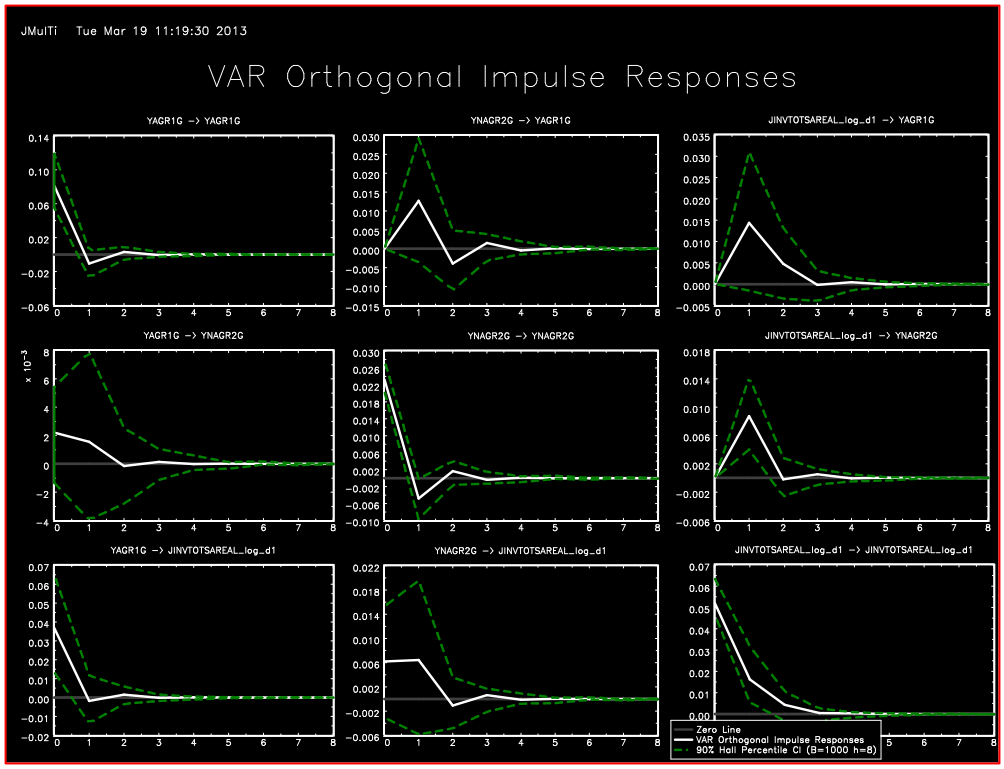
When we look at private investments and its effect on economic activity (Figure 2.19) we observe a positive yet insignificant feedback from private investments to agricultural output; though feedback from private investments to non-agricultural value added is positive and significant. Similar to the case of public investments, feedback from agricultural to non-agricultural output turns out to be insignificant. When private investments are placed the first in VAR ordering, these findings remain intact, see Figure 2.20.

Figure 2.20: Impulse reponses of agriculture and non agriculture output to private investment. Private investment first.



Source: authors.

Figure 2.21: Impulse reponses of agriculture and non agriculture output to total investment

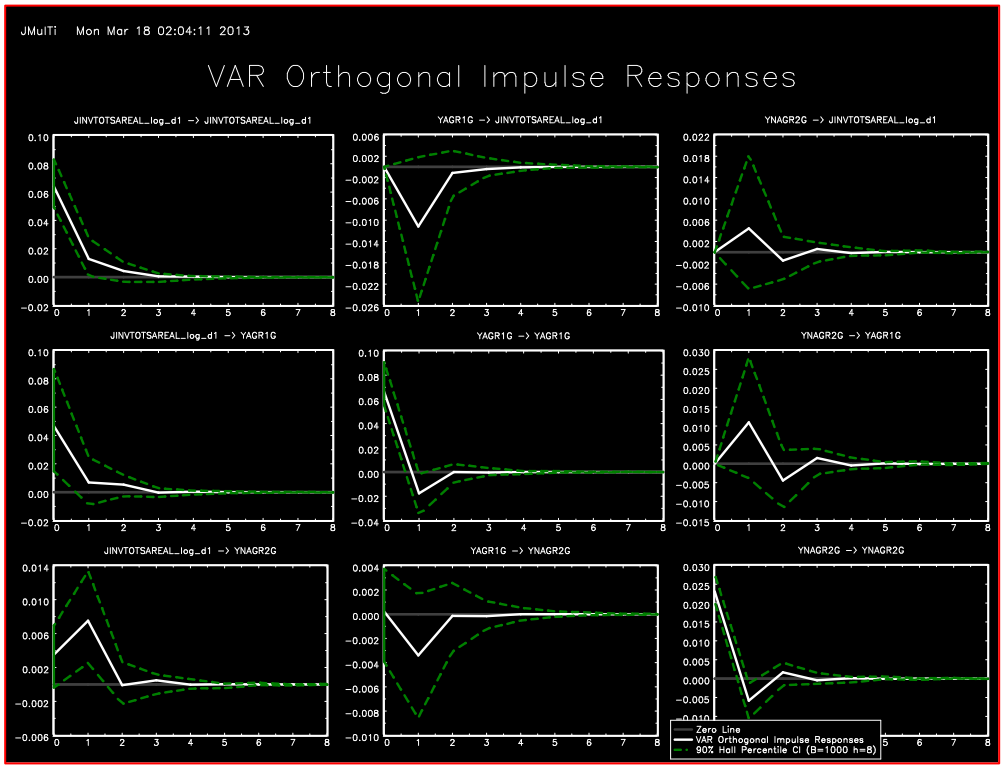


Source: authors.

Regarding the role of investments in mobilizing resources and triggering economic activity, we finally examine the case of total investments (Figure 2.21 and Figure 2.22). In Figure 2.21 we observe a positive and significant feedback from total investments to non-agricultural but not to agricultural value added. The observation that an expansion in agricultural economic activity induces a contemporaneous increase in total investments can also be noted. Feedback from agricultural to non-agricultural output which was positive in the earlier models turns out to be negative, yet insignificant.

Looking at how total investments translate into economic activity based on Figure 2.21, we see that the response to impulse proportion for agricultural output is (JINVTOTSAREAL_LOG_D1 → YAGR1G) 0.0194:0.06351 or 1:3. For non-agricultural output (JINVTOTSAREAL_LOG_D1 → YNAGR2G) the proportion becomes 0.0091:0.06351 or 1:7. Equivalently, total investments are effective more in mobilizing agricultural rather than non-agricultural productive factors.

Figure 2.22: Impulse reponses of agriculture and non agriculture output to total investment. Total investment first.



Source: authors.

When we place total investments as the first variable in VAR ordering, the IRFs display as in Figure 2.22. In this case, the impact of total investments on agricultural and non-agricultural activity turns out to be positive and statistically significant. The impact on the former is contemporaneous whereas the impact on the latter is observed after one quarter.

2.5 Discussion and concluding remarks

Empirical investigation of the Paraguayan agricultural sector was maintained as the focus of this paper owing to its crucial place in the Paraguayan economy. Along with a short assessment of the determinants of agricultural output, the paper was concerned with the propagation of agricultural performance to other sectors of the economy. Throughout the analysis we maintained an exploratory approach, i.e. we followed the simple motto of "let the data speak on its behalf". This approach was especially useful in the absence of solid prior information. In the end, we obtained some clear associations among the variables of interest by means of a sequence of Vector Auto Regression (VAR) specifications.

As far as the direct inputs of agricultural production, for instance the machinery devoted to agriculture, are concerned we could not come up with a rich set of findings. Rather, a contemporaneous relationship between agricultural machinery and value added was documented. As a matter of fact, this became the main cause for omitting a production function approach toward agricultural value added.

Based on our estimates, the Paraguayan agricultural sector can be characterized as a price taking sector as it is quite open to international price shocks. In case of vast shocks to international agricultural or food prices, the Paraguayan agriculture might face, then, undesired outcomes. Price taking behavior is valid not only for the value added from agricultural land but also for the production of cattle, fisheries and forestry. In a similar manner, the size of agricultural output is susceptible to natural factors. Cases of poor rainfall or droughts might jeopardize economic activity to a large extent. It must be noted that there are no trivial or direct cures to these susceptibilities.

At the core of our investigation lies a simple specification which endows us with a clear understanding of the Paraguayan economic dynamics: agricultural output is triggered by increases in rainfall, agricultural value added is translated into expansion in the non-agricultural sector and both sectors affect the export performance of the country positively. Equivalently, agricultural output can be seen as the main input to non-agricultural sector. More importantly, Paraguayan economy enjoys gains from exports of both agricultural and non-agricultural products. In a way, this situation can be seen as the basis for diversification at a macroeconomic scale. Positive effect of soy prices on non-agricultural output also deserves attention as it might be underlying the importance of the connections along the industrial value chain. When we look at the cattle, fisheries and forestry sector, we observe that an increase in beef prices induce an increase in broad agricultural output whereas it has no significant impact on the non-agricultural activity. Beef prices receive feedback from neither of the agricultural or non-agricultural sector output.

