Expectations Decoupled: Inflation and Exchange Rate Dynamics in Argentina and Venezuela

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Expectations Decoupled: Inflation and Exchange Rate Dynamics in Argentina and Venezuela

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Abstract

This paper delves into the complex relationship between high exchange rate depreciation and high inflation expectations in Emerging Market Economies, explicitly focusing on the cases of Venezuela and Argentina. Employing a Bayesian-modeled Dynamic Stochastic General Equilibrium (DSGE) framework, we challenge the conventional Rational Expectations assumption by embracing Adaptive Learning. Our research uncovers that exchange rate expectations are pivotal in driving short-term deviations in exchange rates, leading to "bubbles" in inflation dynamics significantly contributing to hyperinflation episodes. This unconventional approach emphasizes the need to incorporate learning expectation dynamics into macroeconomic models. Our study provides insights into the consequences and implications of countries like Venezuela and Argentina lacking an inflation-targeting regime and, therefore, having difficulties in not achieving a stable nominal anchor in the economy.

1 Introduction

One of the most essential economic contributions undoubtedly is Rational Expectations (Lucas, 1972). Since its conception, economists have used it thoroughly, especially in solving DSGE models. But, although its accuracy explains many economic phenomena, some are so complex that this tool can't explain them well. Among those phenomena, hyperinflation is one of the hardest to explain with only RE. Inflation has long been a persistent challenge faced by numerous countries throughout history. In the late decades of the 20th century, Latin America, in particular, grappled with recurring high inflation episodes. These tumultuous times highlighted the adverse impact of inflation, particularly hyperinflation, on the most vulnerable households as their purchasing power dwindled without adequate safeguards or alternatives. In the present day, most of these nations have successfully navigated away from this problem and have come to appreciate the significance of maintaining price stability and low inflation rates. However, two countries, Venezuela and Argentina, continue to grapple with inflation as a pressing issue. The question arises: What are the underlying causes of these ongoing episodes?

Milton Friedman expressed one of the most important insights about inflation when he said, "Inflation is always and everywhere a monetary phenomenon." In his book *Rational Expectations and Inflation*, Thomas Sargent later expanded upon this idea, which argued that persistently high inflation is primarily a fiscal problem, with central banks playing a supporting role. This means that the source of inflation is most often linked to central banks and their commitments. While this claim has been praised and criticized, it is widely accepted as an effective means of combating inflation, as demonstrated by the policies of most central banks in LATAM, which incorporated inflation-targeting regimes and floating exchange rate regimes. The only two countries that still lack these policies are Venezuela and Argentina.

In this paper, we delve into the issue of hyperinflation and chronic inflation. This problem, as mentioned before, has plagued many countries, particularly Latin America and Eastern Europe, with emblematic episodes occurring in the 1980s. Even today, some countries, such as Venezuela and Argentina, suffer this hardship. Venezuela is the latest example of a country entering a hyperinflationary path, and Argentina is on the brink of following suit. A pertinent and justifiable question that both researchers and readers alike may ask is why these countries are facing such problems. Can the explanations provided by Mr. Friedman and Mr. Sargent suffice to clarify these issues?

Inflation and foreign exchange rates are critical macroeconomic variables significantly impacting emerging market economies. Countries like Venezuela and Argentina, which have experienced severe and uncontrollable inflation, face complex dynamics concerning these two variables. These countries lack a clear inflation goal targeting policy and often have a black or parallel market for foreign currency with a price different from the official rate that their central bank publishes. Also, as we will show in our research, both countries face fiscal dominance, which could spark inflation and depreciation.

This paper aims to develop a theoretical framework to understand these two countries' foreign exchange rates and inflation dynamics. As Marcet and Nicolini (2003), we analyze how a rational expectations model cannot quantitatively replicate Argentina and Venezuela's recent exuberant inflation dynamics. In contrast, adaptative learning is better equipped to describe these dynamics. In comparison to Marcet and Nicolini, we note that in these recent episodes, the official exchange rate does not provide a nominal anchor to the economy to achieve price stability. Moreover, fiscal and external imbalances can interact with the formation of expectations, generating a vicious circle between inflation and exchange rate devaluation, magnifying the dynamics of inflation and the exchange rate. These magnifying dynamics resemble the recent patterns in Argentina and Venezuela regarding inflation and the exchange rate, something that a model where the expectations' formation is based on rational expectations cannot replicate. We include adaptive learning in the form of steady-state learning. This powerful tool can outperform other models in fitting empirical moments. Using this scheme, we analyze Venezuela and Argentina's inflation dynamics and foreign exchange rates.

By calibrating our model to resemble the economies of Argentina and Venezuela, we analyze the dynamics of inflation and foreign exchange rates with different exchange rate configurations to understand recent trends. Our findings highlight the importance of considering exchange rate expectations and adaptive learning in understanding inflation dynamics in emerging market economies.

Our hypothesis suggests that two economic channels directly impact inflation expectations - internal (Fiscal Deficit) and external (Trade Balance Deficit) imbalances. Fiscal Deficit has been studied in detail and is linked to inflation as a monetary phenomenon. This concept is developed under fiscal dominance - a situation where financial authorities (central banks) are not independent and are instead used to fund any fiscal deficits run by the government. When governments cannot pay for all their expenses, they appeal to the Central Bank to print the money needed to fulfill their duties. In section 3, we show that Argentina and Venezuela are incurring this problematic behavior. Literature also supports our claim on fiscal dominance for these two countries, including Saboin (2018) for Venezuela and Fernandez (2020) for Argentina.

The second channel is related to the fact that these countries have experienced a rapid decline in their trade balance, resulting in a severe devaluation of the Argentinian peso and Venezuelan bolivar. This mechanism is vital because if agents expect more depreciation in the future, then prices of imported goods could rise. Previously, this channel was overshadowed by the former fiscal deficit channel. However, there are papers like Burdekin and Burkett (1996) pointing out that the hyperinflation episode in Germany could have been provoked by two main forces: Exchange Rate devaluation and money as a source of deficit financing. In addition to this paper, other literature that studies this kind of phenomenon strongly relies on the internal imbalance rather than the external one.

This paper explores how the dynamics between depreciation and expectations formations impact inflation dynamics in Venezuela and Argentina. Our main goal is to gain insight into the root causes of chronic inflation and provide robust policy recommendations for managing inflation expectations to achieve long-term price stability. We reviewed the related literature on exchange rate pass-through, hyperinflation dynamics, and learning literature. We develop and estimate, using Bayesian techniques, a model that can be solved with rational or adaptive expectations. Our findings suggest that exchange rate expectations are the root cause of short-term or non-fundamental deviations of the exchange rate that affect inflation.

Furthermore, we found that hyperinflation episodes can be explained by the role of expectations in forming inflation bubbles. Our study highlights the importance of incorporating expectations and learning dynamics into macroeconomic models. It provides essential insights into emerging market economies' complex inflation dynamics and foreign exchange rates.

The paper is presented as follows. We discuss what the literature has found in section 2, Section 3 provides information and some stylized facts about or targeted economies, section 4 builds the RE and AL model, which will be estimated and calibrated with Bayesian techniques in 5. We present our results in section 6. We conclude in section 7.

2 Related Literature

We found three main areas of related literature that will help develop our paper: Exchange Rate Pass-Through, Hyperinflation dynamics, and Learning Literature.

The exchange rate pass-through measures how movements in the exchange rate are passed through inflation. Various studies, such as those by Edwards (2006) and Berument and Pasaogullari (2003), are particularly relevant to our topic because they study the co-existence of two exchange rate regimes (official and black or parallel) and their impact on inflation during depreciations, which applies to the countries we are studying. Additionally, Bambi and Eugeni (2021) is an important source in this literature. They show that exchange rate expectations are a crucial factor in short-run or non-fundamental deviations of the exchange rate that affect inflation. Compared to this paper, which relies on sunspot equilibrium, our paper uses learning to study the link between exchange rate expectations and inflation dynamics. Finally, Sumata (2010) and Sirag (2021) have shown the effect of exchange rate depreciations on inflation using empirical and theoretical frameworks. Their findings include that exchange rate pass-through significantly impacts inflation when the economy has an official and parallel exchange rate. This phenomenon is because official exchange rates are usually fixed at a meager price, pushing demand up while supply is restored. If agents in the economy turn to the black market to demand foreign currency to import or other transactions, the price of imported goods, among others, rises as the black rate increases.

A significant paper to consider in hyperinflation dynamics and formation is Cagan (1956), the first paper to rationalize a model capable of recreating hyperinflation episodes. The findings complement the work of Sargent et al. (1973), Sargent and Wallace (1987), and Sargent (2015), where they reviewed hyperinflation episodes in Latin America and Eastern Europe in the 1980s. These papers indicate that expectations are the main factor in forming inflation bubbles. The logic is as follows: In an economy that uses currency as a means of purchase, the demand for the currency depends heavily on its worth today and how much it will be worth tomorrow. As long as inflation expectations are not anchored, this variable will be the primary driver for inflation. What are the reasons that could start this spiral? This literature points out that it is none other than fiscal deficits. The Fiscal Dominance and The Fiscal Theory of Prices are the primary theories that help explain how internal imbalances are produced. These are only some of the approaches to determine hyperinflation. There is also the Post-Keynesian point of view (see Charles and Marie (2016)). Although this paper disregards the origin of hyperinflation in Venezuela for fiscal motives, it suggests that having a system with a fixed exchange rate can lead to the formation of hyperinflation episodes.

According to a study by Burdekin and Burkett (1996), there are two significant drivers behind hyperinflations: internal and external deficits. A recent paper by Schmitt-Grohé and Uribe (2023) explores how a government with fiscal dominance can fund its obligations by having a fixed exchange rate if there is a commercial surplus (more exports than imports). However, this policy could have severe consequences if a sudden shock impacts this delicate equilibrium.

Expectations are crucial in hyperinflations and are impossible to model without making challenging assumptions. According to Buiter (1987) and Evans and Yarrow (1981), it is nearly impossible to replicate hyperinflations assuming Rational Expectations (RE). This is where the Adaptive Learning (AL) literature comes in. In particular, Marcet and Nicolini (2003) introduces two key breakthroughs: firstly, Learning Dynamics models have better empirical fit, and secondly, RE is too restrictive to simulate or reproduce critical events in a hyperinflationary episode. The authors suggest that AL is a generalization of RE and, with the right conditions, can converge into RE. [1]. Our approach is based on steady-state learning, a technique used by Eusepi et al. (2018).

Adaptive learning is a powerful tool that can outperform other models in fitting empirical data (see Slobodyan and Wouters (2012), Milani (2007), Caputo et al. (2010), etc.). The basic idea is that Recursive Least Squares can be used in DSGE models to capture the essential non-linearities, thereby improving their explanatory power. However, relying on Rational Expectations assumptions in conventional models can be problematic, especially given recent events such as the COVID-19 pandemic and inflation breakthrough. Economists are exploring alternative approaches like those proposed by Cole and Milani (2021), Eusepi et al. (2018), Higgins (2023), and Ilabaca et al. (2020), who have deviated from RE using Adaptive Learning or other behavioral methods. Our findings are consistent with those of Carvalho et al. (2023), which suggest that unanchored expectations can cause more substantial depreciation and inflation movements.

Our contribution to Exchange Rate Pass-Through, Hyperinflation dynamics, and Learning literatures lies in developing a DSGE model that combines internal and external unbalanced channels. Unlike traditional models, our model does not rely on rigidities and PPP assumptions but allows fiscal and trade balance deficits to influence prices. In addition, we incorporate the co-existence of two exchange rates, as is observed in the economies we are studying. Furthermore, our model uses the formation of expectations through an endogenous mechanism, achieved by introducing Steady-State Learning.

3 Stylized Facts and Characteristics of Targeted Economies

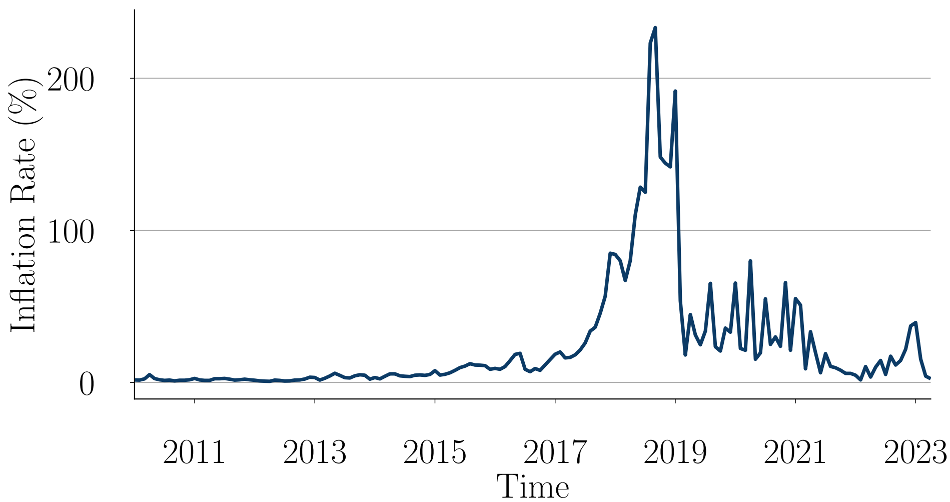
This section presents some evidence and stylized facts from Venezuela and Argentina. We will demonstrate a correlation between exchange rate depreciation and the inflation rate. Additionally, we will highlight the relationship between inflation bursts, fiscal deficit bursts, and trade imbalance bursts. We aim to

[1] This is in line with the findings of Evans and Honkapohja (2009), Evans and Honkapohja (2011), Evans and Honkapohja (2012), Bomberger and Sargent (1999), and Evans and McGough (2020), who all conclude that AL under E-stability converges to an ergonomic distribution Rational Expectations Equilibrium (REE)To learn more about the principle of E-stability and how it connects to REE, please refer to Evans and Evans and Honkapohja (2012) for primary references.

establish some stylized facts about these economies and provide an overview to build a model that can resemble some of them and provide insights.

3.1 Venezuela

Venezuela is currently facing numerous economic challenges [2]. In 2018, Venezuela became the 57th and final country to experience hyperinflation, as recorded by Hanke and Bushnell (2017) in their World Hyperinflation Table. Despite once being a prosperous nation, Venezuela is now grappling with a severe economic crisis where prices continue to rise every month. Figure 1 illustrates the month-to-month inflation rate from January 2010 to May 2023. This figure shows an exponential price increase, particularly in 2018, reaching a peak of around 200% per month. During this period, prices more than doubled every month. In Section 5, we will demonstrate that our estimates indicate Venezuela entered a hyperinflation trend in May 2018 due to the rapid and violent surge in the inflation rate recorded at that time.

