

# Business Cycles Accounting for Paraguay

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## Abstract

This study investigates the role of domestic and external shocks in business cycle fluctuations in Paraguay during 1991–2012. Time-series methods and a structural model-based approach are used to conduct an integrated analysis of business cycles. First, structural vector autoregression is used to assess the role played by external factors and domestic shocks in driving fluctuations in gross domestic product through impulse response functions and variance decompositions. The analysis finds that external shocks such as terms of trade, world interest rate and foreign demand account for over 50 percent of real gross domestic product fluctuations. Given Paraguay's strong dependence on agriculture, an analysis is also done for the agricultural and non-agricultural sectors separately. The analysis finds that non-agricultural gross domestic product is to a large extent driven by external shocks, which account for over 50 percent of its volatility. In contrast, the volatility in

agricultural gross domestic product is primarily due to shocks to domestic variables, mainly shocks to agricultural output. A further difference between the sectors is that shocks to government consumption are more important for agricultural gross domestic product, while shocks to the domestic real interest rate play a larger role in the volatility of non-agricultural gross domestic product. Second, the paper investigates the sources of business cycle fluctuations through the lens of a neoclassical growth model with an agricultural and non-agricultural sector. The analysis finds some signs of improvements, as labor market distortions have declined, firms' access 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 the non-agricultural sector shows no signs of improvement, and households' access to finance has deteriorated.

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# Business Cycles Accounting for Paraguay<sup>1</sup>

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## 1. Introduction

Paraguay used to be one of the less volatile economies in the Latin America. However, this changed at the turn of the century, when the country's economic growth became one of the most volatile in the region. Thus, Paraguay's GDP volatility during 1960-1999 was below average for 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.<sup>4</sup> This contrasts with the last decade when the volatility in Paraguay has exceeded both, the regional average and median. In fact, during 2000-2011, the volatility of GDP growth rate in Paraguay was the fourth highest in the region after República Bolivariana de 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 1-1 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.<sup>5</sup> Second, macroeconomic volatility may have a negative effect on equality.<sup>6</sup> 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.<sup>7</sup>

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<sup>4</sup> Output gap is measured as the deviation of log GDP from its Hodrick-Prescott (HP) filtered trend.

<sup>5</sup> See Table 7 in Hnatkovska and Loayza (2005).

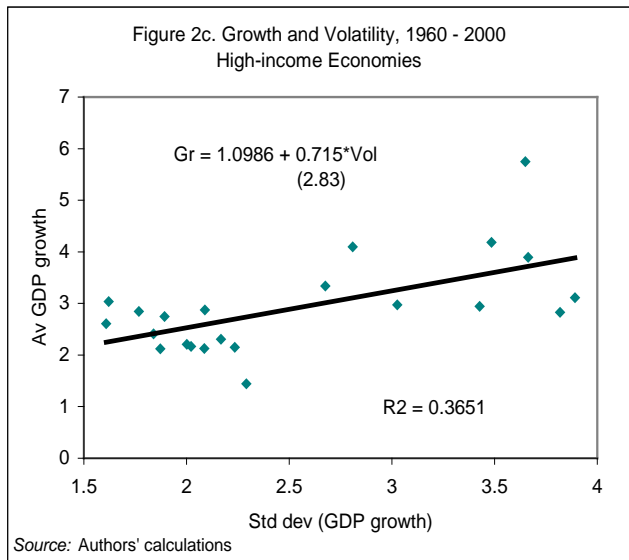
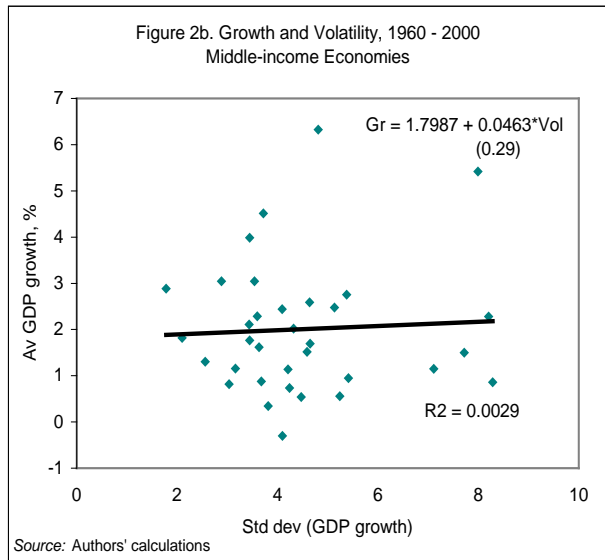
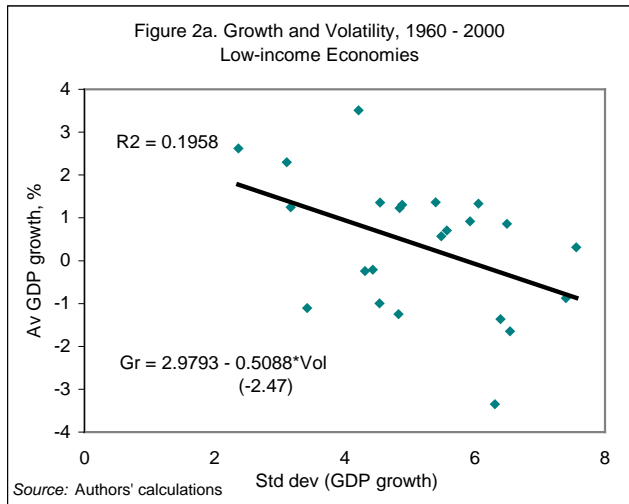
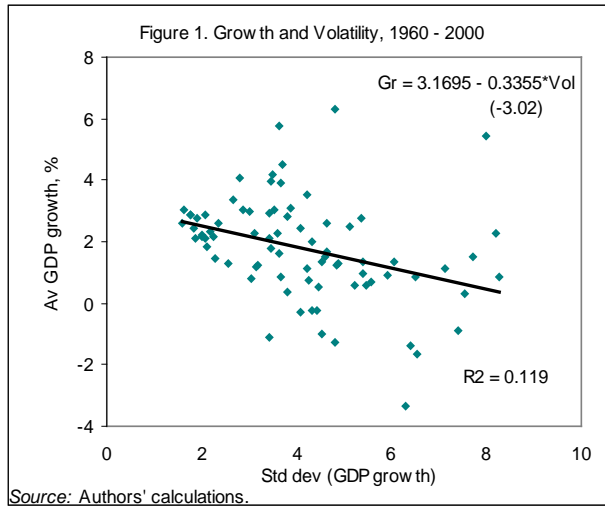
<sup>6</sup> See for example Breen and Garcia-Penalosa (2005), Garcia-Penalosa and Turnovsky (2003) or Huang, Fang, and Miller (2012).