Leaving the interaction between agricultural and non-agricultural output aside and turning our attention to interactions between agricultural sector and sub-sectors of industry, we observe that feedback from agricultural output to services is contemporaneously positive and statistically significant. When the broad definition of agricultural output is used, we observe positive yet insignificant feedback from agriculture to mining and industry, positive and near-significant feedback from agriculture to electricity and water sector after one quarter, and contemporaneously positive and statistically significant feedback from agriculture to construction and services sectors. These findings may be of importance while assessing the inter-sector connections and subsequent policy making practices.

Finally, regarding the effects of investment spending on output, we came up with a picture in which feedback from public investments to output is negative. Despite it is insignificant, this observation is indicative of possible crowding out. Private investments, on the other hand, have a positive effect on both agricultural and non-agricultural value added where the latter has statistical significance. It is interesting to see that an expansion in agricultural economic activity induces a contemporaneous increase in total investments.

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Appendix 2.1: Table 1. Descriptive Statistics of Data

	Mean	Minimum	Maximum	Std.Dev.	Skewness	Kurtosis
[1964, 2011], T = 48						
DLCMARM	3.84875e-02	-1.88116e-01	4.76163e-01	1.27714e-01	1.0510	4.8876
YAGRLCUG	4.25741e-02	-1.90077e-01	2.94439e-01	6.54355e-02	0.1377	8.5058
[1964, 2008], T = 45						
AAMC_D1	2.59593e-02	-1.13395e-01	1.12453e-01	3.25440e-02	-1.0572	9.1311
AAYAGRLCU_D1	2.72909e-02	-1.57970e-01	1.19523e-01	5.70359e-02	-1.1473	4.7711
[1997 Q1, 2011 Q4], T = 60						
BEEFPRI_LOG_D1	1.44871e-02	-2.32908e-01	2.00512e-01	8.05915e-02	-0.2083	3.4653
YAGRCFF_D1	2.77140e-03	-1.59440e-01	2.13260e-01	6.30844e-02	0.1486	4.4054
YAGR2G	1.10627e-02	-2.61655e-01	2.71652e-01	6.11854e-02	-0.0081	12.7162
[1995 Q1, 2011 Q4], T = 68						
RAIN	8.74873e+00	8.13304e+00	9.42441e+00	2.93579e-01	-0.1097	2.4762
YAGR1G	1.44025e-02	-3.84800e-01	3.55742e-01	7.74697e-02	-0.6685	16.7444
YNAGR2G	4.77360e-03	-5.95441e-02	5.60281e-02	2.40231e-02	-0.1388	2.7579
YEXG	3.15772e-03	-1.74308e-01	1.19839e-01	6.28833e-02	-0.1911	2.8705
[1996 Q1, 2011 Q4], T = 64						
RAIN	8.75835e+00	8.13304e+00	9.42441e+00	2.94552e-01	-0.1762	2.5605
SOYPRI_LOG_D1	8.50898e-03	-3.93275e-01	2.52987e-01	1.20596e-01	-0.8103	4.9096
YAGR1G	1.27819e-02	-3.84800e-01	3.55742e-01	7.86731e-02	-0.6538	16.6208
YNAGR2G	5.42964e-03	-5.95441e-02	5.60281e-02	2.36408e-02	-0.2035	2.9437
YEXG	7.30771e-03	-1.74308e-01	1.19839e-01	6.05664e-02	-0.1737	3.0284
[1995 Q3, 2011 Q4], T = 66						
RAIN	8.74999e+00	8.13304e+00	9.42441e+00	2.94008e-01	-0.1140	2.5115
SOYPRI_LOG_D1	1.06078e-02	-3.93275e-01	2.52987e-01	1.19550e-01	-0.8475	4.9980
DLCMARM	6.30847e-04	-1.67156e-01	1.42768e-01	6.14573e-02	-0.4349	3.7587
YAGR1G	1.24948e-02	-3.84800e-01	3.55742e-01	7.74973e-02	-0.6523	17.1080
[1997 Q1, 2011 Q4], T = 60						
BEEFPRI_LOG_D1	1.44871e-02	-2.32908e-01	2.00512e-01	8.05915e-02	-0.2083	3.4653
YAGR2G	1.10627e-02	-2.61655e-01	2.71652e-01	6.11854e-02	-0.0081	12.7162
YNAGR2G	5.14780e-03	-5.95441e-02	5.60281e-02	2.42814e-02	-0.1712	2.8082
[1997 Q1, 2011 Q4], T = 60						
BEEFPRI_LOG_D1	1.44871e-02	-2.32908e-01	2.00512e-01	8.05915e-02	-0.2083	3.4653

CHAPTER 3. PARAGUAYAN AGRICULTURAL AND MACROECONOMIC PERFORMANCE: A WAVELET APPROACH

By

Hakan Berument*

Abstract

This paper investigates the interactions of agricultural output and other sectors in the Paraguayan economy using wavelet analysis. The findings from the wavelet coherence analysis are intuitive. Determinants as well as propagation mechanism of agricultural output were documented in the paper. The empirical findings presented underline the importance of market orientation to obtain better economic outcomes.

JEL Classification:C51 - Model Construction and Estimation; Q11 – Agriculture - Aggregate Supply and Demand Analysis; Prices.

Keywords: Agricultural output, National income, Wavelet analysis, Paraguay.

3.1 Introduction

This paper has been intended as the twin paper of Berument (2013) which investigated the Paraguayan agricultural value added and its impacts on the overall economic performance of Paraguay. Owing to the significant methodological separation, the analyses of this paper were intentionally cast into a separate paper. Though, the motivation of this paper is practically the same as of Berument (2013) as we try to understand the interactions between the agricultural and nonagricultural output for the Paraguayan economy.

The fundamental novelty of this paper stems from our choice of the analytical domain. In this paper, we investigate the agricultural performance, its possible determinants and its propagation to the rest of the economy in frequency rather than time domain. In a nutshell, we first try to reveal the impacts of agricultural output fluctuations on economic performance. Second, we try to understand how the fluctuations of some policy-related variables are translated into changes in agricultural value added.

While attacking an econometric problem involving fluctuations of variables, the natural response could be employing an Autoregressive Conditional Heteroskedasticity (ARCH) family of models, which are more conventional and genuinely developed to attack the problems of that sort. However, having observed the failure of Generalized ARCH (GARCH) assessments, we turned our attention to an alternative methodology. The failures we observed were mainly due to

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insufficient number of quarterly observations (which causes the quadratic optimization routines to fail to converge) and disappearance of the ARCH effects once we have employed rigorous diagnostic controls. For instance, when 2000Q1, 2001Q1, 2007Q1, 2009Q1 and 2010Q1 are controlled for in an AR(3) specification with three seasonal dummies no ARCH effect remains in the residuals, leaving no room for further treatment within a GARCH framework.

Nevertheless, failure in GARCH assessments does not necessarily dismiss the possibility that fluctuations of two variables to be related. Indeed, they can still be attached to each other yet the choice of methodology might be veiling the relationships embedded in the data. Translating this naïve suspicion into scientific terms, one might hypothesize whether two series exhibit associations at alternative cycle lengths. In order to test such hypotheses, we employ a wavelet methodology which allows us to measure the relationship between our variables of interest at different wave lengths, i.e. allows us to pinpoint at what frequencies certain kind of connections exist.

Usual Fourier type analysis of signals (time series) involves decomposing a time series into an array of sinusoidal waves and checking for the linkages between the series of interest at similar wavelengths. In this way, one can pinpoint at what frequencies the series of interest move together, or at what frequencies a time series lead the other one. The wavelet analysis, having a quite resemblance with the Fourier transform, differs in that no indefinite number of sinusoidal waves is involved. Rather, a time series is expressed in terms of wavelets (small waves) which have short durations. Each wavelet starts from a small amplitude and decays after reaching its maximum amplitude. More information on the methodology is provided in the second section.

The next section introduces the methodology. In the third section, results of empirical analysis are provided. Section four concludes the paper.

3.2 Wavelet filter and coherence analysis

Economic time series can be thought to include information in a cascaded manner. Long term variations (historical trends), medium term variations and short term variations are all embedded in a single time series. More importantly, these pieces of information are almost always shaded by some irregular movements what is often called the noise. The cascaded structure itself is not observable to the analyst though. There is no exact formulation to separate the long, medium and short term variations. These components are latent and the analyst is obliged to obtain them using some statistical techniques. These techniques are referred to as filters, the roots of which extend back to Fourier series.

The filters can be defined in either of the time or frequency domains. Indeed, for each filter defined in time domain there should exist an equivalent filter defined in frequency domain. In this section we restrict ourselves to frequency domain filters for better exposition.