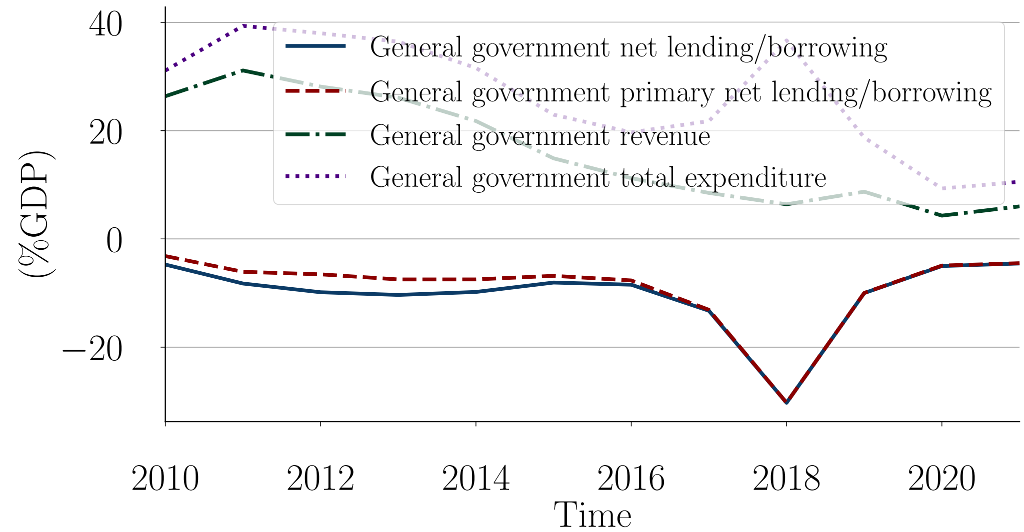


Data from Data until 2017M01 is from BCV: bcv.org.ve/estadisticas/consumidor, onwards data is from Observatorio Venezolano de Finanzas: observatoriodefinanzas.com/inpc-form/

Figure 1: Venezuela MoM Inflation Rate. From 2017 to 2023, we used data from the Observatorio Venezolano de Finanzas, an independent institution. Before that, we used data provided by the Venezuelan Central Bank.

There is ample evidence that suggests that the hyperinflation in Venezuela was caused by the fiscal deficit (as stated in Saboin (2018) study). To see this, we plot in figure 2 the yearly general fiscal deficit, primary fiscal deficit, general expenditure, and general revenue from 2010 to 2021. At the beginning of 2018, the budget deficit was around 10% of the country's GDP. By the end of the year, it had surged to 28% of the GDP, as illustrated in figure 2.

[2] Restuccia (2018) provides an excellent account of the country's economic decline



Data is from IMF: imf.org/en/Publications/WEO/weo-database/2023/April

Figure 2: Venezuela Fiscal Deficit. Data were taken from the IMF.

The relationship between inflation and fiscal deficit is evident in their comovement. Figure 3 plots the year-to-year inflation rate vs budgetary deficit from 2010 to 2021. It shows that inflation rises as soon as the fiscal deficit does.

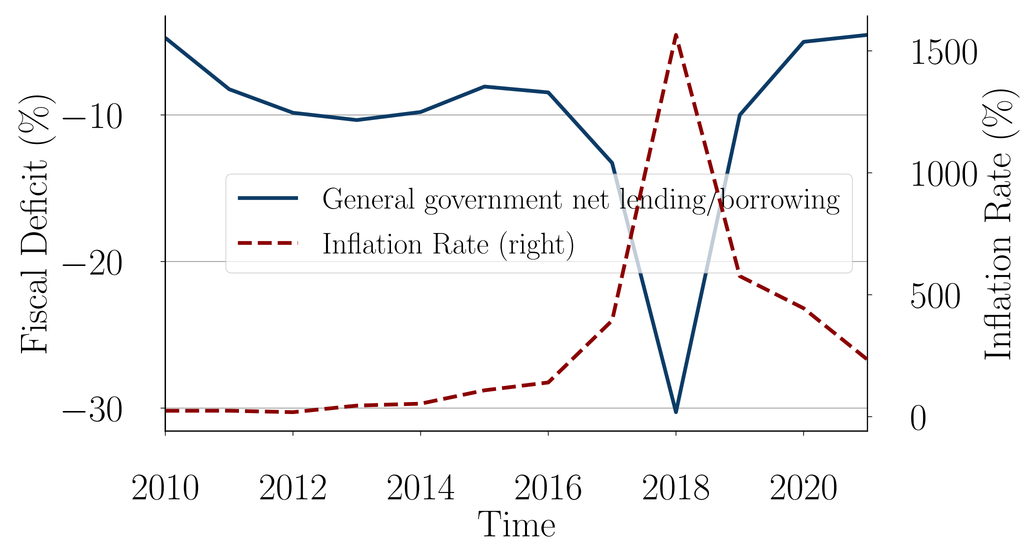


Figure 3: Venezuela Inflation Rate YoY vs. Fiscal Deficit. The month-to-month inflation rate axis is plotted on the right axis. Fiscal deficit as a percentage of GDP; its axis is plotted at the left axis.

Venezuela has been facing a significant challenge of inflation and depreciation of its currency, the Bolivar. To support the claim, we plot in 4 the month-to-month inflation rate, official exchange rate, and parallel exchange rate from June 2010 to May 2023. As shown in figure 4. In 2003, Venezuela introduced a fixed exchange rate policy against the US dollar. This required Petroleos De Venezuela Sociedad Anonima (PDVSA) -the state-owned oil producer company- to sell its US dollar earnings to the Central Bank of Venezuela (BCV) by law. The BCV then supplied US dollars to the economy through various mechanisms but with annual quotas on purchases of US dollars. This restriction led to a parallel "black" market, which served multinational firms, national companies, and individuals seeking more US dollars than the government allowed. The black market became increasingly vital as inflation surged.

In addition, we plot Venezuela's yearly trade balance, imports, and exports from 2010 to 2021. Exports declined, and inflation surged as economic conditions worsened, as seen in figure 5. This led to a higher demand for US dollars, especially around 2013. Websites such as Dolartoday started publishing daily black market exchange rates, serving as a reference for transactions across Venezuela. They collected data from exchange houses near the country's borders and used them as proxies for the Bolivar-to-US dollar exchange rate, known as "Dolar Cucuteño."[3]

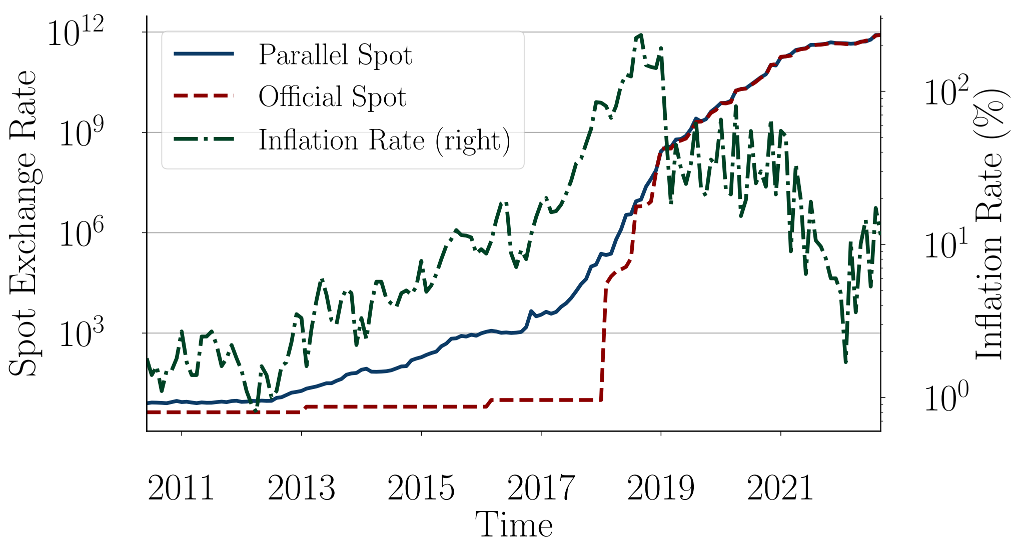
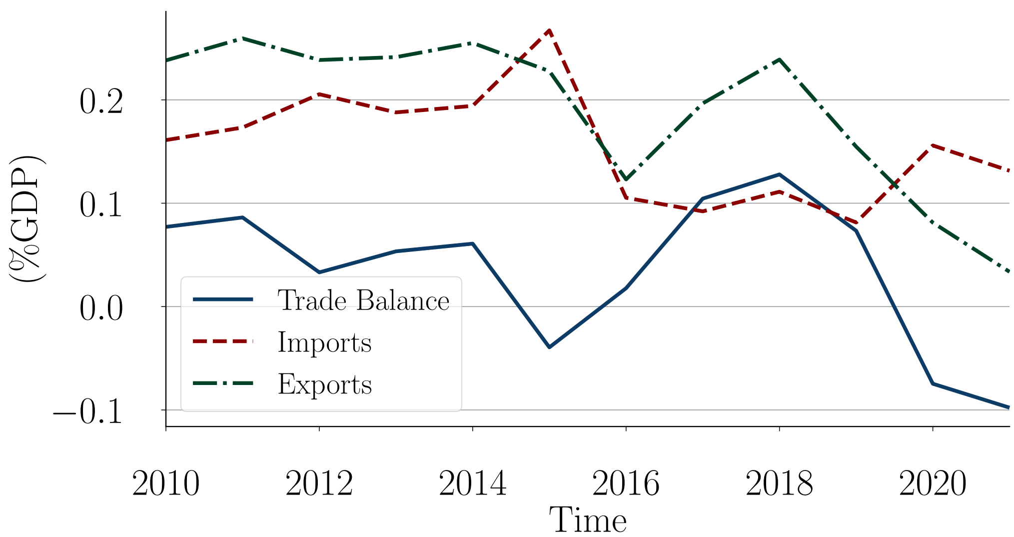


Figure 4: Venezuela Nominal Spot Exchange Rate vs. MoM Inflation Rate. The month-to-month inflation rate axis is plotted on the right axis. The official spot and parallel spot are plotted on the left axis. Official rate data are taken from the FRED database, and parallel rate data are from dolartoday.com. We use the last value observed in the month as the monthly exchange rate. The scale of the y-axis is in log.

[3]For further interest in the exchange rate regimes and their dynamics, please refer to Malone and Horst (2010).



Data is from IMF: data.imf.org/?sk=9d6028d4-f14a-464c-a2f2-59b2cd424b85

Figure 5: Imports as a percentage of GDP. This plot was built with data from IMF.

Initially, Venezuela's official and parallel rates were almost identical. However, over time, the parallel spot price began to deviate from the official rate as depicted in figure 4. By 2012, the parallel rate had more than doubled compared to the official rate, and this trend continued. As the official rate remained fixed, it could not keep up with the continuously depreciating parallel rate. Eventually, in 2018, the difference between the two rates became so significant that the government had to abandon the fixed exchange rate regime and switch to a dirty floating system. This new policy brought the exchange rate closer to the parallel rate. Finally, in May 2019, the government changed the exchange rate to a floating system and successfully unified the two rates.

Analyzing fiscal deficit and inflation is possible by looking at the exchange rate and inflation. As shown in Figure 4, there is a clear correlation between depreciation and inflation rate. Inflation tends to increase when the parallel rate deviates from the official rate. However, inflation is not necessarily affected when the official rate rises similarly to the market.

3.2 Argentina

Argentina is currently facing severe economic challenges[4]. Although its inflation rate has not yet reached Venezuela's levels, it is the second-highest in Latin America.

Figure 6 shows the month-to-month inflation rate for Argentina from January 2010 to May 2023, which has become more volatile and is slowly increasing. The maximum inflation rate was reached in November 2018, and it became evident that inflation had entered an upward trend. Before this peak, inflation was relatively stable, with no noticeable upward trend. In Section 5.2, we estimate that Argentina may be headed toward a hyperinflationary path unless the situation is contained.

[4]For a better understanding of the Argentinian crisis, please refer to Buera and Nicolini (2019)

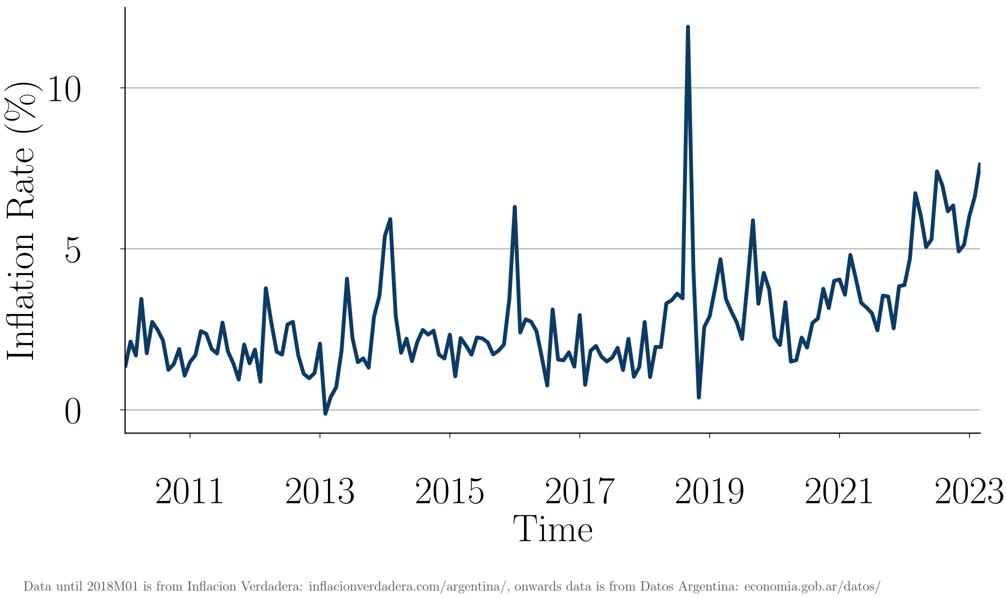
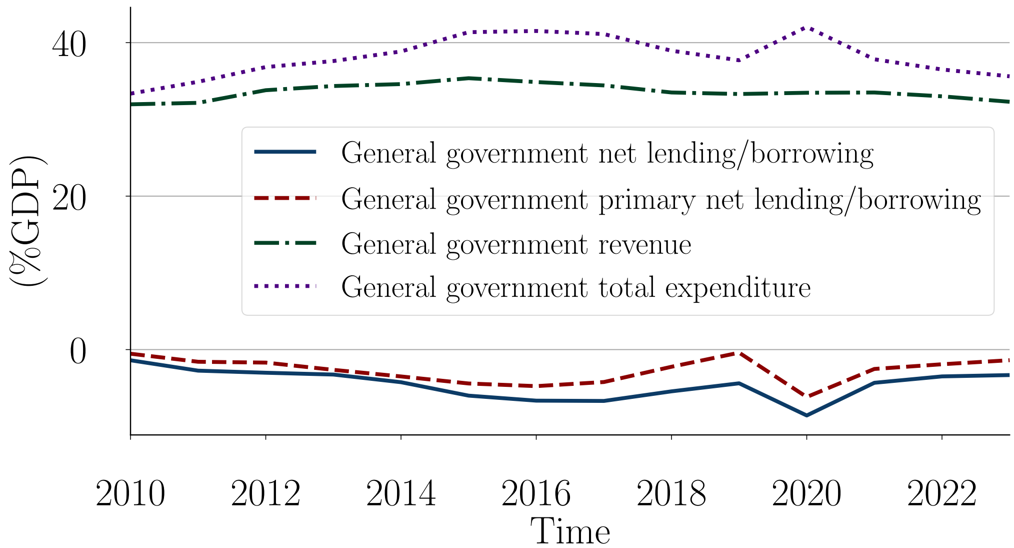


Figure 6: Argentina MoM Inflation Rate. Data from Inflacionverdadera.com until 2018. Then, we use data from the BCRA.

We plot the fiscal general deficit, primary deficit, general revenues, and general expenditures from 2010 to 2021 versus the year-to-year inflation rate. As we can see from figure 7, the fiscal situation in Argentina has taken a drastic turn for the worse. The country is experiencing fiscal dominance similar to that seen in Venezuela. The fiscal deficit has risen to approximately 10% of GDP, and as a result, inflation is starting to increase. This is a significant concern, as it suggests that deficit shocks can lead to a rise in inflation, potentially even reaching hyperinflation levels. This is further supported by figure 8.