<sup>7</sup> The period of study is dictated by the availability of quarterly data for the relevant variables.

**Table 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
<b>Paraguay</b>	<b>4.28</b>	<b>3.88</b>	<b>5.50</b>	<b>4.31</b>	<b>4.22</b>	<b>4.45</b>
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. 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).

## 2. 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. 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, except 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 2: Volatility of Key Variables**

<b>Variable</b>	<b>1994Q1-2012Q4</b>	<b>1994Q1-1999Q4</b>	<b>2000Q1-2012Q4</b>
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 pro-cyclicality 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 pro-cyclical 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 pro-cyclical 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 are not available. From Figure 1.2(c) it is easy to see that government consumption is strongly pro-cyclical during 1994-2012, 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 pro-cyclical, 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 pro-cyclical 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, and 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.

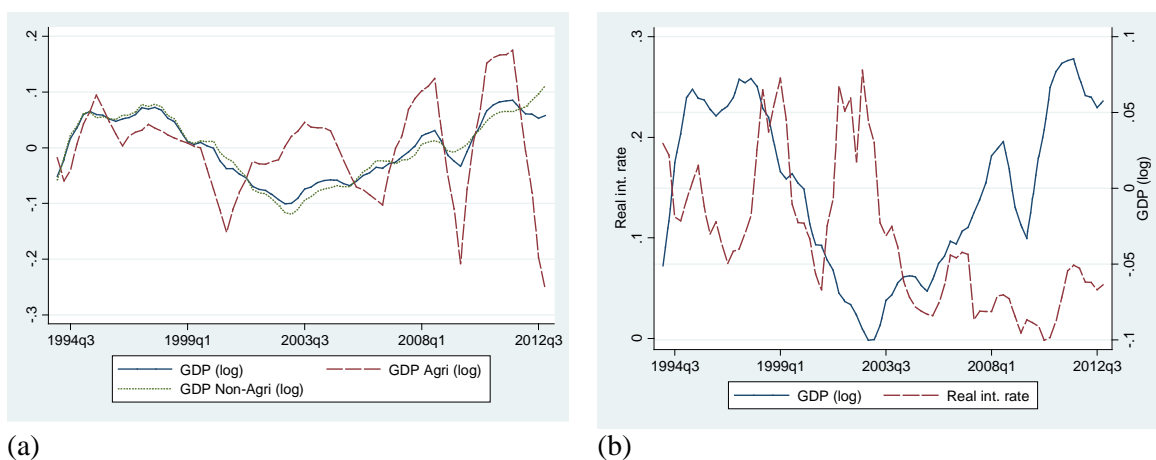
To capture foreign demand conditions for Paraguayan exports, we consider GDP in four main trade partners of Paraguay. More precisely, we construct a weighted foreign GDP using GDP data for Argentina, Brazil, Chile and Uruguay, where their export shares in Paraguayan exports are used as weights. The remaining 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