Fourier series is based on the idea that every periodic series can be expressed as a sum of sinusoidal signals:

$$x(t) = a_0 / 2 + \sum_1^{\infty} (a_n \cos(nt) + b_n \sin(nt)) \quad (1)$$

Here, a_n and b_n are the weights of the sinusoidal waves in the combination that yields $x(t)$. Larger n corresponds to higher frequency oscillations. Fourier transform maps $x(t)$ in time domain to $X(f)$ in frequency domain and is expressed as:

$$X(f) = \int_{-\infty}^{\infty} x(t) e^{-i2\pi ft} dt \tag{2}$$

where f is frequency and $e^{-i2\pi ft} = \cos(2\pi ft) + i\sin(2\pi ft)$. Based on such presentation of the time series $x(t)$, one can implement filters, i.e. processes that select (or disregard) oscillations having (or not having) certain characteristics. An ideal filter is defined as one passing the desired frequencies only. Nevertheless, as the time domain does not allow for ideal filters, the researchers are restricted to approximations to ideal filters. The well-known Hodrick-Prescott, Baxter-King and Christiano-Fitzgerald filters are successful approximate filters. Note that these filters are especially useful as they allow us to filter data series with small sample size which is quite the case in economics.

The filters based on Fourier transform are not problem-free despite their advantages over time domain filters. While constructing a filter of that sort we assume that a series is composed of sinusoidal signals and all these signals are defined over the data sample. If this basic assumption is invalidated then the filter might not be useful when the researcher is faced with transitory shocks or structural changes. As a corollary, these classical filters might not be a good fit for a wide variety of economic data. Wavelet filters effectively address these deficiencies simply by replacing the building blocks of the analysis (sine and cosine waves) with wavelets (small waves). Owing to their adaptation, shrinking and expanding abilities, wavelets allow us to handle a richer set of economic data (with probable data anomalies) in a reliable and practical manner. Wavelet decomposition (wavelet transform) reconstructs the series $x(t)$ from different frequency (or scale) components by using scaled versions of father ($\theta(t)$) and mother ($\varphi(t)$) wavelets.

$$\theta_{j,k}(t) = 2^{-j/2}\theta\left(\frac{t - 2^j k}{2^j}\right) \tag{3.1}$$

$$\varphi_{j,k}(t) = 2^{-j/2}\varphi\left(\frac{t - 2^j k}{2^j}\right) \tag{3.2}$$

Wavelet decomposition is then given as:

$$x(t) = S_j + D_j + D_{j-1} + \ldots + D_1 \tag{4}$$

where, $S_j = \sum_k s_{j,k}\theta_{j,k}(t)$ is called the approximate component and $D_j = \sum_k d_{j,k}\varphi_{j,k}(t)$ are called (for i=1,…,j) the (mutually orthogonal) detail components. As the number i increases, the

frequency decreases or equivalently the period increases. Note that these two quantities are the reciprocals of each other.

The choice of wavelet function is important in the filtering process as different wavelets suit different signal types. Most popular wavelets are Haar, Daubachies, Symmlets, Coiflet, Biorthogonal wavelets as well as the Mexican hot wave.

A useful quantity in this context is the coherence. It is defined as the square of the cross-spectrum normalized by the individual power spectra and lies between zero and unity. Coherence is a function of frequency and simply measures the cross-correlation between two time series. It may not always be straightforward to pick exactly what smoothing procedure in time in order to obtain a useful measure of coherence. Liu (1994) can be visited for a discussion of these issues.

Though wavelets can be viewed as a sophisticated way of performing cointegration in a sense, as the analysis is carried out in frequency domain instead of time domain it is primarily different from cointegration and the like. As mentioned above, wavelet techniques are better in the sense that short, medium and long term fluctuations are addressed neatly within this framework.

3.3 Empirical findings

In the remaining portion of the paper, we refer to two definitions of agricultural value added. In the first one, we consider only the value added from agricultural land. In the second definition, value added from animal breeding was also added to the first one. So we use a nomenclature in which the first [second] definition of agricultural output has been referred to as the narrow [broad] definition of agriculture. This choice of definitions helped us a lot in revealing the economic relationships of interest. The value added out of animal breeding was used in isolation in some specifications, as well. The descriptive statistics of data are provided in Appendix Table 3.1.

Another important note concerns the readability of the results from the wavelet coherence analysis. As presented in the previous section, the wavelet coherence analysis has a complex mathematical structure. However, this complexity does not reduce the readability of estimates. On the contrary, the estimates can be summarized in the form of simple heat maps. In each heat map, the vertical axis shows the period length, for instance a period length of 4 corresponds to oscillations over 4-quarter periods and a period length of 16 corresponds to oscillations over 16-quarter periods. The horizontal axis shows time, which is running from 1997Q1 to 2011Q4 in the subsequent analyses. The shift of colors from blue to red indicates a strengthening relationship and an upward directed arrow indicates the second variable leads the first one at given wavelength (in each case below it is indicated which variable is the first and which is the second). The bold black contours (obtained using Monte Carlo simulations) indicate a significant relationship. The conic envelope can be viewed as the region where estimates have higher reliability.

As a final note, it is crucial to focus on the use of the word “period” in the current context: Here, period does not have its usual meaning as in time-series econometrics. Rather it corresponds to the period of the sinusoidal that constitute our original time series. It might be more intuitive

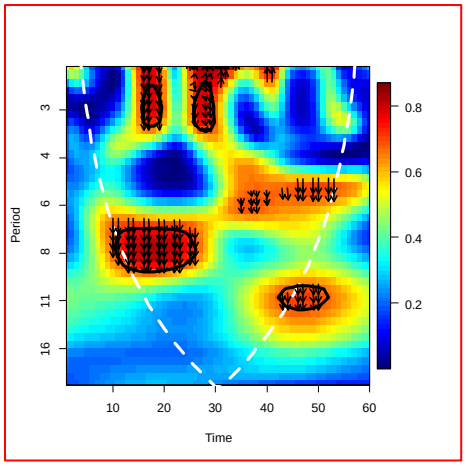
when one observes that inverse of the period yields frequency. The following subsections present our findings from wavelet coherence analysis.

Natural Factors and Economic Activity

Volume of rainfall and the Paraguayan agricultural output

Rainfall cycles lead agricultural output at wavelengths of 2–3 quarters and 7–8 quarters (Figure 3.1).Periods of 2–3 quarters correspond to short-term (or the same year) fluctuations. In that, a generous year of rainfall might have a boosting effect on the volume of agricultural output. Oscillations over 7–8 quarters might seem strange at first sight. Though, associations between agricultural value added and the volume of rainfall at periods of 7–8 quarters might be meaningful when we consider the well-known even year-odd year phenomenon. Specifically, a year of high agricultural productivity is often followed by a poorer performance.

Figure 3.1: Agriculture output cycle after rainfall cycle.



Source: authors.

Prices and Economic Activity

World agricultural raw material prices and the Paraguayan agricultural output

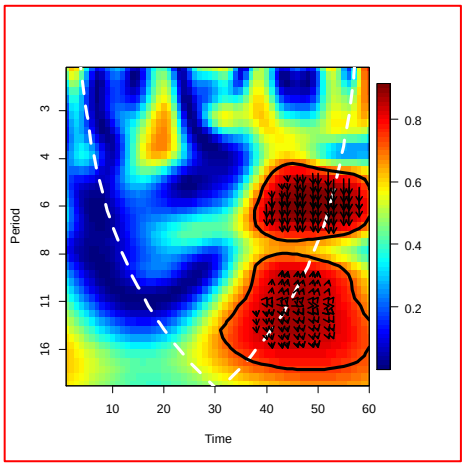
In the first half of the sample, no significant association is observed. In the second half, regarding oscillations with 4 to 16 quarter wavelengths world agricultural prices lead Paraguayan agricultural output (Figure 3.2). Once a pattern of increasing prices is observed, then, this pattern is likely to be translated into expansion of agricultural production from one to four years. In designing policy, these medium term connections are better not to be undermined.

Beef prices and the Paraguayan output of cattle, fisheries and forestry

Beef prices lead CFF output at wavelengths of 6–8 quarters, whereas this finding is valid for the middle section of our sample and the relationship disappears for recent observations (Figure 3.3).

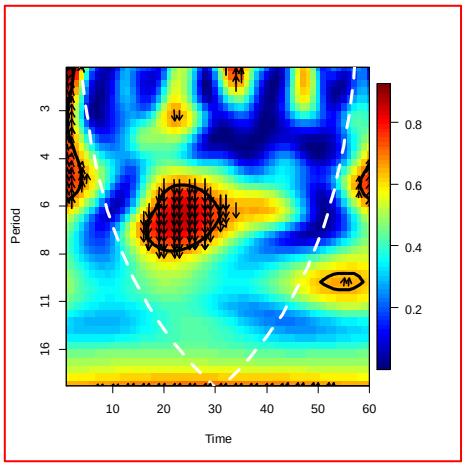
This finding is quite similar to that observed in the case of the narrow definition of agricultural output.