Data is from IMF: imf.org/en/Publications/WEO/weo-database/2023/April

Figure 7: Argentina Fiscal Deficit. Data were taken from the IMF.

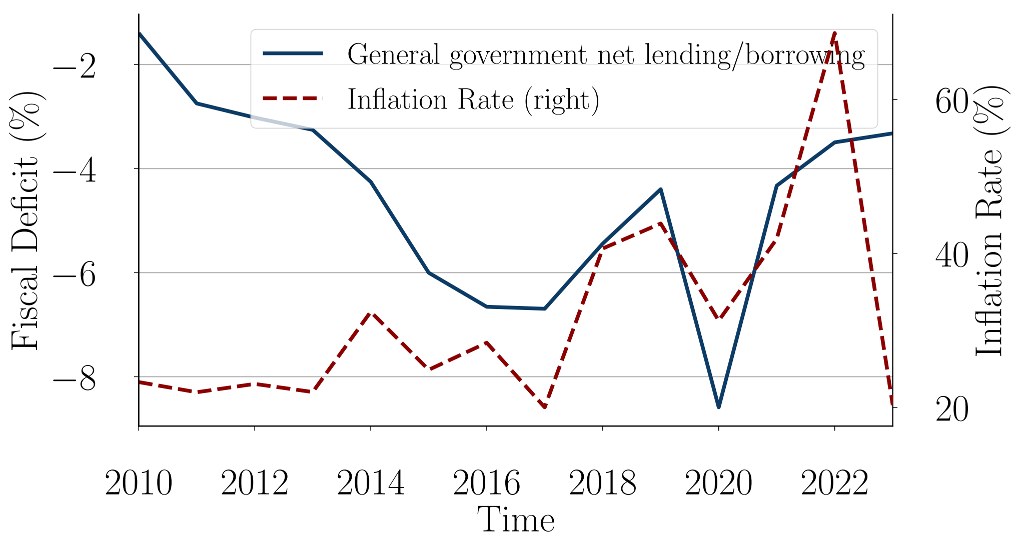


Figure 8: Argentina Inflation Rate YoY vs. Fiscal Deficit. The month-to-month inflation rate axis is plotted on the right axis. The fiscal deficit is a percentage of GDP; its axis is plotted on the left.

The exchange rate situation in Argentina is unique. Officially, the country operates a floating exchange rate policy, but experts classify it as a special regime owing to its intricacies. The Banco Central de la Republica de Argentina (BCRA) has defined 13 exchange rates, each with its own rules and targeted at specific buyers. For instance, the "Dolar Mayorista" is the wholesale exchange rate for businesses. However, strong evidence suggests that Argentina's exchange rate regime is not as free-floating as it should be and is more of a Crawling peg, as shown by Levy-Yeyati and Sturzenegger (2017). The exchange rate situation can be observed by plotting the official exchange rate and the parallel rate as in figure 9. Due to the current economic turmoil in the country, there is an increase in bureaucracy and intervention, which has resulted in a hike in the price of the black market dollar, known as the 'dollar blue' in Argentina. This has widened the gap between the official spot exchange rate and the dollar blue, as illustrated in figure 9.

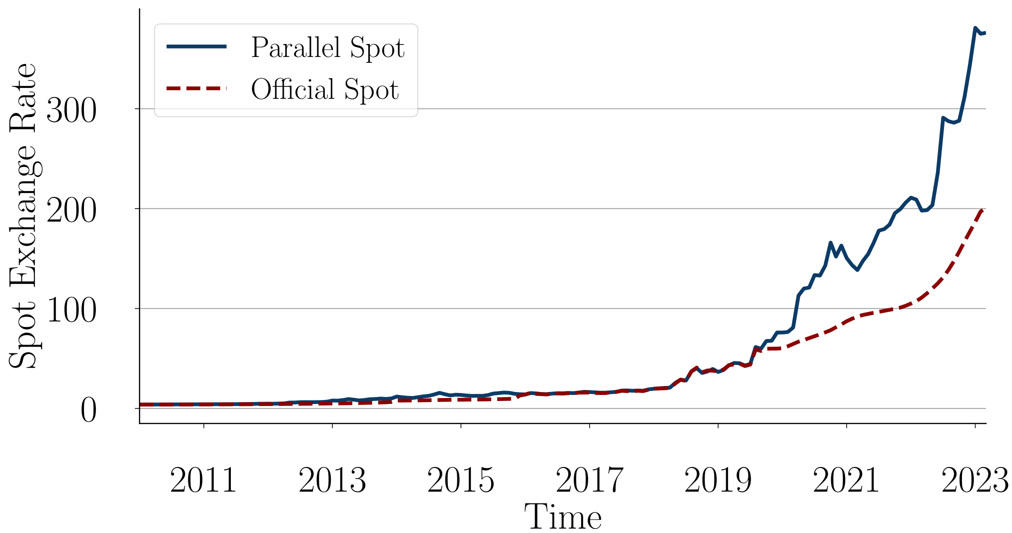


Figure 9: Argentina Nominal Spot Exchange Rate. Official rate data was taken from the BCRA database, and parallel rate data was from ambito.com. We use the last value observed in the month as the monthly exchange rate.

The same pattern emerges between inflation rate and exchange rate: comovement between the two variables as figure 10. This figure plots the month-to-month inflation rate and the official and parallel exchange rate from January 2010 to March 2023.

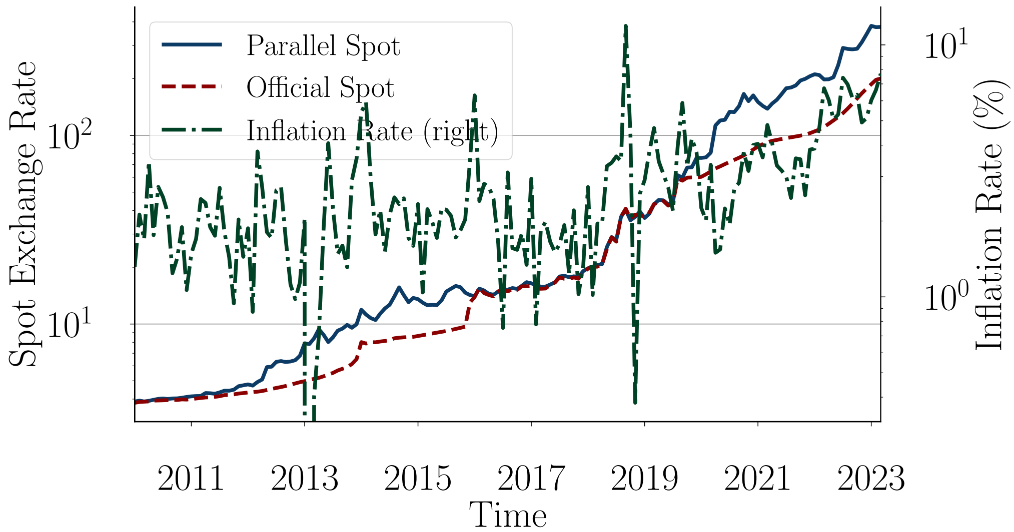


Figure 10: Argentina Nominal Spot Exchange Rate vs. MoM Inflation Rate. The month-to-month inflation rate is plotted on the right axis. The official spot and parallel spot axis are plotted on the left axis.

In summary, both countries experience a correlation between inflation rate and exchange rate depreciation and display strong evidence of Fiscal dominance.

4 Model

This section will develop the theoretical framework for a small open economy with three sectors: representative households, government, and external sector.

4.1 Households

Our first building block consists of a single household with access to local goods, denoted as $y_{H,t}$, and foreign goods, denoted as $y_{F,t}$. The household is assumed to live indefinitely, and its preferences are given as follows:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (\ln(c_t) + \varphi l_t), \tag{1}$$

In time t, $l_t \geq 0$ is leisure, and $c_t \geq 0$ is a consumption basket aggregated across domestic and foreign goods, and $\beta \in (0,1)$ is the discount factor. The consumption bundle follows a CES function:

$$c_t = \left[\alpha^{1/\eta} c_{H,t}^{1-1/\eta} + (1-\alpha)^{1/\eta} c_{F,t}^{1-1/\eta} \right]^{\frac{\eta}{\eta-1}}, \tag{2}$$

Our model assumes that $c_{H,t}$ and $c_{F,t}$ are the consumption of domestic and foreign goods, respectively. The spending minimization problem can be formulated using equation (2), where η is the elasticity of substitution between them.

$$\min_{c_{H,t},c_{F,t}} \frac{P_{H,t}}{P_t}c_{H,t} + \frac{\epsilon_t P^*}{P_t}c_{F,t}$$

$$s.t.: c_t = \left[\alpha^{1/\eta}c_{H,t}^{1-1/\eta} + (1-\alpha)^{1-1/\eta}c_{F,t}^{1/\eta}\right]^{\frac{\eta}{\eta-1}}$$

The price aggregator for the consumption basket at time t is denoted as P_t and is calculated as follows:

$$P_t = \left[\alpha P_{H,t}^{1-\eta} + (1-\alpha)(P^*\epsilon_t)^{1-\eta}\right]^{\frac{1}{1-\eta}}, \tag{3}$$

After solving the minimization problem, we arrived at the following conditions for the optimal composition of the consumption basket c_t, where $P_{H,t}$ denotes the price of the domestic good, P^* denotes the cost of foreign goods in foreign currency (dollars), and ϵ_t denotes the nominal foreign exchange rate implied by our model.

$$c_{H,t} = \alpha c_t \left(\frac{P_{H,t}}{P_t}\right)^{-\eta}, \tag{4}$$

$$c_{F,t} = (1-\alpha)c_t \left(\frac{P^*\epsilon_t}{P_t}\right)^{-\eta}, \tag{5}$$

To solve the dynamic problem of the household, we first need to define the shopping time function. According to the theory of money demand based on shopping time, having money saves time in shopping. We can determine shopping time using a part of consumption and accurate money balances ($m_t = M_t/P_t$). We can define shopping time as $s_t = H(c_t, m_t)$, and available time normalized as $1 = l_t + s_t$, where leisure (l_t) can be expressed as a function of shopping time as in Ljungqvist and Sargent (2004). With the optimal composition of the consumption basket, we can now focus on solving this dynamic problem.

$$l_t = 1 - H(c_t, m_t) \tag{6}$$

To clarify, we have chosen a specific functional form for $H(c_t, m_t)$. The format chosen is explicit.

$$H(c_t, m_t) = a_0 + a_c \ln(c_t) - a_m \ln(m_t) \tag{7}$$

We need to establish the household budget constraint.

$$c_t + m_t \leq \frac{P_{H,t}}{P_t}y_{H,t} + \frac{\epsilon_t P^*}{P_t}y_{F,t} - \frac{P_{H,t}}{P_t}T_t + \frac{M_{t-1}}{P_t},$$

The budget constraint of a household in this model involves two spending decisions: consumption or saving. The variables $y_{H,t}$ and $y_{F,t}$ represent the local and foreign endowments, respectively, while $y_{F,t}$ can refer to imports or capital flows. T_t is a lump-sum tax on domestic goods. The role of m_t is to be the savings vehicle over time. It's important to note that money doesn't yield any return, which means that the same amount of cash will have less value next period in an inflationary context. To make this more transparent, consider the following manipulation:

$$\frac{M_{t-1}}{P_t} = \frac{M_{t-1}}{P_t}\frac{P_{t-1}}{P_{t-1}} = \frac{m_{t-1}}{\frac{P_t}{P_{t-1}}} = \frac{m_{t-1}}{\pi_t},$$

Let us define π_t as the ratio of the price level between time t and $t-1$, i.e. $\frac{P_t}{P_{t-1}}$. This allows us to express our budget constraints as follows:

$$c_t + m_t \leq \frac{P_{H,t}}{P_t} y_{H,t} + \frac{\epsilon_t P^*}{P_t} y_{F,t} - \frac{P_{H,t}}{P_t} T_t + \frac{m_{t-1}}{\pi_t} \tag{8}$$

Our maximization problem is defined by equations (1), (6), (7), and (8).

$$\begin{aligned}
&\max_{c_t, m_t} \mathbb{E}_0 \left(\sum_{t=0}^{\infty} \beta^t (\ln(c_t) + \varphi l_t) \right) \\
&s.t.: c_t + m_t \leq \frac{P_{H,t}}{P_t} y_{H,t} + \frac{\epsilon_t P^*}{P_t} y_{F,t} - \frac{P_{H,t}}{P_t} T_t + \frac{m_{t-1}}{\pi_t} \\
&l_t = 1 - H(c_t, m_t) \\
&H(c_t, m_t) = a_0 + a_c \ln(c_t) - a_m \ln(m_t)
\end{aligned}$$

We can replace equation (7) in (6), and then replace the latter in (8) to condense our budget restraint. Defining λ_t as the Lagrange multiplier, the FOCs of the Lagrangian $\mathcal{L}$ are given by:

$$\frac{\partial \mathcal{L}}{\partial c_t} : \beta^t \left(\frac{1 - \varphi a_c}{c_t} \right) - \lambda_t = 0 \tag{9}$$

$$\frac{\partial \mathcal{L}}{\partial m_t} : \frac{\beta^t \varphi a_m}{m_t} - \lambda_t + \mathbb{E}_t \frac{\lambda_{t+1}}{\pi_{t+1}} = 0 \tag{10}$$

From equation (9), we can obtain $\lambda_t = \beta^t \left(\frac{1-\varphi a_c}{c_t} \right)$ and $\mathbb{E}_t \lambda_{t+1} = \mathbb{E}_t \beta^{t+1} \left(\frac{1-\varphi a_c}{c_{t+1}} \right)$. We substitute these last two definitions into (10), and after some factorization and sorting, we get:

$$m_t = \phi \left[\frac{1}{c_t} - \beta \mathbb{E}_t \frac{1}{\pi_{t+1} c_{t+1}} \right]^{-1} \tag{11}$$

We derived the money demand equation: $\phi = \frac{\varphi a_m}{1-\varphi a_c}$, which depends on current consumption c_t, expected future consumption c_{t+1}, and expected inflation π_{t+1}, assuming $1 - \varphi a_c > 0$.

4.2 Government

The government has limited options in this economy. It can only purchase domestic goods, collect lump-sum taxes from households, and print money. The government's budget constraint is as follows:

$$\frac{P_{H,t}(g_t - T_t)}{P_t} = \frac{M_t}{P_t} - \frac{M_{t-1}}{P_t} \tag{12}$$

Let's break down the equation. Here, g_t represents the government's spending on goods, while $c_{H,t}$, M_t, and M_{t-1} denote the quantity of money in their respective periods. For simplicity, we will assume that T_t remains constant for all periods. This assumption is made for two reasons: firstly, adjusting taxes can be challenging, and sometimes, governments lack the support or authority to do so. Secondly, we want to isolate the tax effect on our analysis, so we are limiting the government's ability to spend more by forcing them to print more money, thereby raising seigniorage. Lastly, we define the fiscal deficit as d_t.

$$d_t = g_t - T \tag{13}$$

Our model defines the deficit at time t, denoted as d_t, to follow an AR1 stochastic process.

$$d_t = (1 - \rho_d)\bar{d} + \rho_d d_{t-1} + \varepsilon_{d,t} \tag{14}$$

Where ρ_d is the persistence coefficient of the process, $\bar{d}$ represents the stationary state of the deficit, and $\varepsilon_{d,t}$ is the white noise of the process. $\epsilon_{d,t} \sim N(0, \sigma_d^2)$.