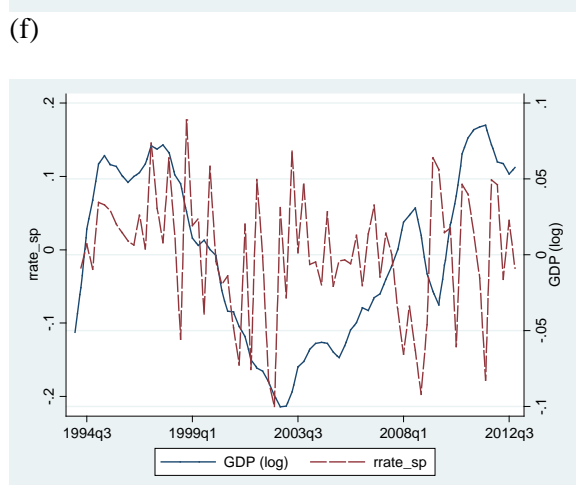
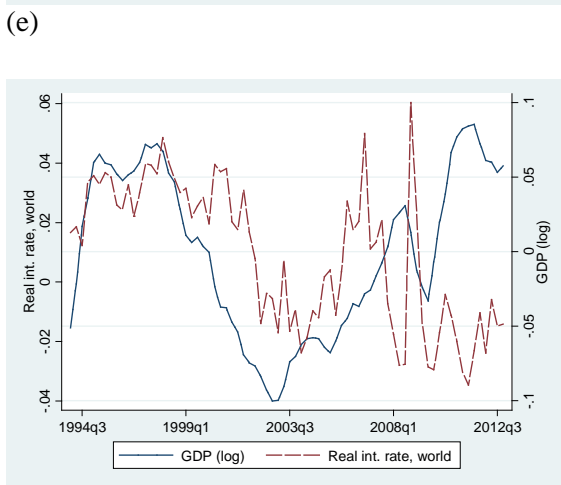
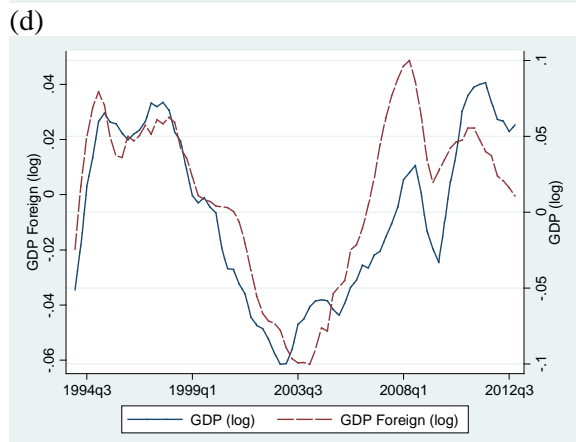
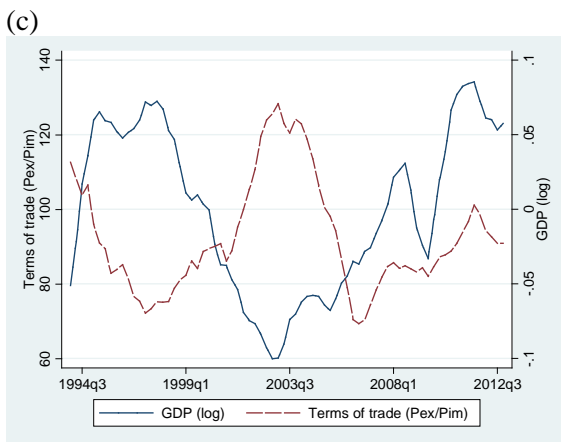
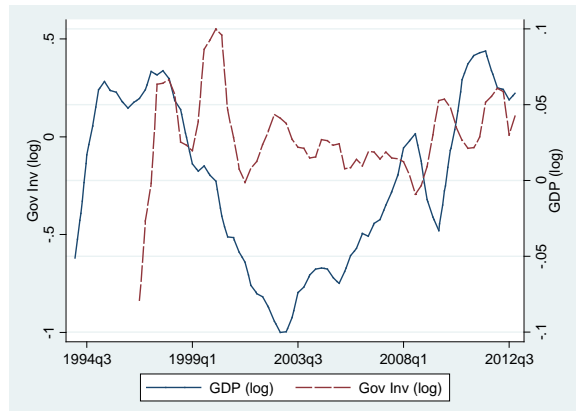
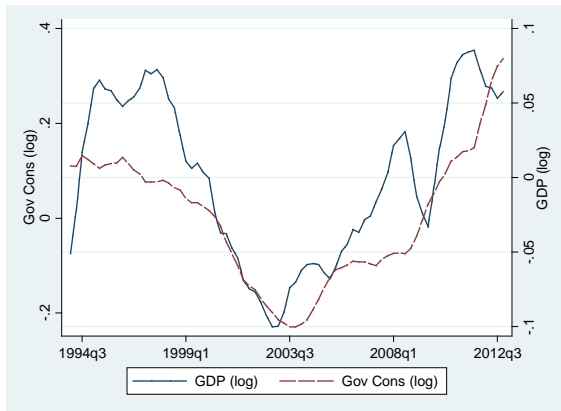
Latin American countries as investors sought higher returns. Such inflows have contributed to domestic expansions in these countries. A very large literature tried to quantify to what extent the world interest rate can explain fluctuations in small open economies using various methodologies. Lubik and 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.

Therefore, we consider the 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.<sup>8</sup> 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**



<sup>8</sup> Data is from the Global Financial Database.



(g)  
Source: authors.