Figure 3.2: Agriculture output cycle after world agriculture raw material prices cycle.



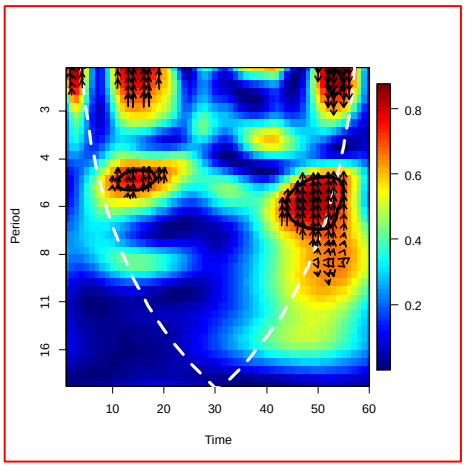
Source: authors.

Figure 3.3: Cattle, fisheries and forestry cycle after beef prices cycle.



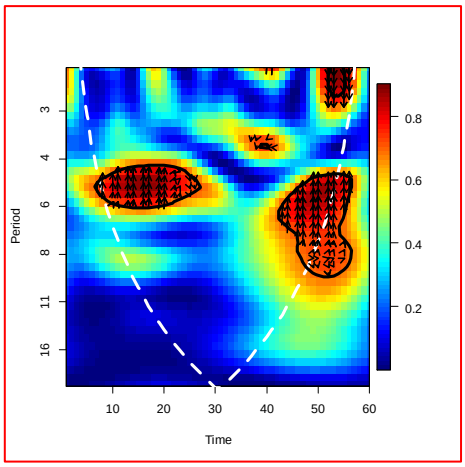
Source: authors.

Figure 3.4: Non-agriculture output cycle after agriculture output cycle.



Source: authors.

Figure 3.5: Non-agriculture output cycle after broad agriculture output cycle.



Source: authors.

Linkages between Agricultural and Non-agricultural Economic Activity

Narrow (broad) definition of agriculture and narrow (narrow) definition of non-agriculture

Using narrow definition of agricultural output and narrow definition of non-agricultural output, in the second half of the sample, at wavelengths of 1 to 3 quarters, agricultural output leads movements of non-agricultural output. At higher wavelengths the picture is reversed (Figure 3.4). This finding preserves its validity when we use the broad definition of agricultural output and narrow definition of non-agricultural output (Figure 3.5).These observations are interpreted as indicative of two mechanisms which are not mutually exclusive: first, expansion in agricultural activity stimulates economic activity in the non-agricultural segment of the Paraguayan economy in the short term, which is intuitive. Second, overall development of the

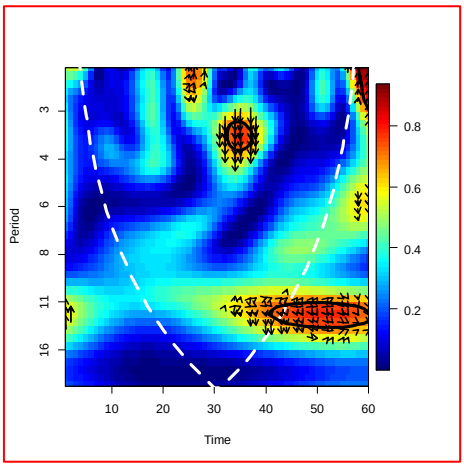
economy in the medium term further fosters agricultural production. As the longer wavelength oscillations are of structural nature, this observation gains larger gravity.

Linkages between economic activity and components of national income

Narrow definition of agricultural activity and private consumption

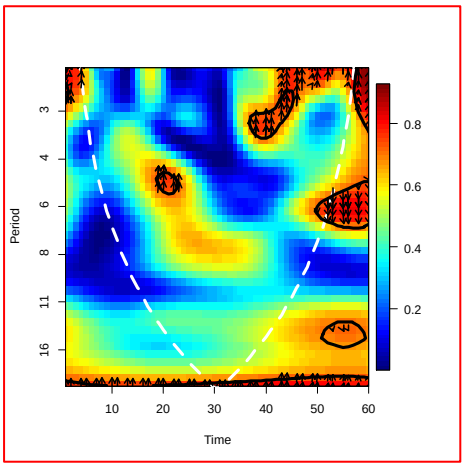
In the middle segment of the data set, agricultural activity seems to have induced consumption at wavelengths of 3 and 4. Toward the end of the sample, the evidence is either mixed or it does not lie within the cone of reliability (Figure 3.6).

Figure 3.6: Private consumption cycle after agriculture output cycle



Source: authors.

Figure 3.7: Non-agricultural output cycle after private consumption cycle

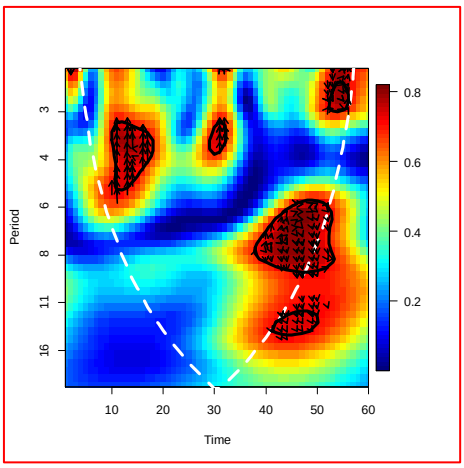


Source: authors.

Narrow definition of non-agricultural activity and private consumption

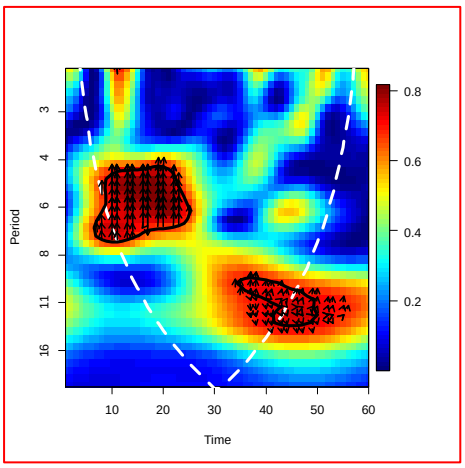
In the recent half of the sample, private consumption induces non-agricultural activity at wavelengths up to 4 quarters (Figure 3.7).

Figure 3.8: Agriculture output cycle after private investment cycle.



Source: authors.

Figure 3.9: Non-agriculture output cycle after private investment cycle.



Source: authors.

Narrow definition of agriculture and private investments

There is a significant association between agricultural output and private investments at wavelengths from 3 to 6 quarters (earlier sample) and at wavelengths from 6 to 16 quarters (recent portion of the sample). Regarding the direction of the effects, i.e. movements of which variable affect the other, the results are inconclusive or mixed (Figure 3.8).

Narrow definition of non-agricultural activity and private investments

At wavelengths from 4 to 7 quarters (earlier sample) movements of private investments lead the movements of non-agricultural economic activity (Figure 3.9).

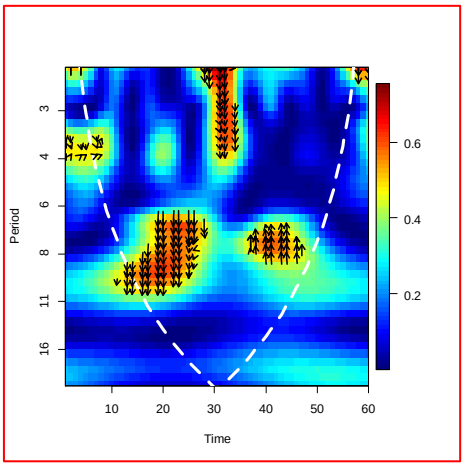
Narrow definition of agriculture and public investments

Regardless of the wavelength and time periods we could not find a significant association between the variables of interest Figure 3.10).

Narrow definition of non-agricultural activity and public investments

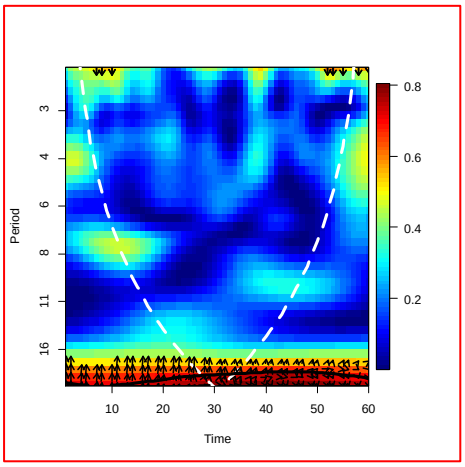
Regardless of the wavelength and time periods we could not find a significant association between the variables of public investment Figure 3.11).

Figure 3.10: Agriculture output cycle after public investment cycle.



Source: authors.

Figure 3.11: Non-agriculture output cycle after public investment cycle.



Source: authors.