4.3 Foreign Sector

Imports enter the country as general form $y_{F,t}$. All imports become foreign goods ready for consumption:

$$y_{F,t} = c_{F,t} \tag{15}$$

We define a second exogenous stochastic process, assuming an AR1 process for imports.

$$y_{F,t} = (1 - \rho_{y_F})\bar{y_F} + \rho_{y_F} y_{F,t-1} + \varepsilon_{y_F,t} \tag{16}$$

The persistence coefficient of the process is denoted by ρ_{y_F}, and $\bar{y_F}$ represents the stationary state of the trade balance. Additionally, $\varepsilon_{y_F,t}$ is the white noise of the process, and it follows a normal distribution with a mean of 0 and variance of $\sigma_{y_F}^2$.

We will adopt the assumption in Cerra (2019) to ensure financial autarky. Based on this assumption, we can express the Trade-Balance as:

$$TB = P^x X_t - P^* y_{F,t} \tag{17}$$

As we have assumed $TB = 0$, we will focus on the total value of exports, $\bar{X}_t = P^x X_t$. Thus, equation (17) can be rewritten as:

$$\bar{X}_t = P^* y_{F,t} \tag{18}$$

This equation links imports and exports: a shock to either affects the other.

4.4 General Equilibrium

We need to add the following equation to ensure general equilibrium in the goods market and summarize the stability of our economy.

$$g_t + c_{H,t} = y_{H,t}, \tag{19}$$

Equation (15) gives the market equilibrium for foreign goods, while equation (19) provides the same for the domestic market. These, along with equations (11), (13), (12), (4), and (5), represent the entire endogenous equilibrium dynamics of our economy. Equations (14) and (16) serve as the exogenous uncertainty.

We are going to rephrase equation (3) in this new format:

$$1 = \left[\alpha \left(\frac{P_{H,t}}{P_t} \right)^{1-\eta} + (1 - \alpha) \left(\frac{P^* \epsilon_t}{P_t} \right)^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{20}$$

From this point forward, we will set the ratio of the price of home goods ($P_{H,t}$) to the cost of the consumption basket (P_t) equal to $P^r_{H,t}$. Similarly, we will set the ratio of the price of foreign goods in terms of the home currency ($P^*\epsilon_t$) to the cost of the consumption basket (P_t) equal to ϵ^r_t. This will allow us to express all prices relative to the price of the consumption basket c_t.

We will assume that the price of foreign goods (P^*) is fixed and equal to 1. This assumption has implications for our trade balance in equation (18), where exports will react similarly, whether we are importing more or at a higher price. Additionally, the effect on our economy will be the same regardless of the exchange rate movement. Consumption is the only variable that could alter the dynamics, but we are unconcerned with its dynamics.

We want to incorporate those features into our model as we work with countries with two exchange rate types. We will use ϵ_t as the nominal theoretical exchange rate the model implies. However, we assume that agents in our economy cannot access this theoretical exchange rate. Instead, they can access a nominal fixed exchange rate $\epsilon_{O,t}$ and a nominal parallel exchange rate $\epsilon_{B,t}$.

$$\epsilon_t = {\epsilon_{O,t}}^{\gamma} {\epsilon_{B,t}}^{1-\gamma}, \tag{21}$$

Certain countries' agents use official and parallel exchange rates to conduct transactions. The parameter γ determines the weight of transactions using either rate. This practice is similar to that seen in Argentina and Venezuela. For instance, if $\gamma = 0.5$, it implies that agents conduct 50% of their transactions using the fixed exchange rate and 50% using the parallel rate. Since the official exchange rate $\epsilon_{O,t}$ remains constant, we can model it as $\epsilon_{O,t} = \epsilon_O$ for all t. This helps us represent the official rate as fixed.

Using the above information, we can rewrite equation (21) to calculate the nominal depreciation rate.

$$\Delta\epsilon_t = \Delta\epsilon^{\gamma}_{O,t} \Delta\epsilon^{1-\gamma}_{B,t} \tag{22}$$

Again, we assume that $\Delta\epsilon_{O,t} = \Delta\epsilon_O \forall t$. Finally, we define our 2 last variables: $\Delta\epsilon_t$ and $\pi_{H,t}$:

$$\Delta\epsilon_t = \frac{\epsilon^r_t}{\epsilon^r_{t-1}} \pi_t, \tag{23}$$

$$\pi_{H,t} = \frac{P^r_{H,t}}{P^r_{H,t-1}} \pi_t \tag{24}$$

We will work with a log-linear version of this DSGE model. For that, we use Uhlig et al. (2199) trick to transform all the variables except for d_t and $y_{F,t}$ [5]. In summary, our Dynamic model consists of the following nine endogenous variables: c_t, ϵ^r_t, $P^r_{H,t}$, m_t, $\Delta\epsilon_t$, $\pi_{H,t}$, $\Delta\epsilon_{B,t}$, $c_{H,t}$, and π_t. We don't consider $y_{H,t}$ and g_t endogenous because they are fixed parameters. The following equations explain all endogenous variables [6]:

[5] From now on, log-lineal variables will be represented with a hat: $\hat{x}$.

[6] In Appendix A, we show the derivation of the log-lineal money demand equation.

$$\hat{m}_t = \hat{c}_t - \frac{\beta}{(\bar{\pi}-\beta)}\mathbb{E}_t\left(\frac{y_{F,t+1}-y_{F,t}}{1-\alpha} + \eta(1-\gamma)\hat{\Delta}\epsilon_{B,t+1} + (1-\eta)\hat{\pi}_{t+1}\right), \qquad \text{(Money Demand)}$$

$$\bar{m}(1+\hat{m}_t) = \bar{d}\hat{P}^r_{H,t} + d_t + \frac{\bar{m}}{\bar{\pi}}(1+\hat{m}_{t-1}-\hat{\pi}_t), \qquad \text{(Money Supply)}$$

$$\hat{\Delta}\epsilon_t = \hat{\epsilon}^r_t - \hat{\epsilon}^r_{t-1} + \hat{\pi}_t, \qquad \text{(Nominal Exchange Rate Devaluation)}$$

$$\hat{\pi}_{H,t} = \hat{P}^r_{H,t} - \hat{P}^r_{H,t-1} + \hat{\pi}_t, \qquad \text{(Domestic Inflation)}$$

$$\hat{\Delta}\epsilon_t = \gamma\hat{\Delta}\epsilon_O + (1-\gamma)\hat{\Delta}\epsilon_{B,t}, \qquad \text{(Exchange Rate Devaluation Composition)}$$

$$\hat{c}_{H,t} = \hat{c}_t - \eta\hat{P}^r_{H,t}, \qquad \text{(Domestic Consumption)}$$

$$y_{F,t} = (1-\alpha)(1+\hat{c}_t - \eta\hat{\epsilon}^r_t), \qquad \text{(Foreign Consumption)}$$

$$\alpha\hat{P}^r_{H,t} + (1-\alpha)\hat{\epsilon}^r_t = 0, \qquad \text{(Price Aggregator)}$$

$$y_H = d_t + T + \bar{c_H}(1+\hat{c}_{H,t}) \qquad \text{(Domestic Equilibrium)}$$

And these two exogenous equations for the two exogenous variables $y_{F,t}$, and d_t:

$$d_t = (1-\rho_d)\bar{d} + \rho_d d_{t-1} + \varepsilon_{d,t}, \qquad \text{(Seigniorage AR1 process)}$$

$$y_{F,t} = (1-\rho_{y_F})\bar{y_F} + \rho_{y_F} y_{F,t-1} + \varepsilon_{y_F,t} \qquad \text{(Capital Flows AR1 process)}$$

It is worth discussing the assumptions that come with the fixed endowment of local goods y_H. In high inflation and hyperinflation studies, models with only nominal variables are commonly used because they are the main focus of interest. Adding the fundamental part of the economy is not a simple task, and the benefits of doing so are not significant. Therefore, we prefer to keep the real economy fixed to better understand the nominal side without distortions.

4.5 Rational Expectations

The model assuming RE has the following Minimal State Variable (MSV):

$$y_t = \Omega x_{t-1} + \Psi\varepsilon_t, \tag{25}$$

where y_t is the endogenous variables vector: $y_t = \left[\pi_t, \Delta\epsilon^r_t, c_t, c_{H,t}, \epsilon^r_t, P^r_H, \pi_{H,t}, m_t, \Delta\epsilon^r_t, d_t, y_{F,t}\right]'$; x_t is the endogenous state variables: $x_t = \left[\epsilon^r_t, P^r_{H,t}, m_t, d_t, y_{F,t}\right]'$ and ε_t is the exogenous shock vector: $\varepsilon_t = \left[\varepsilon_{d,t}, \varepsilon_{y_F,t}\right]'$. Matrices Ω and Ψ are the structural parameters. So, for example, the dynamic for mom inflation is given by:

$$\pi^{RE}_t = \omega_1 \cdot m_{t-1} + \omega_2 \cdot d_{t-1} + \omega_3 \cdot y_{F,t-1} + \psi_1 \cdot \varepsilon_{d,t} + \psi_2 \cdot \varepsilon_{y_F,t} \tag{26}$$

4.6 Adaptive Learning

We introduce Steady-State learning to the model as described in Eusepi et al. (2018)[7]. Suppose we have matrices Ω and Ψ representing the structural parameters of a given model. RE Assumes that agents have full knowledge of the model and its parameters. However, suppose we relax the second assumption and

[7] For more details, refer to Evans and Honkapohja (2012)

assume that agents only see the model without having access to all the parameters. In that case, we call this scenario AL, which stands for Adaptive Learning.

Steady-state learning is a type of Adaptive Learning where agents attempt to learn through the steady-state instead of recovering the parameters Ω using Recursive least-squared learning. Agents instead form their beliefs in this form:

$$\mathbb{E}_t x_{t+1} = \zeta_{x,t-1}, \tag{27}$$

The value of ζ is modified based on the following formula:

$$\zeta_{x,t} = \zeta_{x,t-1} + \theta(x_t - \zeta_{x,t-1}), \tag{28}$$

With θ as the constant-gain learning parameter and $\zeta_{x,0} = \bar{x}$, the learning intuition is as follows:

- In $t = 0$: Agents believe that they are at the steady state where the expected inflation rate equals the average inflation rate, denoted by $\mathbb{E}_{t=0}\pi_{t=1} = \bar{\pi}$.
- In $t = 1$: A sudden, temporary shock occurs, causing the inflation rate to deviate from the steady state. The actual inflation rate in $t = 1$, $\pi_{t=1}$, equals the average inflation rate, pi bar, plus an error term, $\epsilon_{t=1}$. The agents mistakenly believe they misjudged the steady-state inflation rate in $t = 0$, so they adjusted their calculation. They expect to reach the correct steady state in $t = 2$.
- In $t = 2$: Since the shock was temporary, the agents' estimation will again be incorrect. Consequently, they adjust their steady-state calculation again.

This process occurs at various intervals until they converge ergodically to the actual value, as explained in Evans and Honkapohja (2012). It's worth noting that the learning process only affects leading variables, which is the case with the two variables in our log-linear model, $\hat{\pi}_{t+1}$ and $\hat{\Delta\epsilon}_{B,t+1}$. We are imposing that the expectation formation of these variables follows a specific scheme. This, in turn, affects the money demand because we are setting higher inflation and depreciation expectations. Therefore, the need for adaptive learning money is impacted by expectations. Thus, the Adaptive Learning money is affected.

$$\hat{m}_t = \hat{c}_t - \frac{\beta}{(\bar{\pi} - \beta)}\mathbb{E}_t^{AL}\left(\frac{y_{F,t+1} - y_{F,t}}{1 - \alpha} + \eta(1-\gamma)\zeta_{\Delta\epsilon_B,t-1} + (1-\eta)\zeta_{\pi,t-1}\right) \tag{29}$$

The Rational Expectation of money demand is:

$$\hat{m}_t = \hat{c}_t - \frac{\beta}{(\bar{\pi} - \beta)}\mathbb{E}_t^{RE}\left(\frac{y_{F,t+1} - y_{F,t}}{1 - \alpha} + \eta(1-\gamma)\hat{\Delta\epsilon}_{B,t+1} + (1-\eta)\hat{\pi}_{t+1}\right) \tag{30}$$

The equation (26) shows that in the Rational Expectations (RE) model, only m_t, d_t, and $y_{F,t}$ are the endogenous state variables that govern the model π_t. However, in the Adaptive Learning (AL) model, two more endogenous state variables, $\zeta_{\pi,t-1}$ and $\zeta_{\Delta\epsilon_B,t-1}$, are added for π_t. This implies that inflation depends not only on the past real money but also on inflation and exchange rate depreciation from the past.

$$\pi_t^{AL} = \omega_1 \cdot d_{t-1} + \omega_2 \cdot m_{t-1} + \omega_3 \cdot y_{F,t-1} + \omega_4 \cdot \zeta_{\Delta\epsilon_B,t-1} + \omega_5 \cdot \zeta_{\pi,t-1} + \psi_1 \cdot \varepsilon_{d,t} + \psi_2 \cdot \varepsilon_{y_F,t}, \tag{31}$$

5 Calibration and Estimation

In this section, we will explain how we calibrated and estimated the parameters of our model. We require values for various parameters, including α, β, ϕ, γ, η, τ, g, ρ_d, θ, ρ_{Y_F}, and y_H. To determine some of these values, we collected data and calibrated them to reflect certain characteristics of our target economies. The remaining values were estimated using Bayesian techniques.