(h)

**Table 3: Co-movements Across Variables**

	<b>gdp</b>	<b>gdp agri</b>	<b>gdp non-agri</b>	<b>inv</b>	<b>int rate</b>	<b>int rate US</b>	<b>gdp foreign</b>	<b>tot</b>	<b>gov cons</b>	<b>gov inv</b>
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.
- The terms of trade and real interest rate are more volatile than aggregate GDP.
- Aggregate investment and government consumption are strongly pro-cyclical, while the terms of trade and the real interest rate are countercyclical. Public investment is weakly positively correlated with GDP, which implies that the strong pro-cyclicity of aggregate investment is driven by the private and not by the 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.

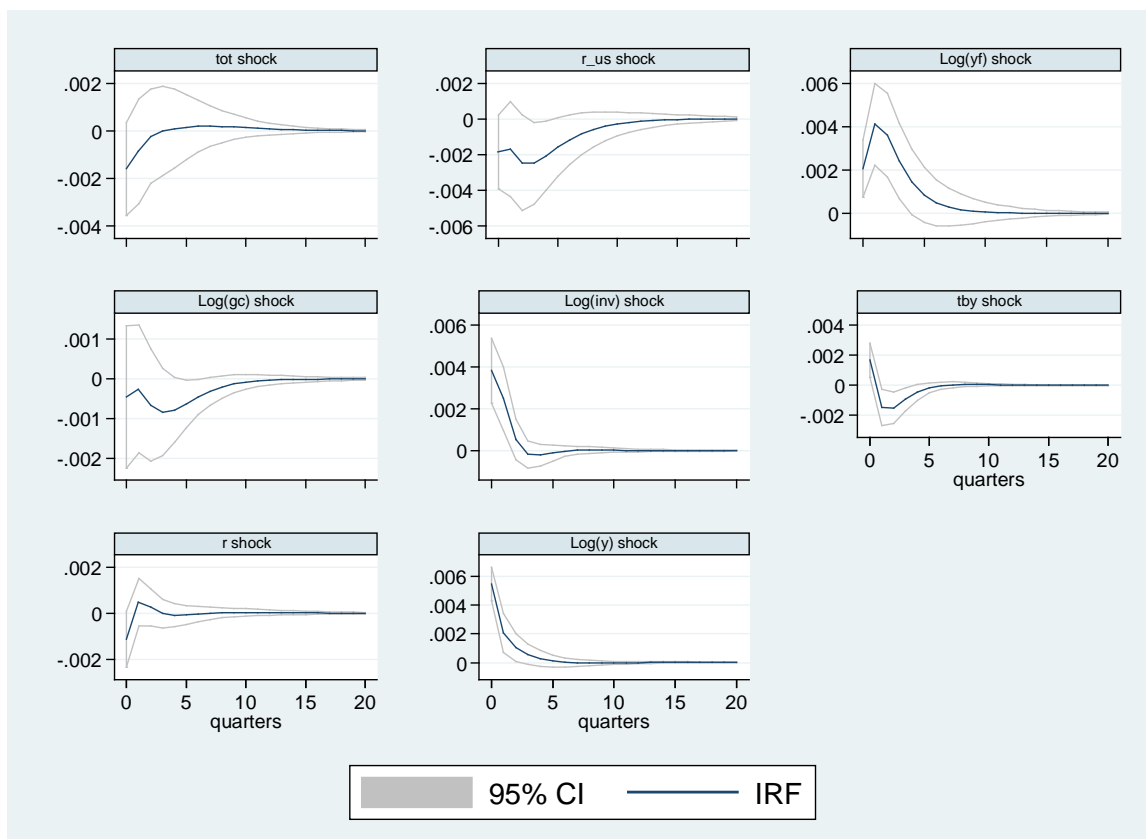
### 3. Impulse response functions

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).

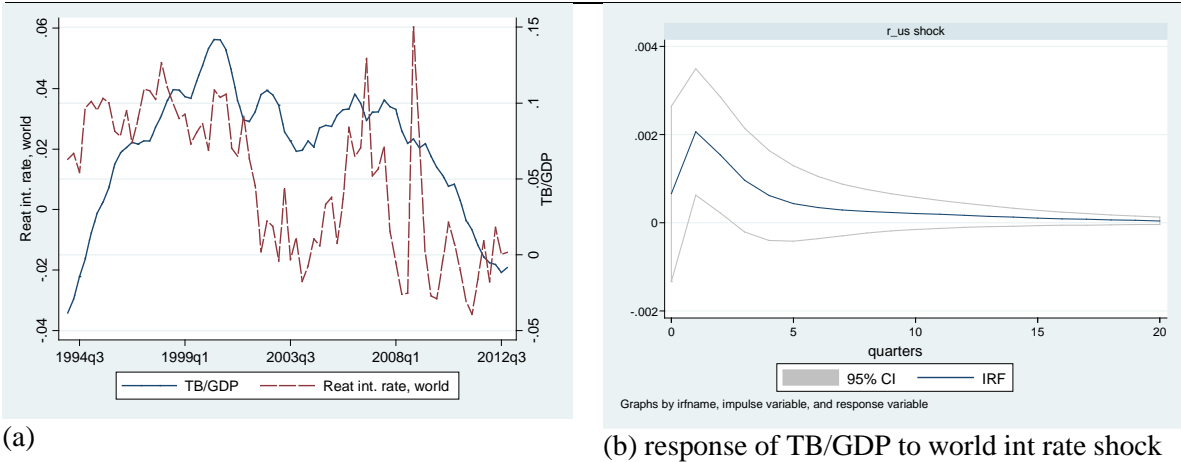
**Figure 1.3: Impulse Responses of Output to Various Shocks**