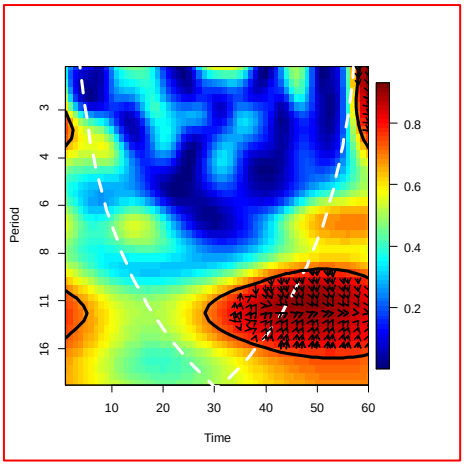
Narrow definition of agriculture and tax revenues

A stronger degree of association has been observed at wavelengths larger than 11 quarters and only in the later segment of the data. However the direction of the effect is inconclusive (Figure 3.12).

Narrow definition of non-agricultural activity and tax revenues

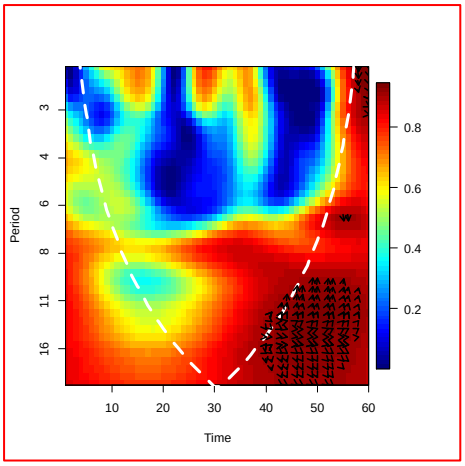
A stronger degree of association has been observed at wavelengths larger than 7 throughout the data. However this association lacks statistical significance (Figure 3.13).

Figure 3.12: Agriculture output cycle after public tax revenue cycle.



Source: authors.

Figure 3.13: Non-agriculture output cycle after public tax revenue cycle.



Source: authors.

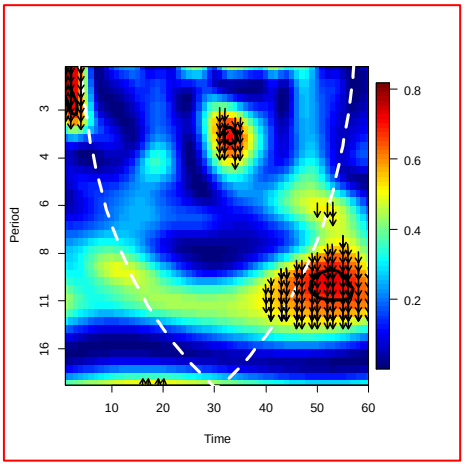
Narrow definition of agriculture and private credits

Regardless of the wavelength and time periods we could not find a significant association between the variables of interest (Figure 3.14).

Narrow definition of non-agricultural activity and private credits

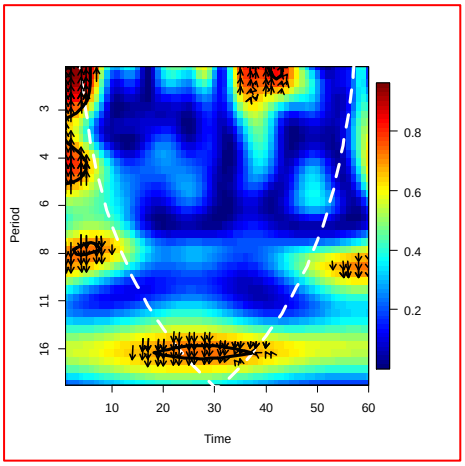
Regardless of the wavelength and time periods we could not find a significant association between the variables of interest (Figure 3.15).

Figure 3.14: Agriculture output cycle after private credit cycle.



Source: authors.

Figure 3.15: Non-agriculture output cycle after private credit cycle.



Source: authors.

3.4 Discussion and concluding remarks

The findings out of the wavelet coherence analysis are mostly intuitive. As introduced earlier in the text, the major advantage of employing a wavelet filter and coherence analysis is that one can develop ability to associate two series on the basis of their frequencies of oscillation. In that, the wavelet coherence analysis allows us to pinpoint associations at business cycle frequencies as well as higher or lower ones. In the case of rainfall volume and agricultural output, for instance, we observe two separate associations. The rainfall volume is a determinant of agricultural performance within the current year as well as being a determinant at periods of 7–8 quarter indicating the even-odd year phenomenon. Verification of the price taking behavior of the Paraguayan agricultural sector can also be counted among our initial observations.

A glance at the relationship between agricultural and non-agricultural value added reveals that agricultural growth has a stimulating role on non-agricultural output. In addition, at longer periods non-agricultural output growth brings out higher agricultural performance. In the first direction, we can simply talk about a simple mechanism of national income determination, i.e. higher agricultural income propagates into non-agricultural sector through elevated demand. The reverse direction, though, tells us a development story where growth-at-large opens a wider room for agricultural activity. A modest reading of these findings might suggest that higher market orientation triggers higher volume of activity in the agricultural sector. In other words, private consumption must have a specific role in further development of the Paraguayan economy. Indeed, while checking for the role of private consumption in determining agricultural and non-agricultural output, we obtain a significant association only for the latter at periods (wavelengths) not larger than 4 quarters.

A similar extension can be studied by considering the role of private investments. At lower than business cycle and at business cycle frequencies private investments have some association with agricultural output; however, the direction of the relationship has not been obtained with clarity. The effect of private investments on non-agricultural production, on the other hand, is clearer and at periods up to two years, private investments do induce non-agricultural activity.

Having assessed the tax generating potential of agricultural and non-agricultural economic activities, the wavelet coherence analysis did not reveal any solid measurements. Despite the existence of a relationship has not been dismissed at all, the direction of causality seems vague. Finally, no significant association between private credits and economic activity was revealed, whether agricultural or not.

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Appendix 3.1 Table 1. Descriptive Statistics of Data