5.1 Baseline Calibration

To start, we will use the equilibrium state of our model to calibrate some of the parameters. We will normalize consumption c_t at the steady-state, $\bar{c} = 1$. This normalization will allow us to match certain national account ratios, such as the deficit as a percentage of GDP and imports as a share of GDP, among others. Due to this normalization and our prices relative to P_t, it is simple to determine that $c_{H,t}$ and $c_{F,t}$ at the steady-state are equal to α and $1 - \alpha$, respectively.[8]

At the steady-state level, we use equation (12) to obtain the implied inflation of the deficit, which we denote by $\bar{\pi}$. This can be interpreted as the government selecting the deficit it desires. Once the deficit has been determined, the government prints the necessary money to balance its accounts. Therefore, the government sets an inflation target by selecting and financing the deficit.

$$\bar{m} = \bar{P_H^r}\bar{d} + \frac{\bar{m}}{\bar{\pi}} \tag{32}$$

$$\frac{\bar{m}}{\bar{c}} = \frac{\bar{d}}{\bar{c}}\left(1 - \frac{1}{\bar{\pi}}\right)^{-1} \tag{33}$$

By imposing the condition given in (33) and using (11) at the steady state, we can obtain the parameter ϕ as a residual:

$$\frac{\bar{m}}{\bar{c}} = \phi\left[1 - \beta\frac{1}{\bar{\pi}}\right]^{-1} \tag{34}$$

With (33) and (34) we can get:

$$\phi = \frac{\bar{m}(\bar{\pi} - \beta)}{\bar{c}\bar{\pi}} \tag{35}$$

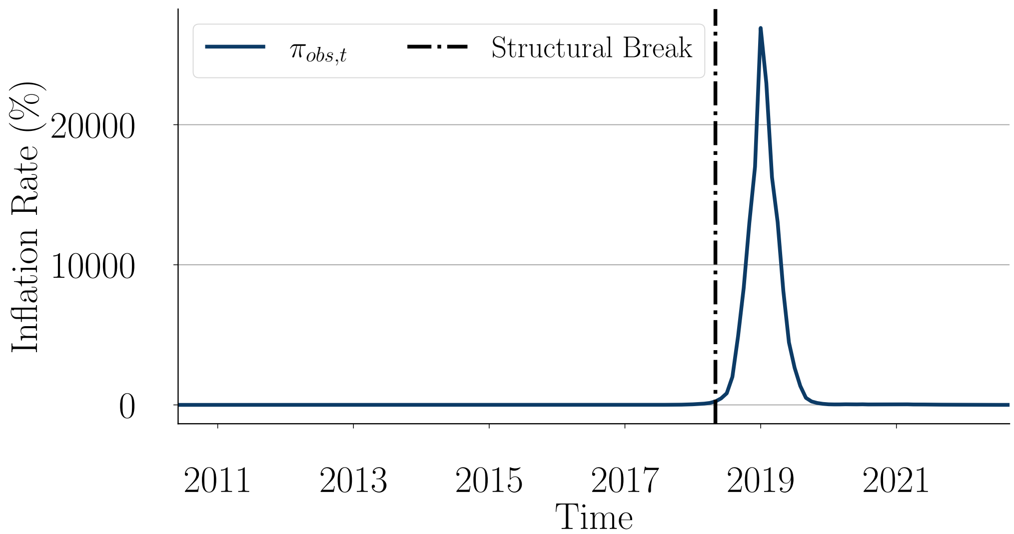
To determine the values of $\bar{d}$ and $\bar{\pi}$, we rely on information about the fiscal deficit as a percentage of GDP and the monthly inflation rate. We aim to calibrate these parameters to match the target economies before inflation surpasses a certain threshold. We use a Binary Segmentation algorithm to identify this moment, developed by Truong et al. (2020).

Binary Segmentation is a process that takes a time series as input and searches for the first point that lowers the sum of a cost function. It then divides the sample into two sub-samples and repeats the process. This continues until a stopping content the stopping standards to detect n breaking points for our purposes. The algorithm divides the sample into n segments, which all minimize the sum of the cost function. The cost function used is the Least Squared Deviation, which detects mean shifts in a signal.

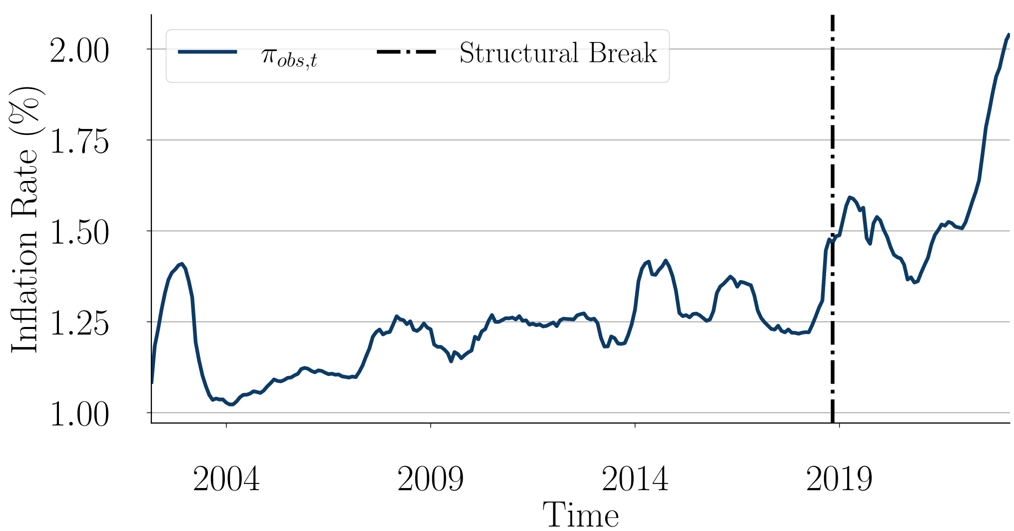
Figure 11 presents Venezuela and Argentina's accumulated monthly inflation rate during the full sample. Thanks to this algorithm, we can identify that a structural break-point occurred in May 2018

[8] Equation (20) shows that $\bar{P_H^r} = 1$ and $\bar{\epsilon^r} = 1$.

in Venezuela and in October 2018 in Argentina. These break-points indicate a change in the behavior of inflation rates, as seen in the inflation rate increases after these dates.



(a) Venezuela Breaking Point detection



(b) Argentina Breaking Point detection

Figure 11: Monthly accumulated inflation rate. The segmented black line indicates a break-point detected by the Binary Segmentation algorithm with $n = 1$

We can split the sample into two parts: a calm period and a messy period. We will use the calm period to match most of the observable variables. To calculate the values of $\bar{d}$, $\bar{\pi}$, and α, we will use the average of the calm sub-sample. The parameter α represents the share of domestic consumption $c_{H,t}$ in the overall consumption basket c_t. We will use imports as a proxy to derive $1 - \alpha$, the share of foreign goods consumed in the final consumption basket.

Similarly, we will use government spending as a share of GDP to estimate the value of parameter g. Tax T is the only parameter that is left. With $\bar{d}$ and g, we can calculate it as a residual from equation (13). We will follow the same approach to calculate y_H from equation (19).

Parameter Name	Venezuela	Argentina	Parameter Description	Target
ρ_d	0.899	0.982	Deficit Persistence	Fiscal Deficit as share of GDP AR1 Estimation
β	0.990	0.990	Discount Factor	Fixed
η	0.633	0.993	Elasticity of Substitution Between Foreign and Domestic Goods	Baseline Assumption
ρ_{y_F}	0.992	0.986	Imports Persistence	Imports as share of GDP AR1 Estimation
θ	0.025	0.025	Learning Gain Parameter	Baseline Assumption
ϕ	0.097	0.011	Money demand Sensitivity	$\frac{\bar{m}(\bar{\pi}-\beta)}{\bar{c}\bar{\pi}}$
α	0.844	0.879	Share of Domestic Goods	1 - Average Imports as share of GDP in calm period
γ	0.500	0.500	Share of Transactions in Official Currency	Baseline Assumption
$\bar{c_H}$	0.844	0.879	Steady-State Domestic Consumption	1 - Average Imports as share of GDP in calm period
$\bar{y_H}$	1.108	1.217	Steady-State Domestic Goods	$\bar{g} + \bar{c_H}$
$\bar{d}$	0.090	0.007	Steady-State Fiscal Deficit	Average Fiscal Deficit as share of GDP in calm period
$\bar{y_F}$	0.156	0.121	Steady-State Foreign Goods	Average Imports as share of GDP in calm period
$\bar{g}$	0.263	0.337	Steady-State Government Spending	Average Government Spending as share of GDP in calm period
$\bar{\pi}$	1.124	1.018	Steady-State Inflation	Average month-to-month Inflation Rate in calm period
$\bar{T}$	0.173	0.331	Steady-State Lump-Sum Taxes	$\bar{g} - \bar{d}$
$\bar{m}$	0.819	0.392	Steady-State Real Money	Steady-State Real Money

Table 1: Baseline Calibration

In Table 1, we present the calibration for our model. We set β to 0.99 for Venezuela and Argentina, which is consistent with Higgins (2023). The parameter η is obtained from Devarajan et al. (2023), which estimates this parameter for various countries, including Venezuela and Argentina. We arbitrarily set γ and θ to specific values for our baseline calibration. However, we plan to estimate these parameters as well as ρ_d and ρ_{y_F} using Bayesian techniques.

Since both fiscal and trade balance deficits are in annual data, we will estimate the values and perform a simple transformation: $\rho_{x,m} = \rho_{x,y}^{1/12}$, where y represents the yearly data. We will estimate the AR1 process directly from the data using OLS and then perform the exact estimation using Bayesian estimation.

We use data from different sources. Fiscal expenditure, fiscal deficit, trade balance, imports, exports, and GDP are taken from the IMF WEO Database. The official nominal exchange rate data come from the Argentina Central Bank (BCRA) and the FRED database. Unofficial exchange rate values are taken from internet sources: Ambito.com and Dolartoday.com. Finally, we use Observatorio Venezolano de Finanzas (OVF), Inflacionverdadera.com, Venezuelan Central Bank (BCV), and BCRA data.

Using the available data, we can see that Venezuela has an average fiscal deficit of approximately 10% of its GDP, while Argentina's is only 2%. Regarding government expenditure, Venezuela spends around 26% of its GDP, while Argentina spends 33%. During the calm period, the average inflation rate for Venezuela was 12%, compared to only 1% for Argentina. Additionally, the share of imported goods for Venezuela was roughly 15% of GDP, while for Argentina, it was around 12%.

5.2 Bayesian Estimation

Bayesian Estimation is a powerful tool that has gained popularity in DSGE estimation literature. Despite its relative newness, considerable knowledge has been achieved, and the method has become standardized. Cornerstone authors such as An and Schorfheide (2007), Fernández-Villaverde and Rubio-Ramírez

(2007), and Fernández-Villaverde et al. (2015) have laid the theoretical foundations and popularized this approach. Smets and Wouters (2007) also made significant contributions when successfully applying Bayesian Estimation to a large DSGE model. Their work has set an example for upcoming papers, such as Slobodyan and Wouters (2012), where they estimated a medium DSGE economy incorporating Adaptive Learning. We follow the approach developed by these two papers, and our choices of prior are inspired by their work.

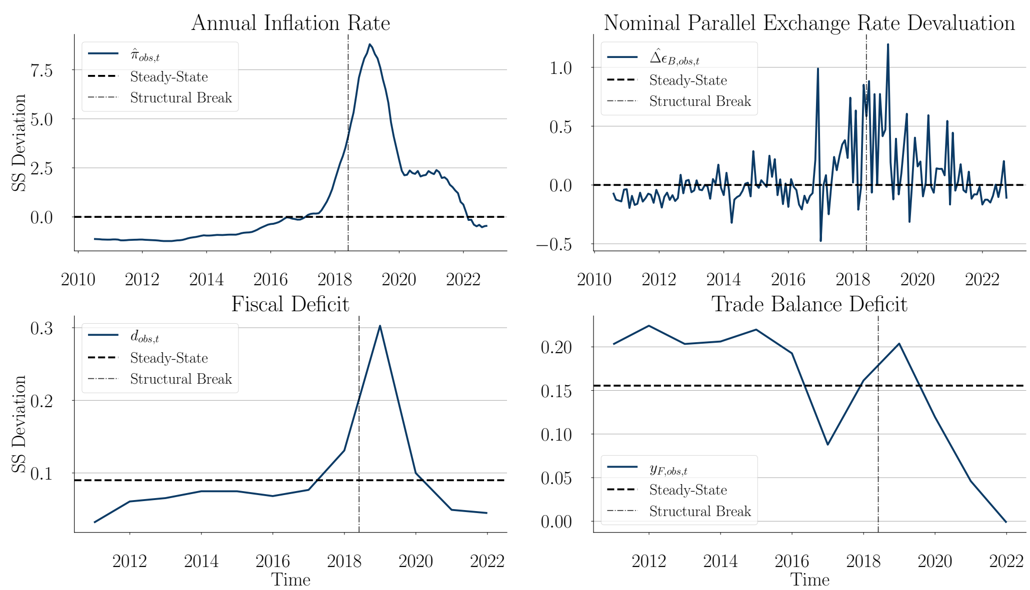
We need to estimate seven parameters: η, γ, ρ_d, ρ_{Y_F}, and θ. We use Bayesian techniques to get these values. To do this, we first need to match the observable variables. We chose the observable variables: inflation, fiscal deficit, trade balance, and black exchange rate depreciation. We can only propose two visible variables a priori because we have only two exogenous shocks. To avoid stochastic singularity, we add two additional endogenous variables.

$$\hat{\pi}_{obs,t} = \hat{\pi}_t + \hat{\pi}_{t-1} + \hat{\pi}_{t-2} + \hat{\pi}_{t-3} + \hat{\pi}_{t-4} + \hat{\pi}_{t-5} + \hat{\pi}_{t-6} + \hat{\pi}_{t-7} + \hat{\pi}_{t-8} + \hat{\pi}_{t-9} + \hat{\pi}_{t-10} + \hat{\pi}_{t-11} + \varepsilon_{\pi,t} \quad (36)$$

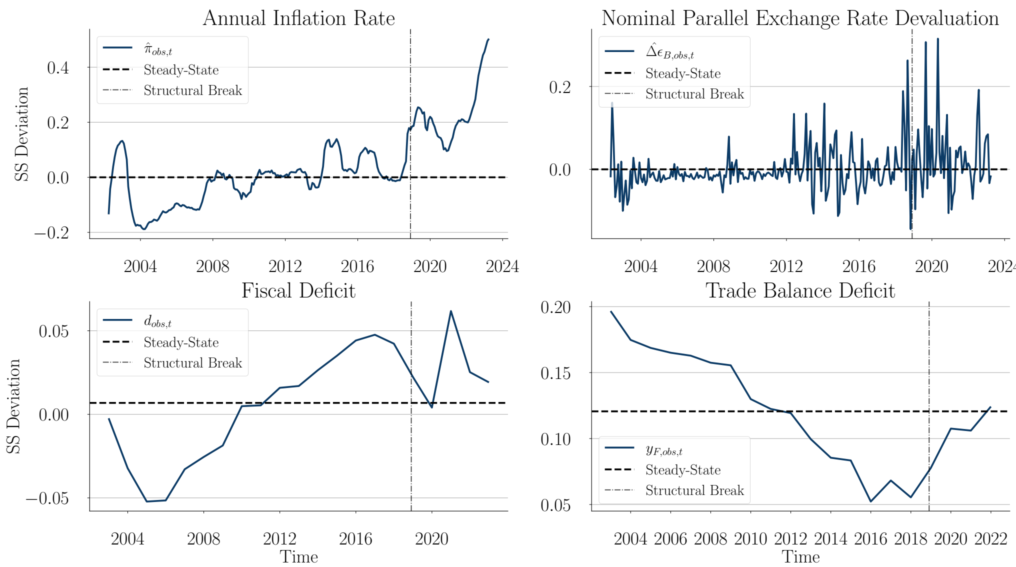
$$\hat{\Delta\epsilon}_{B,obs,t} = \hat{\Delta\epsilon}_{B,t} + \varepsilon_{\Delta\epsilon_B,t} \quad (37)$$

However, we encounter a discrepancy due to the difference in time frames. While the model works with month-to-month inflation rates, we use an observable monthly accumulated inflation rate to control for any seasonality. We estimate the standard error of the time series to see how much inflation and other variables move on the estimated shocks or by a measuring mistake during Bayesian estimation.

Similarly, in equation (37), we estimate the standard error of the black exchange rate. We use a simple mapping for the other observable variables, transforming from low to high frequency by averaging the previous 12 months. We use the Kalman Filter to address missing observations while doing our Bayesian Estimation.