*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**



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 rates 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.<sup>9</sup> 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.<sup>10</sup> Thus it is possible that some of the effects of commodity price changes on Paraguayan economy are subsumed in the world interest rate shocks.

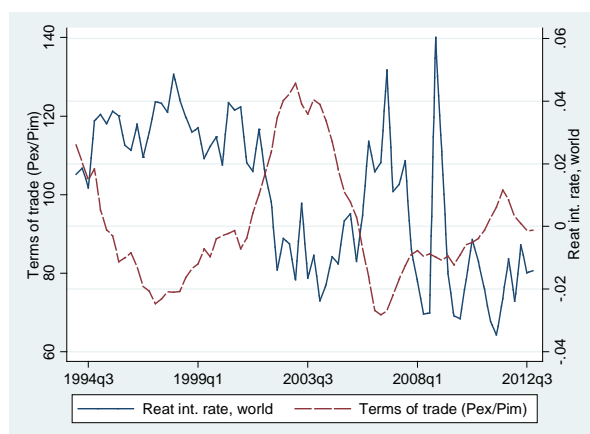
To illustrate the interrelation between the two variables, consider Figure 1.5 which plots the U.S. real T-bill rate together with the terms of trade variable. It is easy to see the negative relationship between the two. Indeed, the correlation is equal to -0.44 during our sample period. These results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

<sup>9</sup> For further empirical analysis of the relationship between international interest and commodity prices see Byrne, Fazio, and Fiess (2012) and Frankel and Rose (2010).

<sup>10</sup> 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.

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 the 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 the 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 allow us to explore this hypothesis in detail.<sup>11</sup> 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 the Paraguayan economy, a detailed investigation of them is left for future work.

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.

<sup>11</sup> These numbers are computed using annual Balance of Payments data from the Banco Central del Paraguay.



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 rates leads to a contraction in GDP but the effect is short-lived.

#### 4. 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 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. 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.<sup>12</sup>

<sup>12</sup> 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

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.

## 5. 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

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

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

---

response to these. Podpiera and Tulin (2012), focusing on the role of financial external variables find a relevant role of external factors.

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 feeds back 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 pro-cyclical 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 our identification assumption, but lead to a small decline in agricultural GDP in the year following the shock.

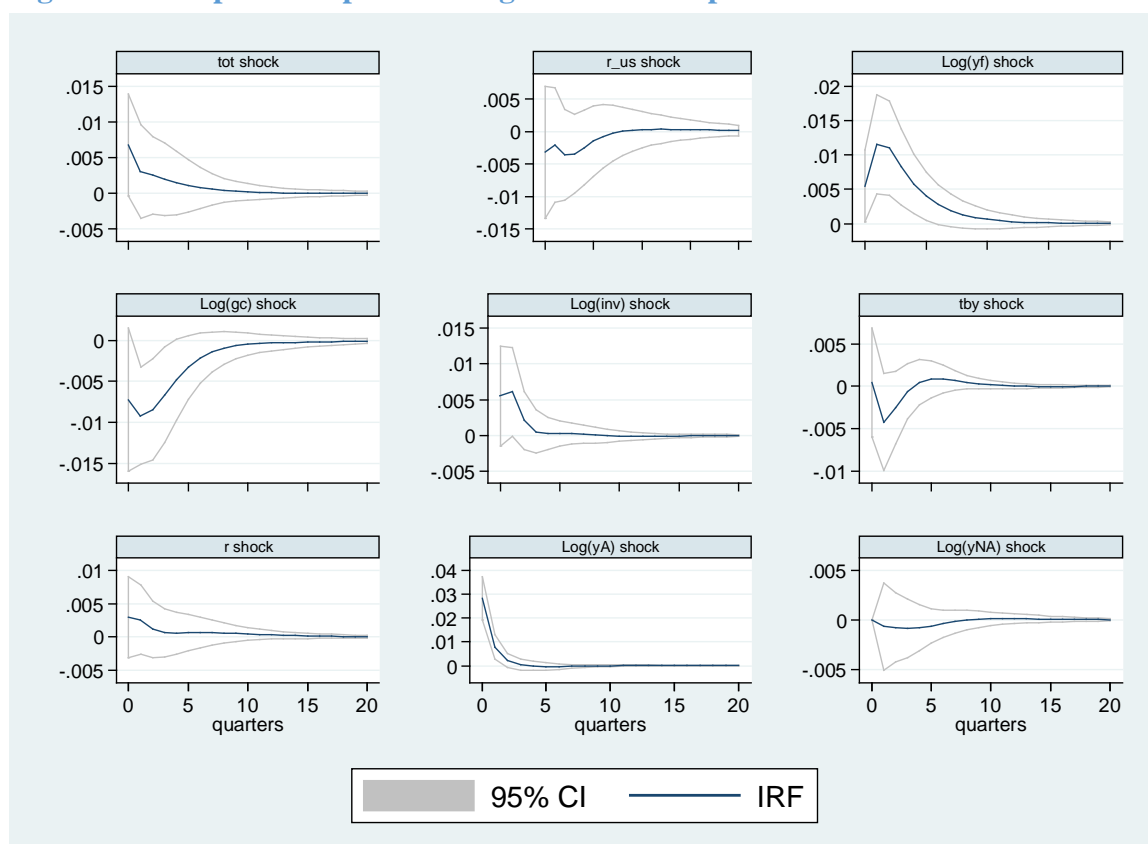
Impulse response functions for the effects of various shocks on non-agricultural GDP are presented in Figure 8. These results show that the effects of the external shocks on non-agricultural output are very much in line with our findings for the aggregate GDP. Specifically, shocks to the world interest 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, in such case, will raise the relative price of non-agricultural goods, leading to a negative wealth effect 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**