	Mean	Minimum	Maximum	Std.Dev.	Skewness	Kurtosis
[1964, 2011], T = 48						
DLCMARM	3.84875e-02	-1.88116e-01	4.76163e-01	1.27714e-01	1.0510	4.8876
YAGRLCUG	4.25741e-02	-1.90077e-01	2.94439e-01	6.54355e-02	0.1377	8.5058
[1964, 2008], T = 45						
AAMC_D1	2.59593e-02	-1.13395e-01	1.12453e-01	3.25440e-02	-1.0572	9.1311
AAYAGRLCU_D1	2.72909e-02	-1.57970e-01	1.19523e-01	5.70359e-02	-1.1473	4.7711
[1997 Q1, 2011 Q4], T = 60						
BEEFPRI_LOG_D1	1.44871e-02	-2.32908e-01	2.00512e-01	8.05915e-02	-0.2083	3.4653
YAGRCFF_D1	2.77140e-03	-1.59440e-01	2.13260e-01	6.30844e-02	0.1486	4.4054
YAGR2G	1.10627e-02	-2.61655e-01	2.71652e-01	6.11854e-02	-0.0081	12.7162
[1995 Q1, 2011 Q4], T = 68						
RAIN	8.74873e+00	8.13304e+00	9.42441e+00	2.93579e-01	-0.1097	2.4762
YAGR1G	1.44025e-02	-3.84800e-01	3.55742e-01	7.74697e-02	-0.6685	16.7444
YNAGR2G	4.77360e-03	-5.95441e-02	5.60281e-02	2.40231e-02	-0.1388	2.7579
YEXG	3.15772e-03	-1.74308e-01	1.19839e-01	6.28833e-02	-0.1911	2.8705
[1996 Q1, 2011 Q4], T = 64						
RAIN	8.75835e+00	8.13304e+00	9.42441e+00	2.94552e-01	-0.1762	2.5605
SOYPRI_LOG_D1	8.50898e-03	-3.93275e-01	2.52987e-01	1.20596e-01	-0.8103	4.9096
YAGR1G	1.27819e-02	-3.84800e-01	3.55742e-01	7.86731e-02	-0.6538	16.6208
YNAGR2G	5.42964e-03	-5.95441e-02	5.60281e-02	2.36408e-02	-0.2035	2.9437
YEXG	7.30771e-03	-1.74308e-01	1.19839e-01	6.05664e-02	-0.1737	3.0284
[1995 Q3, 2011 Q4], T = 66						
RAIN	8.74999e+00	8.13304e+00	9.42441e+00	2.94008e-01	-0.1140	2.5115
SOYPRI_LOG_D1	1.06078e-02	-3.93275e-01	2.52987e-01	1.19550e-01	-0.8475	4.9980
DLCMARM	6.30847e-04	-1.67156e-01	1.42768e-01	6.14573e-02	-0.4349	3.7587
YAGR1G	1.24948e-02	-3.84800e-01	3.55742e-01	7.74973e-02	-0.6523	17.1080
[1997 Q1, 2011 Q4], T = 60						
BEEFPRI_LOG_D1	1.44871e-02	-2.32908e-01	2.00512e-01	8.05915e-02	-0.2083	3.4653
YAGR2G	1.10627e-02	-2.61655e-01	2.71652e-01	6.11854e-02	-0.0081	12.7162
YNAGR2G	5.14780e-03	-5.95441e-02	5.60281e-02	2.42814e-02	-0.1712	2.8082
[1997 Q1, 2011 Q4], T = 60						
BEEFPRI_LOG_D1	1.44871e-02	-2.32908e-01	2.00512e-01	8.05915e-02	-0.2083	3.4653
YAGR2G	1.10627e-02	-2.61655e-01	2.71652e-01	6.11854e-02	-0.0081	12.7162
YNAGR2G	5.14780e-03	-5.95441e-02	5.60281e-02	2.42814e-02	-0.1712	2.8082
YEXG	6.73375e-03	-1.74308e-01	1.19839e-01	6.03533e-02	-0.2202	3.0807
[1994 Q3, 2011 Q4], T = 70						
RAIN	8.75422e+00	8.13304e+00	9.42441e+00	2.91566e-01	-0.1510	2.4955
YAGR1G	1.44997e-02	-3.84800e-01	3.55742e-01	7.65008e-02	-0.6777	17.1098
JMININDSA_LOG_D1	2.40513e-03	-9.95690e-02	1.07132e-01	3.98792e-02	-0.0825	3.3049
JEWSA_LOG_D1	7.35299e-03	-1.46603e-01	1.39697e-01	5.05797e-02	-0.0648	3.8116
JCONSA_LOG_D1	4.59116e-03	-2.57213e-01	3.91924e-01	8.60296e-02	1.0660	7.9682
JSERSA_LOG_D1	7.22094e-03	-7.08270e-02	6.58028e-02	3.16191e-02	-0.2414	2.5124
YAGR2G	1.18547e-02	-2.61655e-01	2.71652e-01	5.93469e-02	0.0221	12.4670
[1997 Q3, 2011 Q4], T = 58						
YAGR1G	1.38149e-02	-3.84800e-01	3.55742e-01	8.12824e-02	-0.6614	16.0849
YNAGR2G	4.74507e-03	-5.95441e-02	5.60281e-02	2.45845e-02	-0.1267	2.7512
JINVPUBSAREAL_LOG_D1	1.28044e-02	-4.90005e-01	4.26629e-01	1.78869e-01	-0.2525	3.2635
JINVPRISAREAL_LOG_D1	-5.72616e-04	-5.30103e-01	2.35671e-01	1.27107e-01	-1.9265	9.5284
JINVTOTSAREAL_LOG_D1	1.89456e-03	-2.85744e-01	1.39451e-01	6.40569e-02	-1.4237	8.5447
[1995 Q1, 2011 Q4], T = 68						
RAIN	8.74873e+00	8.13304e+00	9.42441e+00	2.93579e-01	-0.1097	2.4762
YAGR1G	1.44025e-02	-3.84800e-01	3.55742e-01	7.74697e-02	-0.6685	16.7444
YNAGR2G	4.77360e-03	-5.95441e-02	5.60281e-02	2.40231e-02	-0.1388	2.7579
JTAXSA_LOG_D1	4.58211e-03	-4.31882e-02	6.30394e-02	2.39661e-02	0.1985	2.4916

CHAPTER 4. STUDY OF AGRICULTURAL VOLATILITY IN PARAGUAY

By

Dionisio Borda, Franchesco Anichini and Julio Ramírez[19]

4.1 Introduction

Paraguay has seen a significant rise in its agricultural production in the last decade. Grain (soybean, wheat, corn and sunflower) and cattle production for export have uninterruptedly increased.

Agricultural volatility, however, has also been more frequent, with a positive year with high production followed by a bad year with falling production or a lowering international price. This type of volatility affects the performance of the agricultural and non-agricultural sectors, due to the impact of foreign exchange earnings, expansion and contraction of investment, aggregated consumption, employment and exchange rates.

This qualitative study sheds light on the causes and effects of volatility and the mechanisms that are available to counter it. The study includes the study's objectives, the applied field methodology, and the corresponding findings. Analyzed data comes from interviews with relevant economic actors in the agricultural and non-agricultural sectors, either from public or private sectors.

4.2 Objectives

- To understand the causes and effects of agricultural volatility
- To identify transfer channels of agricultural sector volatility and their impact on the rest of the economy.
- To describe the interaction between agricultural volatility with other sectors of the economy.

4.3 Methodology

This study is based on structured-interviews with actors that are directly or indirectly related to agriculture.

Data was gathered in the following areas: (a) how volatility affects economic agents; (b) risks and opportunities that volatility represents to economic agents and; (c) the adjustment of policies and behavior to reduce the impact of volatility. The interview transcriptions and the corresponding reports are in annexes.

[19]CADEP'sResearchers.

Actors that took part of the study were selected intentionally according to their main activities or business occupations, and being grouped into: (a) corporate farming and businesses from the chain production in this sector, including production, logistics of provision, inputs, machinery and equipment, storage, transport, consulting services, technical and financial assistance (b) Family-based agriculture, in which case organizations that support this sector and micro-finance institutions were interviewed (c) Livestock, where firms from the productive sector and those in the sector of provision of inputs, products, and bio-technology were interviewed (d) Basic services and medical insurance sector and (e) Academic centers.

Notes were sent to 40 organizations approximately, out of which 29 replied and were interviewed. The final list of interviewed by sector is listed in Annex 1. Surveys took placed between April 15 and May 15 in the city of Asunción, and Departments (States) of Central, Alto Paraná, and Caazapá. Attached is the questionnaire guide of all interviews in Annex 2.

4.4 Study results

Sources of volatility in the agricultural sector

Data gathered from different economic actors that are directly or indirectly related to the agricultural sector in Paraguay allow identifying **four main factors** explaining current volatility: (i) climate, (ii) commodity prices, (iii) the level of investment and technological innovation and, iv) sanitary conditions in the livestock sector.

Climate constitutes the prominent cause of agricultural volatility, since a lack of rainfall reduces agricultural productivity and affects also the navigable conditions of the Paraguay and Paraná rivers - the main transport means for agricultural products to the international markets. To a less extent, frost is another climate factor that affects agricultural production – especially corn and wheat – as well as excessive rain and humidity during the harvest seasons of main commodities.

The **price** of commodities affects volatility because the country is a price taker in international commodity markets. Some sectors clearly indicated that commodity demand from China and the US has an effect on the international price, thus impacting the local market. Prices have been favorable in the last five years, but price volatility in the future - as it has been experienced in the past - cannot be ruled out.

The level of **investment and technological innovation** has an impact on volatility, due to little acquisition of high-technology genetic materials on the part of the productive sector. Interviewed firms consider that genetic innovation – by obtaining varieties with bio-technological procedures – can help reduce climate effects and keep up productivity throughout the agricultural season, thanks to rotation techniques with different varieties. In addition to technological innovation, limited level of investment in irrigation systems is worthwhile mentioning as it could mitigate the effects of droughts. The reason for this is that irrigation systems demand a high fixed investment, in particular as the crops are cultivated using large surfaces. Also, access to water is a challenge given the quantity of water that irrigation systems need.

Failure of sanitary measures in the livestock sector, regarding prevention of foot-and-mouth, becomes an element that harms the sector and generates volatility as a result of international market restriction on meat.[20]

Beyond these features, the survey gathers some **complementary elements** that add to the analysis of this sector's volatility. According to the livestock sector, the grains exports increase[21] and the subsequent appreciation of the dollar - due to high inflows of foreign currency - mainly affect the payment capacity of reefer container companies to producers of meat. This situation is due to financial commitments that reefer container companies have in the guaranties, while the export prices are fixed in dollars. When the exchange rate appreciates, an additional cost falls on meat exporters, who have to pay back their debts in guaranties.

The appreciation of the exchange rate also affects the capacity to import equipment and machinery and the consumption of family's basic goods. A cheaper dollar makes it easier to import capital goods and household goods.[22]

Another identified element is the **monopoly strategy** in the value chain of each commodity. Multinational grain traders (Cargill, ADM, etc.) operate from the provision of seeds, to financing production, to transport and storage, making competition difficult for national firms or cooperatives, a reason why the latter have higher market access costs and smaller profit margins.

Lastly, it is worth noting that it is the **speculative strategy** of the middleman that generates volatility in other profitable commodities (sesame and cotton), by buying production when the price is cheapest due to surpluses, and selling it at higher prices later when the demand goes up.

Volatility effects in business

In this section, the effects of volatility in agricultural businesses and other non-agricultural sectors are examined.

Agricultural sector

The surveys analyze the way in which firms in the agricultural sector deal with the case of volatility, especially in a situation where production and exports fall. Decisions are normally linked to the next agricultural cycle (the following production cycle).

As a first step, livestock firms reduce investment in infrastructure and innovation with pure-breed genetic material, and in a second step, they also reduce investment in pasture improvement (farmed pasture).