(a) Venezuela Observable Variables



(b) Argentina Observable Variables

Figure 12: Observable variables Time Series. All variables were subject to a demeaning/filtering to be expressed as deviations from the steady-state, except for deficits

The figure shown in Figure 12 displays the variables deviating from the steady state. To plot these variables, we made some changes and transformations. For instance, the variables $d_{obs,t}$ and $y_{F,obs,t}$ were initially in a share of GDP. Therefore, we did not need to demean these series around the steady-state $\bar{d}$ and $\bar{y_F}$. We followed a similar approach with $\hat{\pi}_{obs,t}$. Since we will log-linearize this variable when we solve the model, we need it to be expressed correctly. Therefore, we took the original month-to-month inflation rate, computed the implied CPI with 100 for the first year, and applied the transformation $\frac{P_t}{P_{t-12}}$ to get the accumulated monthly inflation rate. Finally, we applied ln and demeaned around the steady state. The steady-state of variable $\varepsilon_{\Delta\epsilon_B,obs,t}$ was centered around $\bar{\pi}$ before applying ln, as it was already at one.

Once the observed variables were ready, we estimated the desired parameters using the Metropolis-Hasting Algorithm. We tune the j-scale parameter to get an acceptance ratio of around 23.5%. The MCMCs are up to 1,000,000 draws with five replication blocks. We discarded 33% of the first observations the algorithm generated in each chain. Table 3 summarizes our choices for priors and the results of the Bayesian estimation for Venezuela, while Table 4 does the same for Argentina. Table 2 provides information on each country's sub-sample length. Appendix B includes all the convergence and identification tests.

Country	Full Sample	Calm Sample	Messy Sample
Venezuela	148	95	53
Argentina	253	200	53

Table 2: Number of observations per sample

According to our estimation results in tables 3 and 4, we observe a particular high η and low γ. We want to discuss the implications of these results further. For this, we need to return to our log-lineal version of the money demand equation:

$$\hat{m}_t = \hat{c}_t - \frac{\beta}{(\bar{\pi} - \beta)} \mathbb{E}_t \left(\underbrace{\frac{y_{F,t+1} - y_{F,t}}{1 - \alpha}}_{\text{Exogenous}} + \underbrace{\eta(1-\gamma)\hat{\Delta\epsilon}_{B,t+1}}_{\text{Black Exchage Rate Expectations}} + \underbrace{(1-\eta)\hat{\pi}_{t+1}}_{\text{Inflation Rate Expectations}} \right) \tag{38}$$

Our model demonstrates that exchange rate depreciation and inflation expectations influence agents' behavior. This highlights the importance of exchange rates in determining their behavior. Estimating a big η means that agents in our model economy assign more weight to exchange rate depreciation than inflation rate when they demand money. In simpler terms, agents are more sensitive to the depreciation of the parallel exchange rate rather than the actual movement of the inflation rate. The role of γ is also to weigh the share of transactions done with the parallel exchange rate. As the estimation suggests, a lower γ implies that the economy is doing most of its imports by the unofficial rate.

Another significant aspect of the model is that it allows us to estimate the measurement errors and compare the accuracy between the models. In our model, there are four sources of noise or shocks: fiscal and trade balance shocks and inflation rate and exchange rate depreciation error measurements. In an ideal scenario, we want the shocks to account for 100% of the uncertainty and dynamic. When we estimate, if the model infers a high measurement error, it cannot fit specific data, so it needs to give more noise. As shown in Table 3 and Table 4, we can observe that the RE model has a higher measurement error for inflation than the AL model. This means we can explain data with our AL model with less noise than the RE setting.

The last feature worth discussing is the estimation of θ. This parameter is the learning rate. As it is closer to 0, we are more in a RE model. For Venezuela, this parameter is estimated to be 0.007, 0.054, and 0.06 for the calm, complete, and messy periods. These results are logical with the notion of unanchoring of expectations. In the calm period, we estimate a lower learning rate; in the messy period, the rate is higher. This could work as evidence suggesting that expectations are anchored in the calm period, but as soon as things get out of control, we move to an unanchored setting with learning. These same results are not found in Argentina. In this country, θ was estimated to be close to 0 for the entire period. This could mean that overall expectations are still anchored in the Argentinian economy despite the increasing trend.

Country	Parameter	Prior Shape	Prior Mean	Prior Std	Sample	Setting	Posterior Mean	Posterior Std
Venezuela	η	Beta	0.500	0.200	Calm Sample	AL	0.935	0.037
						RE	0.935	0.037
					Full Sample	AL	0.967	0.020
						RE	0.887	0.061
					Messy Sample	AL	0.853	0.077
						RE	0.730	0.113
	γ	Beta	0.500	0.200	Calm Sample	AL	0.044	0.025
						RE	0.090	0.047
					Full Sample	AL	0.018	0.011
						RE	0.061	0.033
					Messy Sample	AL	0.042	0.025
						RE	0.109	0.056
	ρ_d	Beta	0.500	0.200	Calm Sample	AL	0.836	0.049
						RE	0.868	0.014
					Full Sample	AL	0.835	0.040
						RE	0.508	0.120
					Messy Sample	AL	0.910	0.039
						RE	0.373	0.148
	ρ_{y_F}	Beta	0.500	0.200	Calm Sample	AL	0.874	0.007
						RE	0.927	0.026
					Full Sample	AL	0.994	0.003
						RE	0.957	0.016
					Messy Sample	AL	0.985	0.006
						RE	0.944	0.023
	θ	Gamma	0.035	0.030	Calm Sample	AL	0.007	0.002
					Full Sample	AL	0.054	0.001
					Messy Sample	AL	0.060	0.006
	$\varepsilon_{\Delta\epsilon_B}$	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.205	0.018
						RE	0.133	0.018
					Full Sample	AL	0.423	0.028
						RE	0.188	0.018
					Messy Sample	AL	0.334	0.040
						RE	0.243	0.037
	ε_π	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.007	0.004
						RE	0.423	0.037
					Full Sample	AL	0.006	0.003
						RE	1.827	0.111
					Messy Sample	AL	0.009	0.007
						RE	3.028	0.310
	ε_d	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.040	0.004
						RE	0.013	0.002
					Full Sample	AL	0.067	0.005
						RE	0.067	0.017
					Messy Sample	AL	0.057	0.008
						RE	0.123	0.035
	ε_{y_F}	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.019	0.002
						RE	0.017	0.003
					Full Sample	AL	0.060	0.004
						RE	0.017	0.002
					Messy Sample	AL	0.028	0.005
						RE	0.021	0.004

Table 3: Venezuela Bayesian Estimation Results

Country	Parameter	Prior Shape	Prior Mean	Prior Std	Sample	Setting	Posterior Mean	Posterior Std
Argentina	η	Beta	0.500	0.200	Calm Sample	AL	0.987	0.008
						RE	0.389	0.044
					Full Sample	AL	0.897	0.055
						RE	0.423	0.039
					Messy Sample	AL	0.904	0.053
						RE	0.473	0.096
	γ	Beta	0.500	0.200	Calm Sample	AL	0.013	0.008
						RE	0.014	0.008
					Full Sample	AL	0.013	0.008
						RE	0.011	0.007
					Messy Sample	AL	0.077	0.043
						RE	0.050	0.029
	ρ_d	Beta	0.500	0.200	Calm Sample	AL	0.801	0.038
						RE	0.198	0.076
					Full Sample	AL	0.954	0.016
						RE	0.137	0.061
					Messy Sample	AL	0.845	0.059
						RE	0.129	0.069
	ρ_{y_F}	Beta	0.500	0.150	Calm Sample	AL	0.966	0.004
						RE	0.995	0.003
					Full Sample	AL	0.997	0.001
						RE	0.992	0.004
					Messy Sample	AL	0.937	0.011
						RE	0.925	0.031
	θ	Gamma	0.025	0.020	Calm Sample	AL	0.028	0.000
				0.010	Full Sample	AL	0.000	0.000
					Messy Sample	AL	0.022	0.005
	$\varepsilon_{\Delta\epsilon_B}$	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.436	0.027
						RE	0.110	0.007
					Full Sample	AL	0.099	0.005
						RE	0.106	0.006
					Messy Sample	AL	0.102	0.013
						RE	0.063	0.021
	ε_π	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.008	0.006
						RE	0.916	0.047
					Full Sample	AL	0.926	0.042
						RE	0.870	0.040
					Messy Sample	AL	0.006	0.003
						RE	0.563	0.066
	ε_d	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.153	0.009
						RE	0.045	0.005
					Full Sample	AL	0.008	0.001
						RE	0.047	0.004
					Messy Sample	AL	0.028	0.004
						RE	0.049	0.009
	ε_{y_F}	Inv. Gamma	0.010	2.000	Calm Sample	AL	0.041	0.003
						RE	0.004	0.000
					Full Sample	AL	0.004	0.000
						RE	0.004	0.000
					Messy Sample	AL	0.006	0.001
						RE	0.006	0.001

Table 4: Argentina Bayesian Estimation Results

6 Results

In this section, we will solve our model and perform three exercises. These exercises are IRF to fiscal and trade balance shocks, Bayesian model comparison between RE and AL models, and theoretical mean-variance decomposition. The main objectives of these exercises are to evaluate our model's performance under different settings and calibrations, identify which has a better empirical fitting, and ultimately understand the role of fiscal and trade balance shocks in generating inflationary episodes.

6.1 Baseline IRFs

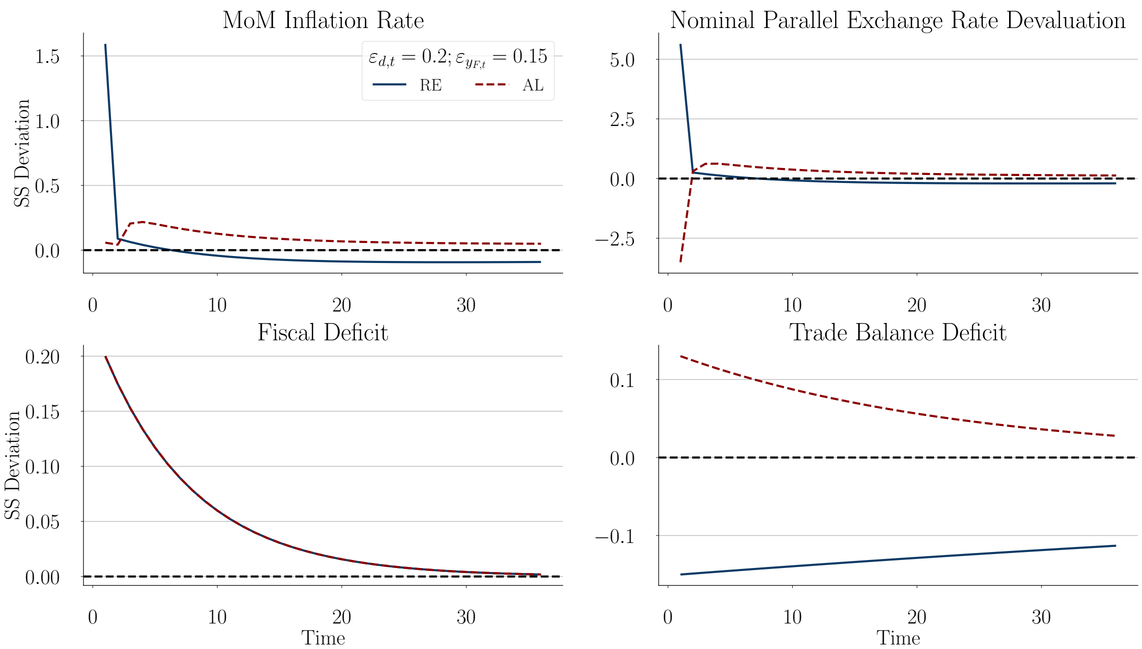
In this section, we solve the model that was presented in section 4 using Rational Expectations (RE) and Adaptive Learning (AL) approaches. For this purpose, we utilize the baseline calibration results in table 1. Using baseline calibration examines our model's dynamics and identifies the differences between the expectations settings.

We aim to observe the simultaneous reactions of the model to fiscal and trade balance deficit shocks while varying the size and length of the surprises. To accomplish this, we establish two scenarios: one in which the entire deficit shock hits the country simultaneously and the second in which the same nation experiences shocks for a year. In the case of the first scenario, the size of the shocks that hit the economy in one month is 0.2 and 0.13 for the internal and external shocks, respectively, as a share of GDP. These shock sizes correspond to what we observe in the data for Venezuela. In 2018, the average fiscal deficit was around 10% of GDP, but it increased dramatically to about 30% of GDP, indicating a 20-point increase from one year to the next. A similar story took place with the trade balance deficit. In the second scenario, we assume the 20-point rise in fiscal deficit happens throughout the year rather than in one month. This means that for 12 months, the economy will be affected by a deficit shock of 0.20/12 and a trade balance shock of 0.13/12 every month.

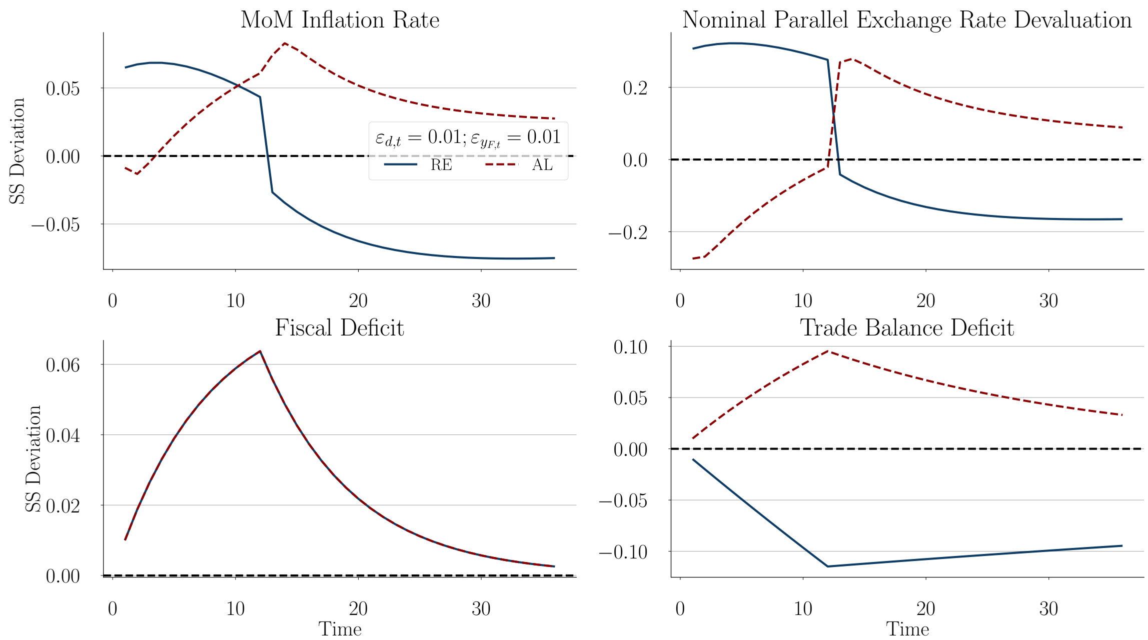
We present IRF plots for π_t, d_t, $y_{F,t}$ and $\Delta\epsilon_{B,t}$ in figure 13. Our model suggests that internal (fiscal deficit) and external (trade balance deficit) deficits have inflationary effects.

When there is a fiscal deficit shock, the government increases the money supply to finance the deficit. This extra money is then used to buy local goods. However, since the supply of these goods is limited, their prices go up due to increased demand. As a result, inflation rises, and people buy fewer local goods because they become more expensive. Since the supply of foreign goods remains the same, their prices become relatively cheaper, and people start buying more. This causes the overall cost of goods, leading to higher inflation and reducing the purchasing power of money.