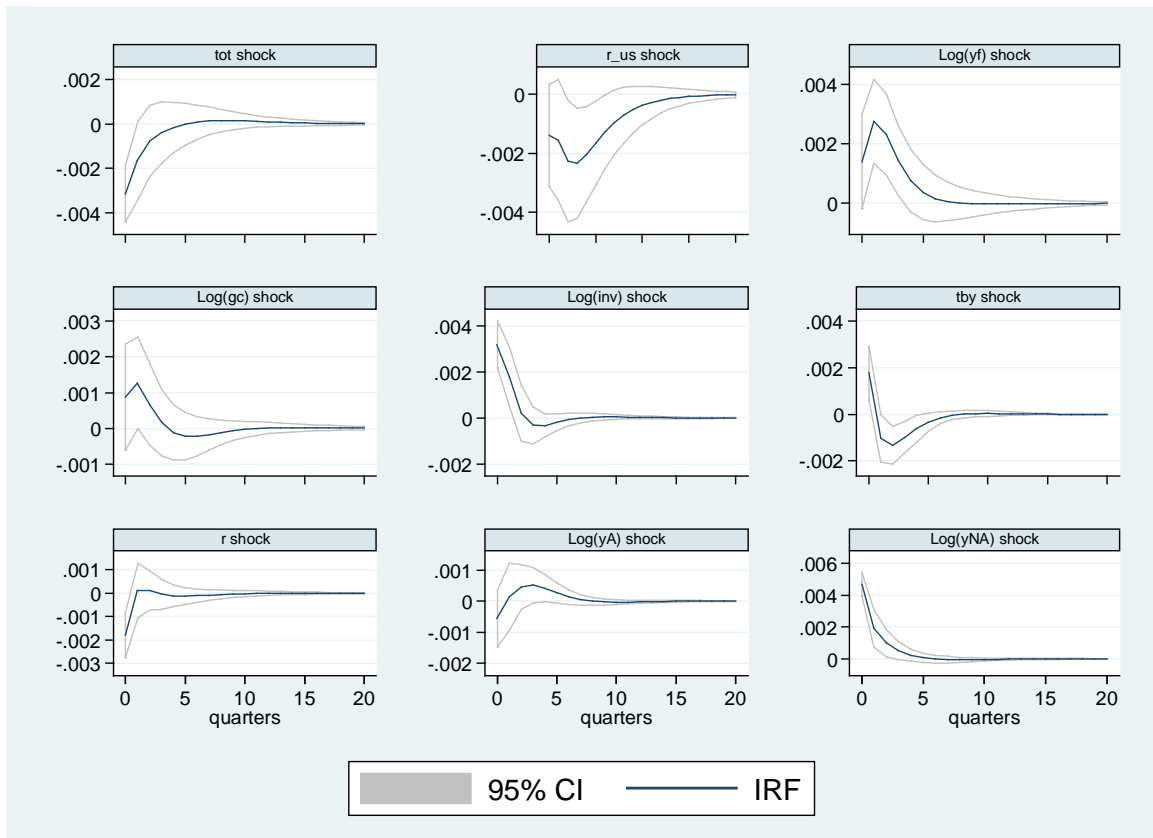
Source: authors.

**Table 5: Variance Decomposition of Agri and Non-Agri GDP Volatility**

<b>Agri</b>											
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
<b>Non-Agri</b>											
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.<sup>13</sup> Domestic shocks were significantly more important for agricultural volatility, with shocks to agricultural output itself accounting for more than 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).<sup>14</sup> 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, the Paraguayan agricultural sector has become more sensitive to them. This could be the result of a growing concentration of Paraguayan agricultural production in a few commodities, such as soy beans and livestock.<sup>15</sup> Less diversified production structure makes the 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.

## 6. 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, 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

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<sup>13</sup> As before, we mainly focus on the variance decomposition results at the 12 quarters horizon.