[20]An interviewee mentioned a particular case related to the change of SENACSA's president (SENACSA being the state institution in charge of animal health control) from a technician to a person with a political profile. For this reason, there were deficiencies in animal health control, which led to the spread of mouth-and-foot in San Pedro, impacting the whole country.
[21]Soy, wheat, corn and sunflower.
[22] 30 percent of basic consumption goods are imported into the country.

On the one hand, agricultural firms **diminish investment in machinery** for farming mechanization and **storage infrastructure** for agricultural products, and on the other hand, they reduce investment for enlargements of farmed land.

Agricultural volatility also affects the credit system that finances agricultural production. Financial institutions (banks or cooperatives) have **higher rates of financial late-payments** from producers, who are their clients. Thus, given that the latter find it impossible to pay back, they need to establish mechanisms for partial or total credit refinancing. For the most part, surveyed firms sustain that the credit cost goes in the face of high volatility.

Firms that sell their inputs with a fixed credit period find the need to **extend the repayment period** of their clients or to resort to legal actions so they can obtain payment for their sold products.

Against a backdrop of constant volatility, sector firms and production cooperatives generally adopt a **strategy of diversification of the production and services lines**. The diversification of products from inputs firms and financial services companies broaden available markets and reduce dependency on the agricultural sector, thus remaining competitive in spite of negative years that the sector might have to deal with.

Production diversification is also adopted within the agricultural sector, to curtail the firm or cooperative's dependency on one commodity or agricultural product; to that effect, they invest in milk and flour products, production of small animals and the fruits and vegetables sector, in order to spread the risks along different lines of products.

Adjustment of strategic production plans is another mechanism that the agricultural sector adopts. This strategy consists in adjusting the farmed land size of various commodities so that the effects of volatility – generated by international prices – are buffered and economic profitability is sustained.

Non-agricultural sectors

The interviews help to understand the impact of volatility on those sectors that do business with the agricultural sector; sectors that are not directly related state that there is a volatility effect in the contraction of the economy.

For the **transport sector**, the effects of volatility impinge upon the reduction of volumes of grains that are transported, and on their profit margin, which is reduced due to the relative rise of fixed costs. Ship management firms express that when agricultural production falls, imports of fuel decrease, which signify less activity in the sector given that less quantities of fuel are transported.

For transport firms that belong to multinational corporations in the agricultural sector, volatility has a strong negative impact because business is exclusively about the transport of commodities. As a strategy, multinational corporations absorb the losses in the transport area with the earnings coming from other lines of business.

Economic actors that are dedicated to **technological innovation, machinery and inputs** for the agricultural sector are strongly affected by volatility. Most are forced to activate refinancing mechanisms for the producer as a strategy of support to the sector and to reduce losses. Firms that sell machinery experience a strong decline in sales that block the market and decrease imports of new technologies.

In the livestock sector, importers of **veterinary products and genetic material** diminish their billing transactions given the lack of investment that volatility causes; in the case of veterinary products, the effect on the market translates into producers buying products of lower quality and lower prices.

The **seed sector** reduces physical capacity usage to 40 percent generally, and it also experiences a drastic reduction of hired personnel. At the same time, during good production seasons, seed firms experience a reduction of seed sales, given that grain producers keep a portion of their production for the next campaign. Theses seeds do not have the same quality as the ones produced by seed firms, which are also certified.

Apart from this, this sector expresses that when the price of grain is high, the price of its product is higher, since it has to pay a price differential to their seed producers to avoid production leakages. In this way, its products reach the market with a higher price than the price of grain; this situation motivates the grain producer to supply itself in the informal market.

Financial actors that do business with the agricultural sector see a rise in late-payments from their clients, having to implement credit measures (refinancing, payment period extension, etc.) to reduce losses or increment their interest rates; in the case of some cooperatives, the urban loan portfolio allows to compensate for the negative impacts of the agricultural sector. Volatility affects the insurance, silo and transport sectors, given that during seasons of agricultural recession producers do not hire their services at all.

The economic sector which offers **storage services** is divided into two categories: a) the first one is static storage comprised by big silos and b) the second one is non-static storage comprised by small silos (silos bag). In the first case volatility does have an impact on the sector since investments are medium and long-term - the reason why the producer continues to compensate for such investment; in the second case firms suffer a strong reduction of business due to smaller sales in the agricultural sector (grains) and the livestock sector (forage).

Given the sales boom of insurance policies in the urban sector, the **general insurance sector** has not been affected by volatility in the last years - as opposed to the agricultural sector. According to firms in the agricultural insurance sector, profitable commodities for insurance companies are those that weigh the most in national production and that count on active involvement of big firms: soy, corn and wheat. Rise is a growing commodity nationally, and the insurance sector is evaluating it in order to verify profit margins that could permit service coverage for this commodity. Another highlighted element is the selection mechanism of risks that the producer establishes - since a producer is the one who selects which crops or crops harvest to secure based on the risk of losing productivity -, thus generating a highly elevated concentration of risks during productive seasons in the insurance sector.

When the producer expects good production, he does not acquire insurance, and yet when expectations are bad, he seeks insurance. These changes in the producer's behavior bring up uncertainty and greater risks to insurance companies, obliging them to keep a high policy price. In a bad year, when a major disaster has taken place, the compensation mechanism of agricultural insurance firms is to raise next year's insurance policy price to the producer.

From the **small producers' perspective**, no agricultural insurance suits the sector. The greatest risk that a small producer contemplates is the credit risk during a bad agricultural year. This is what leads to suggest that instead of agricultural insurance, credit refinancing should be the most important mechanism for this type of producer.

Other sectors, such as those in **construction and sales of consumption products**, are also affected by agricultural volatility due to the reduction of economic agents' purchasing power and the uncertainty that the downturn of the economy as a whole generates. In the construction sector, housing construction companies are badly hit, receiving a direct impact. Given that most are state contractors, **road companies** have not been strongly affected, with rising investment expenditures in the past years through the public budget.

Volatility has benefited **importers** in recent years due to the appreciation of the dollar.

Volatility has not had an impact on **supermarkets**, since boom years have more than compensated downturn years in the agricultural sector. Generally, this sector has been dynamic due to rising consumption in the urban areas.

Volatility effects on economic activities

In the interviews about the effect of volatility in economic activities, the most relevant information that comes up relates to the lack of knowledge of how and how much volatility affects the economy as a whole from the interviewees' perspective.

Some economic sectors not directly related to the agricultural sector (basic services, non-agricultural insurance, etc.) admitted of being unaware about the impact of volatility on the country's economy. On the other side, factors directly linked to the agricultural sector asserted that volatility does have an impact in the following ways: (i) economic slowdown in all sectors and ii) downsize of direct and indirect employment in the agricultural sector.

When sectors that are directly related to the agricultural sector receive the negative impact of volatility, this effect is transferred to other sectors such as construction, followed by logistics, machinery, and inputs sales. Consequently, those that are barely related to the agricultural sector are also affected, like the tourism and sales of household appliances, clothing, shoes, and personal consumption goods sectors. In general, all interviewed actors express a reduction of purchasing power on the part of consumers as a consequence of the effects of volatility in the agricultural sector.

Volatility - when it impinges upon the dollar exchange rate by lowering it due to positive impacts on commodities and grain exports - favors the sector which imports veterinary products or raw materials for manufacturing of agrochemical products; importers of genetic material (semen) for improvement of cattle in the agricultural sector are also benefited.

Interviews reveal that volatility affects the agricultural sector directly, altering a company's plan for capital investment. A number of economic actors in this sector cited how their investment plans with fixed costs turn obsolete during a productive cycle due to volatility effects, in some cases obliging them to reconvert investment or to remain at a loss at the end of the productive cycle. This situation was acute particularly during the 2011/2012 productive cycle, when the agricultural sector was strongly affected by the effects of a drought, as well as livestock production as a result of mouth-and-foot and the subsequent closure of markets.

As for employment, the seed and livestock (reefer companies) sectors are those that emphasize a high rate of unemployment, subject to volatility. Contrary to this, actors in the agricultural sector highlight few job losses, since the high level of ongoing mechanization requires well-qualified personnel, that even in the face of adverse volatility consequences, are not dismissed. In the technical services sector for agricultural production (inputs and technical assistance), a large removal of its personnel could take place since most technicians are hired for the productive periods.

Some sectors mention that it is convenient to keep the dollar stable while appreciating the domestic currency - the guarani – in order to favor local consumption, thus reducings the effects of volatility.

It is also worth noting that unemployment is caused as a result of agricultural volatility in the housing sector, forcing it to adjust investment plans for construction or to delay building works.

Risks and opportunities of agricultural volatility

All economic actors agree that the main risk that agricultural volatility poses is the loss of business profits - be it by a smaller volume of revenue from provision of services and inputs, or by the reduction of margin profits in those sectors dealing with annual contracts, and where the company has to absorb ongoing costs variations of the contract's application.