In the case of an external shock to the trade balance, the opposite happens. More foreign goods enter the economy, and their prices decrease because people are the only ones buying them. This means that people can spend more on local interests, but since their supply is limited, their prices go up, too. As a result, inflation increases, and people demand more money, which reduces inflation. This causes the exchange rate to depreciate to adjust for the external imbalance.



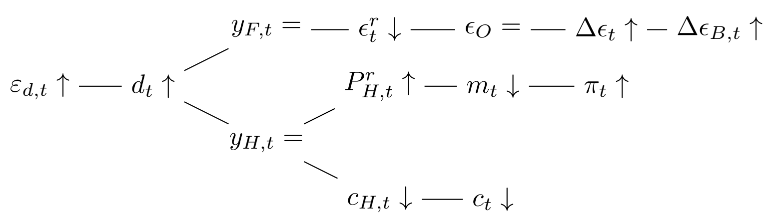
(a) Venezuela's IRFs for One Transitory Big Shocks



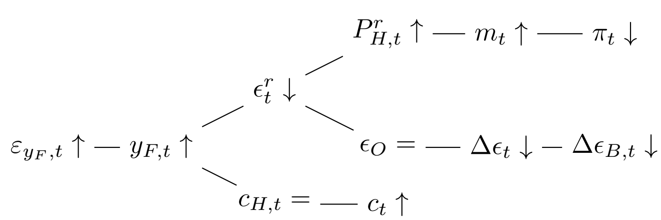
(b) Venezuela's IRFs for Multi Transitory Small Shocks

Figure 13: Venezuela's IRFs

Figure 14 represents how the dynamic spreads in our DSGE model.



(a) Fiscal Shock Dynamic

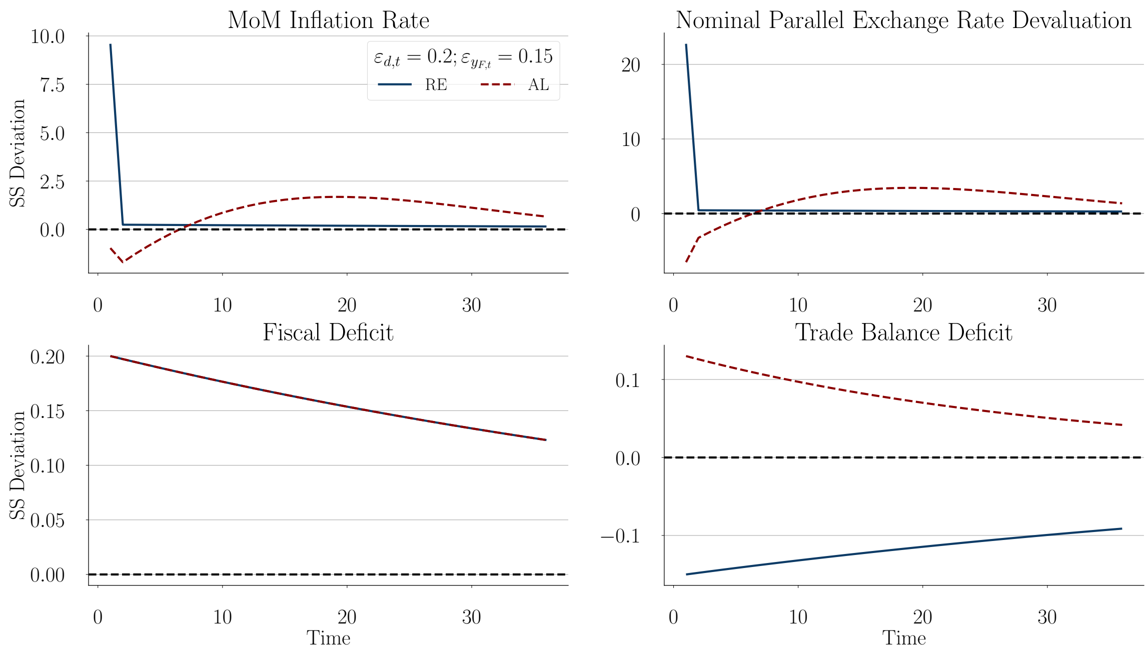


(b) Trade Balance Shock Dynamic

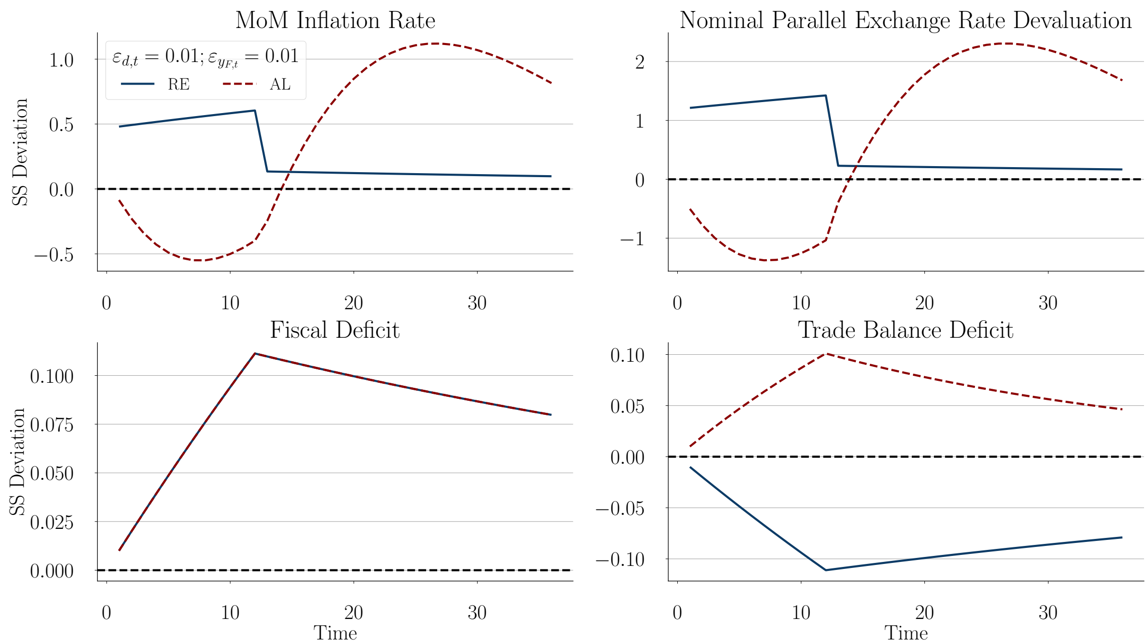
Figure 14: Dynamic effects with a fiscal deficit shock and a trade balance shock

In Figure 13, we observe that when a country experiences internal and external shocks in a single month, the RE model significantly impacts the month-to-month inflation rate more than the AL model. However, it is essential to note that in the RE model, a 1-month shock dissipates almost entirely after a few months. On the other hand, the AL model's impact seems less potent at first, but it is more persistent, leading to higher annual inflation. We observe longer and stronger persistence with the AL model when we supply shocks over a year. The only notable difference between the two models is the delayed overshooting of the exchange rate in the AL model. This occurs without imposing that the country's risk premium depends on past depreciation.

In the second exercise, we conducted a counterfactual analysis using the calibration for the Argentinian economy while maintaining the same shocks as before. The significant difference between the two calibrations is the steady state. The Venezuelan economy has a higher inflation rate and a constant fiscal deficit than Argentina. Due to the starting point differences between the two economies, we should also see differences in how the shocks impact the economy. This difference is evident in Figure 15.



(a) Argentina's IRFs for One Transitory Big Shocks



(b) Argentina's IRFs for Multi Transitory Small Shocks

Figure 15: Argentina's IRFs

Compared to Figure 13, the impulse response function (IRF) remains the same. However, the RE shocks have a more substantial impact, while the AL shocks persist over time. The AL model becomes more prevalent when the shocks are supplied every month. Not only is it persistent in time, but it also has a more significant effect.

Our research showed that by allowing short doses of the same shock in magnitude over time, the AL model outperformed the RE model in terms of persistence and significance. The RE model's resolution process does not allow internal feedback between the endogenous variables. However, when learning is introduced and agents begin to calculate their expectations, feedback occurs within the model, leading to a larger dynamic.

We have also conducted an IRF for a RE model encompassing only fiscal deficit shocks. This is to compare our results with the empirical findings of Catão and Terrones (2005). Their research shows that the inflation elasticity on a 1% increase in fiscal deficit is approximately 2.95. In other words, they estimated that a 1% rise in budgetary deficit over GDP could increase inflation by 19.1 percent. In our model, when we performed the same shock, we observed that inflation rose by 12.5% for Venezuela and 45% for Argentina. This indicates that our RE model is performing well and is not underperforming. This is essential as we will compare the model's fitness next and have evidence that the RE model is satisfactory overall. We have reported the results in table 5.

Country	RE model	AL model	Benchmark
Venezuela	14.9%	2.5%	19.1%
Argentina	96.4%	3.6%	19.1%

Table 5: Inflation Response to a 1% Fiscal Deficit Shock Comparison

6.2 Bayesian Model Comparison

To determine which model has a better empirical fit, we perform the second exercise of calculating the Bayes Ratio and obtaining the Posterior Model Probability. We compare the fitness of the AL and RE models for a given country and sample by comparing the Log Data density obtained after Bayesian Estimation. In other words, we check which model has a more significant Log Data density.

Country	Sample	Setting	Log Data Density	Log Bayes Ratio	Posterior Model Probability
Argentina	Calm Sample	RE	green -141.718	green 291.653	green 1.000
		AL	-433.371	-291.653	0.000
	Full Sample	RE	-145.584	-36.402	0.000
		AL	-109.183	36.402	1.000
	Messy Sample	RE	-36.730	-68.926	0.000
		AL	green 32.196	green 68.926	green 1.000
Venezuela	Calm Sample	RE	-58.203	-77.380	0.000
		AL	green 19.177	green 77.380	green 1.000
	Full Sample	RE	-330.880	-198.906	0.000
		AL	green -131.974	green 198.906	green 1.000
	Messy Sample	RE	-189.094	-143.953	0.000
		AL	green -45.141	green 143.953	green 1.000

Table 6: Empirical Fitness Evaluation

Based on the data in table 6, we can conclude that the AL model consistently performs better than the RE model regarding fitness in Venezuela. This is supported by the fact that the Posterior Model Probability is 1 for the AL model, indicating that it is more likely to predict the data accurately than the RE model.

In Argentina, the AL model performs better than the RE model for the full and messy samples. However, the RE model outperforms the AL model for the calm selection, suggesting that agents are more rational during this period due to better anchoring of expectations. Nevertheless, the AL model better fits the data in the messy sample where expectations are unanchored.

6.3 Theoretical Mean Variance Decomposition

Finally, our last exercise is to test how vital internal and external shocks are in the propagation of inflation and depreciation. To check this, we use the theoretical unconditional mean-variance decomposition. We will now use both models for both countries fully estimated.

Country	Shock Contribution (%)	π_t^{RE}	π_t^{AL}	$\Delta\epsilon_{B,t}^{RE}$	$\Delta\epsilon_{B,t}^{AL}$
Argentina	Fiscal Deficit Shock	1.00	0.99	0.69	0.75
	Trade Balance Deficit Shock	0.00	0.01	0.31	0.25
Venezuela	Fiscal Deficit Shock	1.00	0.72	0.73	0.52
	Trade Balance Deficit Shock	0.00	0.28	0.27	0.48

Table 7: Theoretical Mean Variance Decomposition

In Venezuela, the evidence presented in Table 7 supports our hypothesis of two channels. Fiscal deficit shocks in the RE setting for both countries drive inflation entirely. The same happens for Argentina in an AL model, but in the case of Venezuela, a trade balance shock gains relevance and explains almost 30% of the variance. Depreciation depends on both models of the two channels.

7 Conclusion

In this paper, we aim to explore three points: Firstly, we analyze how inflation expectations are formed. Secondly, we examine the role of exchange rate depreciation, mainly caused by external and internal shocks, in developing inflation expectations. Lastly, we compare and contrast the critical differences between the economies of Venezuela and Argentina.

Our analysis focuses on inflation dynamics and foreign exchange rates in emerging economies, notably Venezuela and Argentina. We have drawn three main conclusions from our study. Our research shows that internal and external imbalances can trigger high or hyperinflation episodes. Fiscal deficits and exchange rate depreciation can contribute to inflationary spirals, and these imbalances interact in complex ways. Secondly, we have developed a DSGE model that considers internal and external imbalances and incorporates the expectations of inflation rates and exchange rate depreciation. Our model shows that money demand and inflation are both heavily influenced by these expectations and that the dynamics of these expectations are critical in understanding inflationary episodes. Finally, we have found that agents in our model weigh more on exchange rate depreciation expectations, underscoring the significance of considering exchange rate expectations in understanding inflation dynamics in emerging market economies. Our analysis offers insights into the complex dynamics of inflation and foreign exchange rates in emerging market economies and emphasizes the importance of incorporating expectations into macroeconomic models.

Our study leads us to several key findings. Firstly, we have used two ways of modeling expectations, Rational Expectations (RE) and Adaptive Learning (AL), and found that AL provides better empirical fitness to the data, highlighting the importance of incorporating learning dynamics into macroeconomic models like Slobodyan and Wouters (2012) and Marcet and Nicolini (2003). Secondly, we have discovered that hyperinflation and high inflation episodes are more related to persistence than magnitude, underscoring the importance of considering the dynamics of inflation expectations in understanding inflationary episodes. Finally, we have found that RE models tend to perform better depending on the inflation level, which suggests better anchoring of expectations, while AL is related to more chronic problems. Our analysis provides insights into emerging market economies' complex inflation dynamics and foreign exchange rates. It emphasizes the significance of incorporating expectations and learning dynamics into macroeconomic models. Moreover, our model provides evidence that any perturbation in Argentina's internal and external balances could have potential effects and bring the country into a hyperinflation episode.

This paper contributes several ways to the literature on inflation expectations and exchange rate dynamics. Firstly, we provide a detailed analysis of the formation of inflation expectations, highlighting the role of exchange rate depreciation. Secondly, we draw insights into the differences between Venezuela's and Argentina's economies, which have recently experienced chronic inflation. Thirdly, we draw on related literature on exchange rate pass-through, hyperinflation dynamics, and learning to develop a rational expectations model that can be used to estimate and calibrate the impact of exchange rate shocks on inflation. Finally, we offer policy recommendations for addressing chronic inflation and protecting vulnerable households, which can be helpful for policymakers and central banks in other countries facing similar challenges.