<sup>14</sup> 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.

<sup>15</sup> 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.

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

$$\begin{aligned} \max \quad & \sum_{t=0}^{\infty} \beta^t u(c_t, 1 - l_t) N_t \quad \text{subject to} \\ (1 - \tau_{k,t}) r_t k_t + (1 - \tau_{l,t}) w_t l_t &= c_t + x_t, \\ N_{t+1} k_{t+1} &= [(1 - \delta) k_t + x_t] N_t, \\ c_t &\geq 0 \quad \text{for all } t \text{ and in all states} \end{aligned}$$

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.<sup>16</sup>  $1 - \tau_{k,t}$  and  $1 - \tau_{l,t}$  are time-varying capital wedge and labor wedge, respectively. The capital wedge acts as a tax on rental payments to capital and thus interferes in the inter-temporal consumption-saving decision of the household. The 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, this is unrealistic in an 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:

$$\begin{aligned} Y_a &= K_a^v (z_a L_a)^\mu \\ Y_{na} &= K_{na}^\alpha (z_{na} L_{na})^{1-\alpha} \end{aligned}$$

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<sup>16</sup> We use total population numbers since working-age population data is not easily available.

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  $j=a, na$ .<sup>17</sup> The final good is produced by combining two intermediate goods:

$$Y = (\widehat{Y}_a)^\varphi (\widehat{Y}_{na})^{1-\varphi}$$

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:

$$N_t k_t = K_{a,t} + K_{na,t}$$

$$N_t l_t = L_{a,t} + L_{na,t}$$

We assume the following functional form for the utility function:

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

where  $\psi$  is the relative weight of leisure in the utility function.

---

<sup>17</sup> Note that the production function for agricultural good is functionally equivalent to  $Y_a = AK_a^\nu L_a^\mu$ , 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:  $(1 - \tau_{l,t}) = \frac{\psi \tilde{c}_t}{(1-l_t)w_t}$  (1)

2. Capital wedge:  $(1 - \tau_{k,t}) = \left[ \frac{\tilde{c}_{t+1}}{\beta \tilde{c}_t} - (1 - \delta) \right] \frac{1}{r_t}$  (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:  $z_{a,t} = \left[ \frac{\tilde{y}_{a,t}}{\tilde{K}_{a,t}^\alpha \tilde{L}_{a,t}^{1-\alpha}} \right]^{1/\mu}$  (4a)

Efficiency wedge in non-agriculture:  $z_{na,t} = \left[ \frac{\tilde{y}_{na,t}}{\tilde{K}_{na,t}^\alpha \tilde{L}_{na,t}^{1-\alpha}} \right]^{1/(1-\alpha)}$  (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  $\gamma_n$  to denote population growth and  $\gamma_z$  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. 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 6: Model Parameters**

	<b>parameter</b>	<b>value</b>
$\psi$	weight of leisure in utility	3.36
$\beta$	subjective discount factor	0.99
$\delta$	depreciation rate	0.08
$\gamma_n$	population growth rate	2.1%
$\gamma_z$	productivity growth rate	-1.0%
$\alpha$	capital share in non-agriculture	0.35
$v$	capital share in agriculture	0.25
$\mu$	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.<sup>18</sup> We estimate average annual population growth to be equal to 2.1 percent during 1991-2010 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.

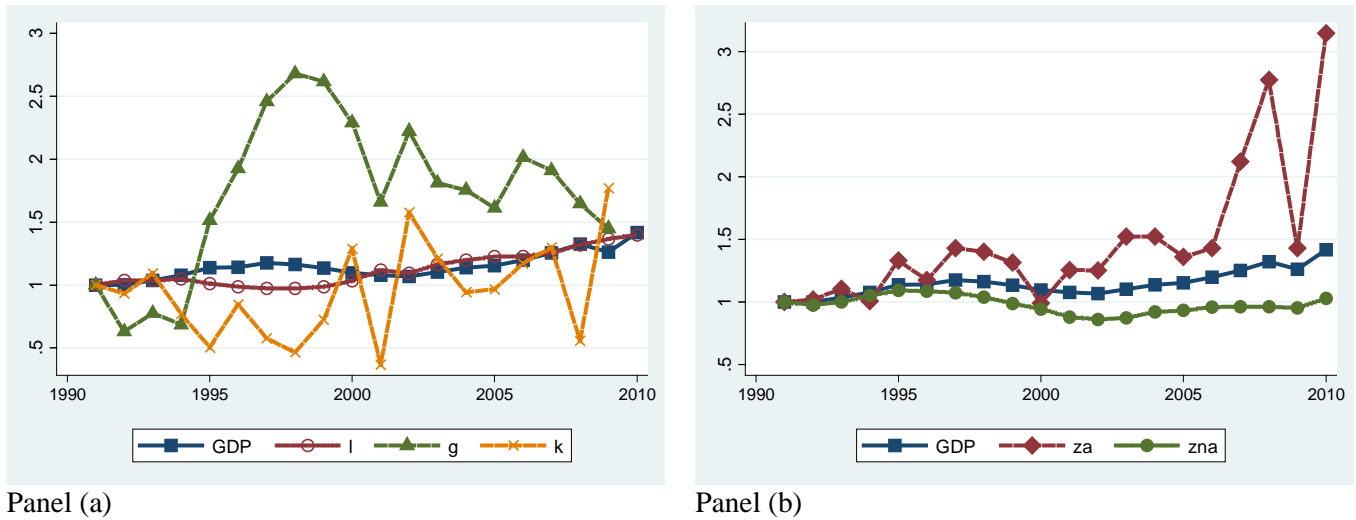
Parameters governing production technology are calibrated as follows. We assume that the labor share in non-agriculture is equal to 0.65, while the capital share in non-agriculture is equal to 0.35. These numbers are standard in developed countries and are close to the estimates for Ecuador (labor share = 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.<sup>19</sup> 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 1.8.