The main risk in inputs sales is late-payment from the producer or from the inputs distribution agents that work with the company indirectly; the sales sector of veterinary inputs highlight a stable portfolio and a circle of clients that minimize risks, given that the company has built a degree of trust with its clients and is willing to wait payment, as long as it is financially capable to do so.

Some sectors emphasize volatility risks that could be generated in the financial sector; these risks are mainly speculative in nature, in the sense that they tend to rise as a result of the need of refinancing debts from a negative campaign.

Various sectors highlight the volatility risk that impacts on the logistic sector due to the entrance of products to markets through fluvial space, subject to climate factors (which could represent 4 to 5 months in a year), becoming a strong barrier in the economy.

According to most interviewees, agricultural volatility does not create opportunities. However, some actors point at some opportunities that could open up, such as: (a) the development of new lines of businesses that are functional to risk factors like: irrigation systems or equipment sales to push for agricultural mechanization, (b) joining up a chain value, as a specialized company in

one chain link and, in doing so, remain competitive in spite of the negative effects of volatility; (c) orienting the production or services system towards quality, allowing to compensate profits reduction. In the case of multinational corporations, another opportunity that arises is to keep legal headquarters in other countries that could provide products to the local headquarters, thus staying active with a competitive price in the market.

For the livestock sector, an opportunity comes up from successfully complying with sanitary measures at a national level and by keeping up to the strictest international standards. Compliance with sanity measures will open up more demanding markets to the meat sector, like those from Asian countries.

Industrialization in the agricultural sector is another option that interviewees identify as an opportunity in the face of agricultural volatility risk. In fact, in the last years, the number of agro-industrial companies in the country has increased significantly, with the establishment of wheat (flour), corn and soy (oil) processing plants. If climate affects any of the commodities within the grain complex (soy, wheat, corn, sunflower), there is an alternative to compensate with other commodities, which includes a greater aggregated value with industrialization.

Risk management mechanisms

The survey shows that for the most part, economic actors do not apply measures or prevention mechanisms to mitigate agricultural volatility risks. An important data is that agricultural insurance mechanisms that are available to the productive sector have not been well advertised, or that there is effort to implement such mechanisms only under hostile circumstances. Given the reason that during the last ten years, there has been a negative cycle and a positive one subsequently in the productive cycles, producers have been able to compensate the negative effects of production falls with the recovery from the following year, without having to resort to agricultural insurance. The risk would increase if climate adversities lasted for two years in a row, in which case the loss and earning balance – as a result of the downtown and recovery pattern – would not occur, the damage being greater while not covered by any mechanism of risk control. In the soy sector, insurance is not widely adopted because the productive cycle is short and the producer considers that the probability of an adverse event is low. Moreover, some producers think that the expected profit losses so that a casualty occurs - as contemplated by insurance policies - are too high even for such an event to take place in reality. This is the reason why they believe insurance policies are not convenient.

The livestock sector does not apply any type of insurance mechanisms since coverage services that would safeguard livestock production are not widely advertised. Contractual guarantee clauses are implemented in the logistics and services sector; the transport sector applies a safeguard clause regarding volumes and operational timeframes (loading and unloading) with each client.

Insurance or clients' risk analyses are quite new in different economic sectors, which is the reason why the majority does not apply these types of mechanisms; moreover, many business agreements between provider companies of inputs and machinery and the production sectors are kept informally (i.e. Mennonites), for which no clauses or risk prevention elements are taken into consideration.

In regards to the seed sector, there is no required legal framework – or least one that has been implemented – that forces the usage of certified seeds as a mitigating mechanism of productive risks (the Bank of Brazil is cited as an example; it provides credits for agricultural production only to applicants that use certified seeds). In this sense, the level of compliance with legal obligations in the country remains weak.

Agricultural insurance companies explain that insurance is basically about safeguarding a producer's investment in the event of a performance loss, due to a climate event. Various types of coverage for casualties are available for soy, being the most widely spread insurance policy: (a) Drought (b) Hail (c) Frost (d) Excessive rain (e) Weather depression due to high and low temperatures (d) Flooding and (e) Strong winds.

A hectare is the minimum insurable unit, and the producer can insure his farmed area partially or totally. The minimum performance that is required, under which there can be casualty coverage, is 1.600 to 1.700 kilos per hectare, depending on the region or province and the type of soil where the company operates.

Public policies to alleviate volatility

In regards to public policies, a few fundamental elements can be emphasized: (i) infrastructure for roads and fluvial transport, (ii) a financial policy that favors private investment, (iii) to strengthen the insurance market and iv) policies that support production and protect national products. In the case of infrastructure, state investment in road improvements is clearly needed, so that the roads can support the cargo that the agricultural sector transports. Similarly, the need for strong investment in river navigability emerges, rivers being the only way out for products to reach international markets. A number of actors in the logistics sector agree that the investment cost to improve navigability would be minimized, and it will be highly beneficial to the country's economy.

In relation to financial policies, actors agree that interest rates and current financial costs in the national market should be reduced. Furthermore, some actors in the insurance sector and others agree that there is a lack of a framework to foster the growth of the market for agricultural insurance, which would favor its adoption on the part of the productive sector; particularly, interviewees indicate that an adequate public policy could spread agricultural insurance and guarantee better access, with incentives that would decrease currents costs.

In the case of policies related to the productive sector, the state ought to foment production of various commodities; in this way, newly competitive and stable markets that do not depend on the temporary success of some agricultural commodity could open up.

At the same time, protection policies for agricultural production at the national level are suggested (particularly those that prevent smuggling). Also, the livestock and veterinary sectors pose the need of greater operative capacity over control and regulation from SENACSA, the animal health oversight entity. A number of economic actors declared that it is not up to them to propose adequate public policies to reduce the impacts of volatility in the agricultural sector and the national economy, since these should be formulated by government.

ANNEX 1

Segmento	Actor
Producción Agrícola	Asociación Productores de Soja
	FECOPROOD
	CAPPRO: Cámara Paraguaya de Exportadores de Aceite
Provisión de Granos	
	COPATIA
	Relmo Paraguay
	Aprosemp
Insumos	
	Diagro S.A.
	Agrofield
Equipos y Maquinarias	
	COMAGRO-ROCKING
	Campos del Mañana
Almacenamiento	CAFI
	SILOMAQ
Trasporte	
	Naviera Mercosur
	Multimar
Servicios de consultoría en asistencia técnica.	
	Agrotec
Financiero	
	Banco Nacional del Fomento
	CooperativaCaapibary
	CooperativaYcuaBolaños
Frigorífico	Frigorifico Concepción
Provisión de Insumos: productos veterinarios, sales minerales	LASCA
	Ciavet
Biotecnología: Reproductores, embriones.	Gyba SA

Seguro Agricola	Sancor
	Garantia de Seguros.
SegurosGenerales	La Agricola SegurosGenerales
	La Consolidada
Agua y Electricidad	Essap
Inversion y Exportación	REDIEX
Centros de Investigación	CADEP
	CECTEC

ANNEX 2

Guía de Entrevistas

(a) ¿A qué atribuye la gran volatilidad de la producción agropecuaria/ del PIB agropecuario y como afecta a este sector?

(b) ¿Cómo cambian las decisiones de negocio en el sector agropecuario en años malos y buenos del sector?

(c) ¿Cual es el impacto de las fluctuaciones del sector agropecuario sobre las inversiones en la economía, el consumo, el empleo, la tasa de cambio?

(d) ¿Cuál es la naturaleza y el nivel de relacionamiento con el sector agropecuario de su negocio?

(e) ¿Cuáles son la consecuencias de la volatilidad en su sector/ comercio/ empleo/ ingreso/ actividad económica?

(f) ¿Cómo cambian en su sector/ comercio/ empleo/ ingreso/ actividad económica las decisiones de negocio debido a las fluctuaciones en el sector agropecuario?

(g) ¿Por favor especifica los impactos directos y indirectos a su sector/ comercio/ empleo/ ingreso/ actividad económica de las fluctuaciones en el sector agropecuario?

(h) ¿Cómo y en qué grado afecta la volatilidad del PIB agropecuario a su sector? 10% ? 100%?

(i) En su opinión, además de su sector ¿A quién más y como les afecta la volatilidad?

(j) ¿Qué Riesgos y Oportunidades usted ve en la volatilidad que origina en el sector agropecuario?

(k) ¿Qué mecanismos existen para asegurarse en contra de/ para transferir/ para evitar estos riesgos?

(l) ¿Usa Usted cualquier mecanismo de aseguro contra los riesgos? ¿Si no, porque no? ¿Que necesitaría cambiar para que puedan usar un aseguro? ¿Si usa mecanismos de aseguro cuales son? ¿Cómo funcionan?

(m) ¿Qué se puede hacer en términos de política pública y/o intervención de los agentes económicos para mitigar/evitar la volatilidad/ el impacto de la volatilidad?