<sup>18</sup> The depreciation rate for the capital stock is taken from Acosta-Ormaechea and Dabán Sánchez (2011).

<sup>19</sup> 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



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. 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 are 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 (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.<sup>20</sup> 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 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. 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.

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<sup>20</sup> These numbers are for wages measured in US dollars.

**Table 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 Latin America and the Caribbean.

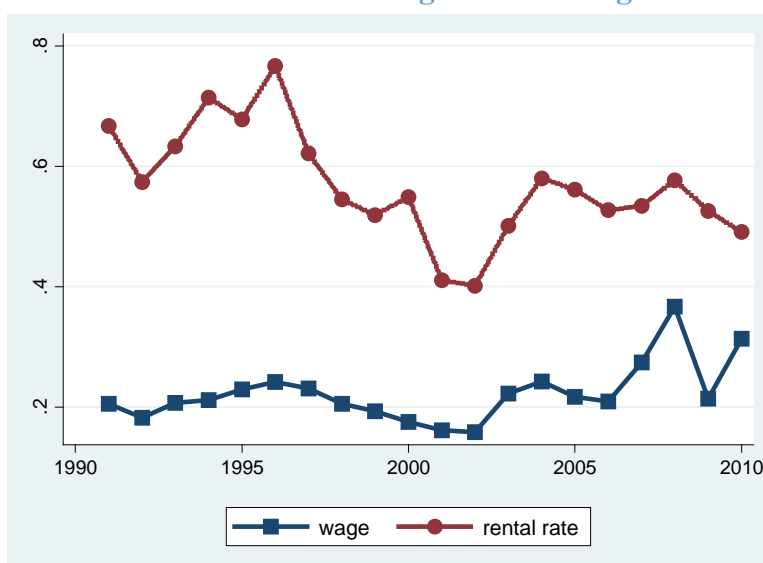
Government spending and the trade balance wedge computed from equation (3) show little change through the early 1990s, but increase in the late 1990s and remains well above 1 throughout the 2000s. The increase reflects mainly the improvement in the Paraguayan net exports starting mid-1990s. Namely, in 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, 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 the Paraguayan economy.

## 7. Conclusions

In this paper we document and analyze the sources of macroeconomic volatility in Paraguay during 1991-2012. 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 the Paraguayan economy: with labor market distortions declining, firms' access 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 the 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									
		Can the workweek for a single worker extend to 50 hours per week (including overtime) for each year to respond to a seasonal increase in production?	Are there restrictions on "weekly holiday" work?	Are there restrictions on "weekly holiday" work?	What is the maximum number of working days per week?	What is the maximum number of working days per year?	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 before dismissing a collective worker?	Must the employer notify or consult a third party before dismissing a collective worker?	Is there a retraining or reassignment obligation before an employer can make a collective worker redundant?	Are there priority rules that apply to redundancy dismissals or lay-offs?	Are there priority rules applying to redundancy dismissals or lay-offs?	Are there priority rules applying to redundancy dismissals or lay-offs?	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		
year	Are fixed-term contracts prohibited for permanent tasks?	What is the maximum cumulative duration of a fixed-term relationship (in months), including all renewals?	Are there restrictions on night work?	Are there maximum number of working days per week?	Are there maximum number of working days per year?	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 worker?	Does the employer need the approval of a third party in order to dismiss one worker?	Must the employer notify or consult a third party before dismissing a collective worker?	Must the employer notify or consult a third party before dismissing a collective worker?	Is there a retraining or reassignment obligation before an employer can make a collective worker redundant?	Are there priority rules that apply to redundancy dismissals or lay-offs?	Are there priority rules applying to redundancy dismissals or lay-offs?	Are there priority rules applying to redundancy dismissals or lay-offs?	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	
2010	Yes	No Limit	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	Yes	5.0	7.5	10.0	2.1	10.7	42.9
2011	Yes	No Limit	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	Yes	5.00	7.50	10.00	2.14	10.71	42.86
2012	Yes	No Limit	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	Yes	5.00	7.50	10.00	2.14	10.71	42.86
2013	Yes	No Limit	Yes	No	6	12	18	30	Yes	Yes	Yes	Yes	Yes	No	Yes	5.00	7.50	10.00	2.14	10.71	42.86