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A Money Demand Log-lineal Derivation

This section will show the process that gave us the log-lineal Money Demand. First we define the following relation: $\hat{x}_t = \ln(x_t) - \ln(\bar{x})$. If we re-arrange, we get: $x_t = \bar{x}e^{\hat{x}_t}$. This will be our log-lineal transformation. We apply this to all the variables in equation (11) getting:

$$\bar{m}e^{\hat{m}_t} = \phi\bar{c}e^{\hat{c}_t}\left[1 - \beta\mathbb{E}_t\frac{\bar{c}e^{\hat{c}_t}}{\bar{\pi}e^{\hat{\pi}_{t+1}}\bar{c}e^{\hat{c}_{t+1}}}\right]^{-1}$$

We defined in section 5 that c_t will be normalized at the steady state to 1. Simplifying and sorting, we can re-write the equation as:

$$\bar{m}e^{\hat{m}_t} - \frac{\beta\bar{m}}{\bar{\pi}}\mathbb{E}_t e^{\hat{m}_t + \hat{c}_t - \hat{\pi}_{t+1} - \hat{c}_{t+1}} = \phi e^{\hat{c}_t}$$

Now, we can linearize this equation around steady-state and get:

$$\bar{m}(1 + \hat{m}_t) - \frac{\beta\bar{m}}{\bar{\pi}}\mathbb{E}_t(1 + \hat{m}_t + \hat{c}_t - \hat{\pi}_{t+1} - \hat{c}_{t+1}) = \phi(1 + \hat{c}_t)$$

In section 5, we also got an expression for ϕ in equation (35). If we use it, we get:

$$\bar{\pi}(1 + \hat{m}_t) - \beta\mathbb{E}_t(1 + \hat{m}_t + \hat{c}_t - \hat{\pi}_{t+1} - \hat{c}_{t+1}) = (\bar{\pi} - \beta)(1 + \hat{c}_t)$$

Further algebra gets us:

$$\hat{m}_t = \hat{c}_t - \frac{\beta}{(\bar{\pi} - \beta)}\mathbb{E}_t(\hat{\pi}_{t+1} + \hat{c}_{t+1} - \hat{c}_t)$$

We want our money demand to be completely dependent on inflation rate expectations and exchange rate depreciation, so we replace $\hat{c}_{t+1}$ using the definition of the Optimal Foreign Consumption:

$$\hat{c}_{t+1} = \frac{y_{F,t+1}}{1 - \alpha} + \eta\hat{\epsilon}^r_{t+1} - 1$$

$$\hat{c}_t = \frac{y_{F,t}}{1 - \alpha} + \eta\hat{\epsilon}^r_t - 1$$

So:

$$\hat{c}_{t+1} - \hat{c}_t = \frac{y_{F,t+1} - y_{F,t}}{1 - \alpha} + \eta(\hat{\epsilon}^r_{t+1} - \hat{\epsilon}^r_t)$$

We replace this expression in our money demand equation:

$$\hat{m}_t = \hat{c}_t - \frac{\beta}{(\bar{\pi} - \beta)}\mathbb{E}_t(\hat{\pi}_{t+1} + \frac{y_{F,t+1} - y_{F,t}}{1 - \alpha} + \eta(\hat{\epsilon}^r_{t+1} - \hat{\epsilon}^r_t))$$

We know that $\hat{\Delta\epsilon}^r_{t+1} = \hat{\epsilon}^r_{t+1} - \hat{\epsilon}^r_t$ and using the definition of the exchange rate composition we get:

$$\hat{\Delta\epsilon}^r_{t+1} = (1 - \gamma)\hat{\Delta\epsilon}_{t+1} - \hat{\pi}_{t+1}$$

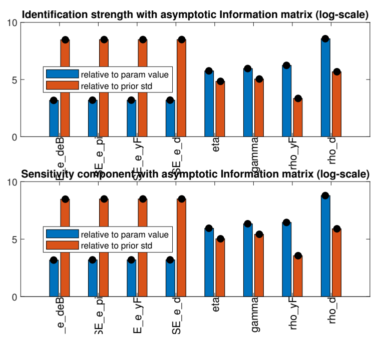
Plug into our money demand equation to get:

$$\hat{m}_t = \hat{c}_t - \frac{\beta}{(\bar{\pi} - \beta)}\mathbb{E}_t\left(\frac{y_{F,t+1} - y_{F,t}}{1 - \alpha} + \eta(1 - \gamma)\hat{\Delta\epsilon}_{t+1} + (1 - \eta)\hat{\pi}_{t+1}\right)$$

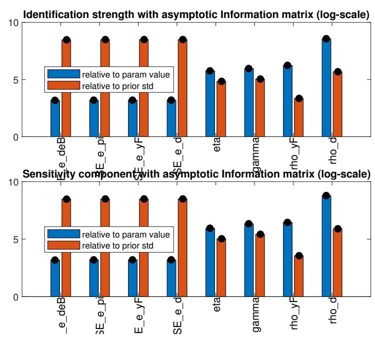
B Bayesian Estimation Diagnostics

This section provides all the tests and diagnostics performed during our Bayesian Estimation.

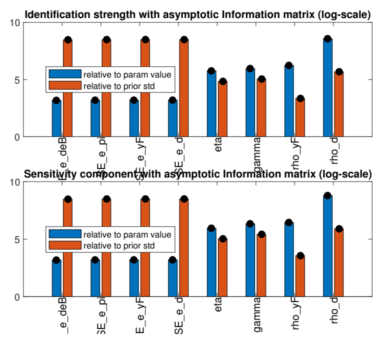
B.1 Identification



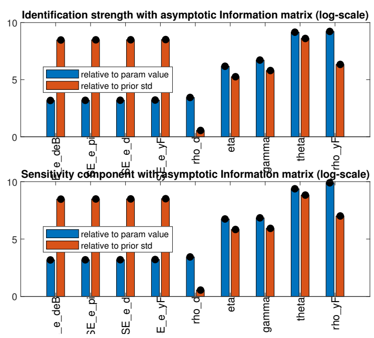
(a) RE Full Sample



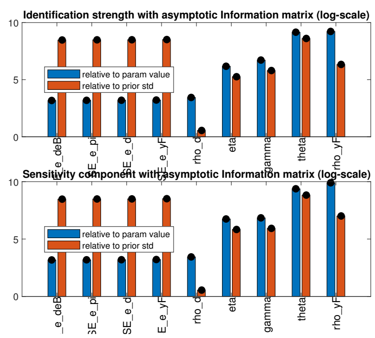
(b) RE Calm Sample



(c) RE Messy Sample



(d) AL Full Sample



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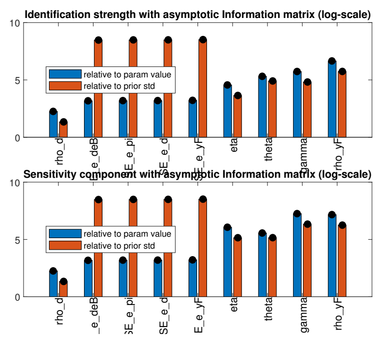
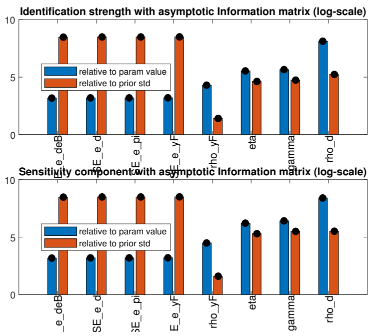
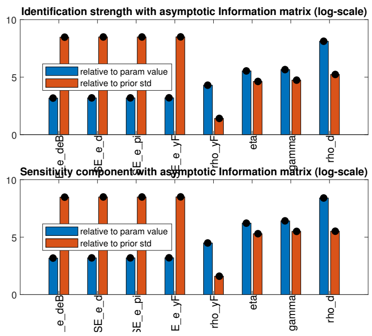


(f) AL Messy Sample

Figure 16: Venezuela Prior mean - Identification using info from observables.



(a) RE Full Sample



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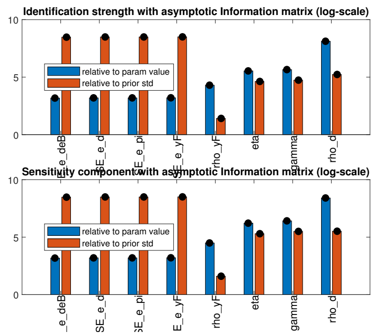

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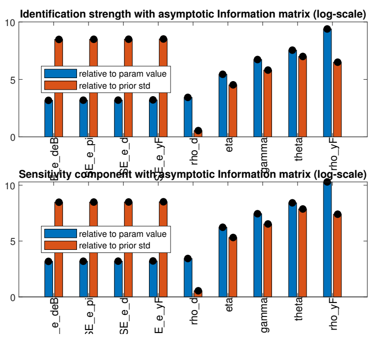
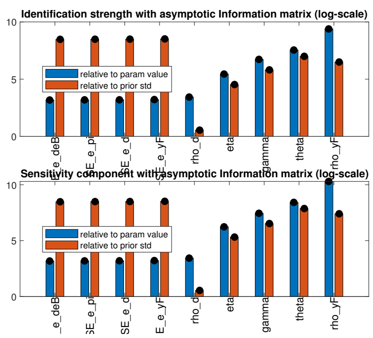
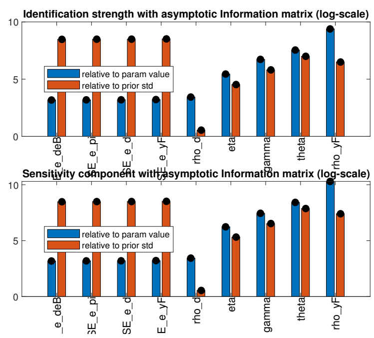


(d) AL Full Sample



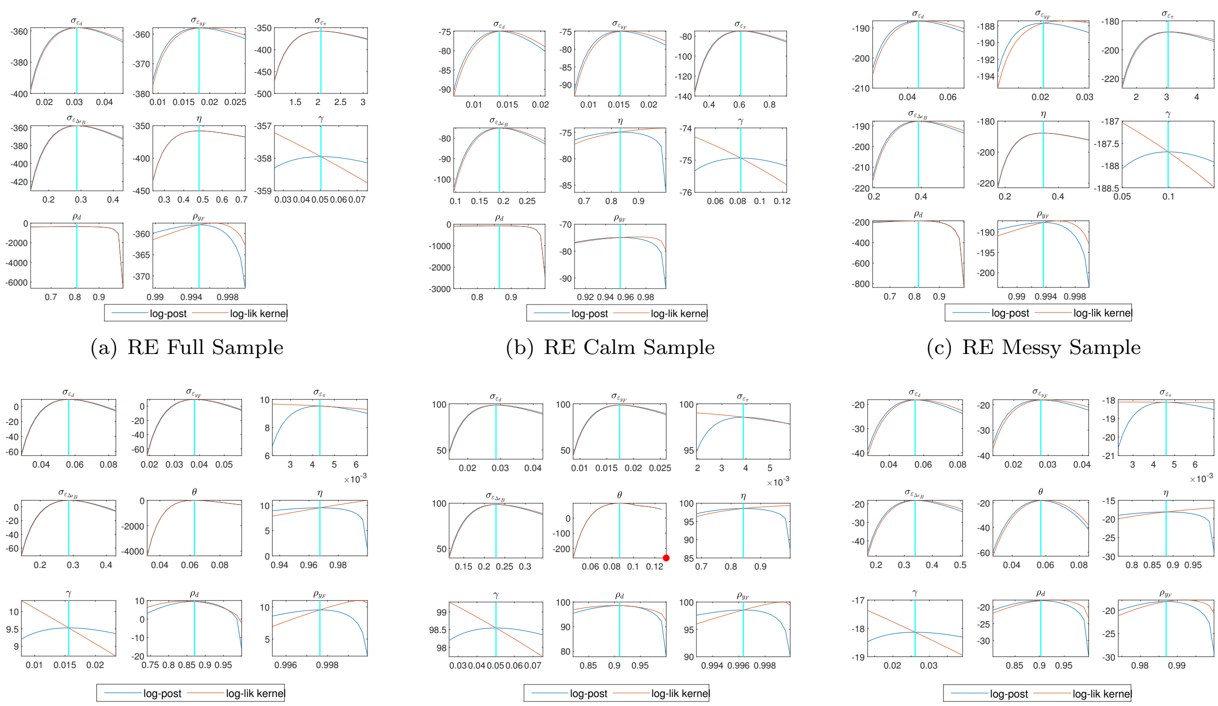
(e) AL Calm Sample



(f) AL Messy Sample

Figure 17: Argentina Prior mean - Identification using info from observables.

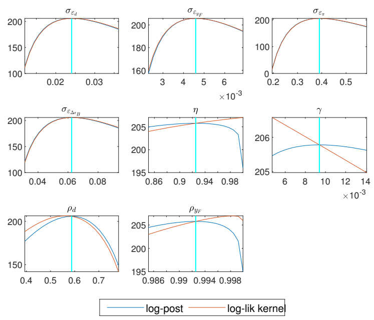
B.2 Mode Check



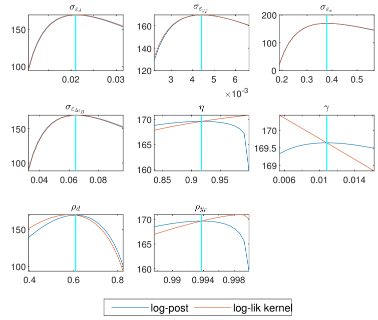
(a) RE Full Sample (b) RE Calm Sample (c) RE Messy Sample

(d) AL Full Sample (e) AL Calm Sample (f) AL Messy Sample

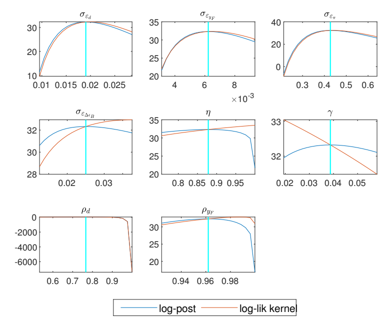
Figure 18: Venezuela Mode Check Plots



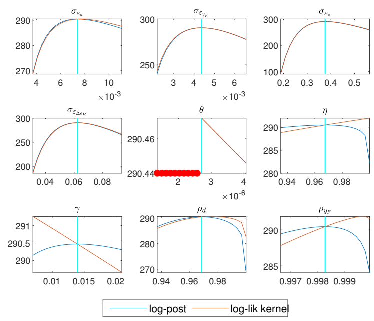
(a) RE Full Sample



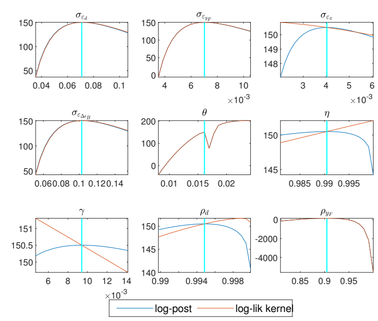
(b) RE Calm Sample



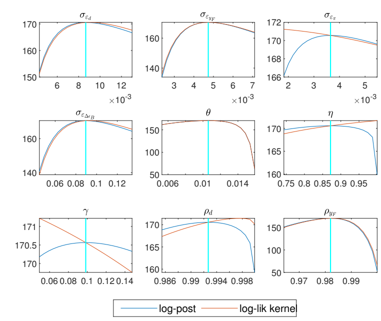
(c) RE Messy Sample



(d) AL Full Sample



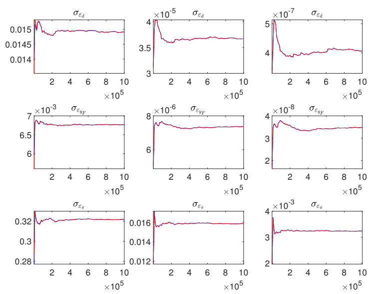
(e) AL Calm Sample



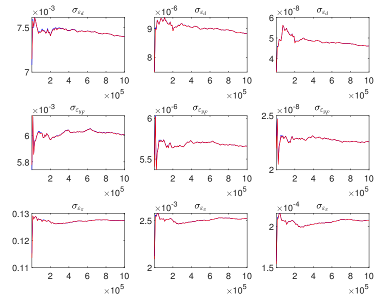
(f) AL Messy Sample

Figure 19: Argentina Mode Check Plots

B.3 Univariate Diagnostics



(a) RE Full Sample Part 1



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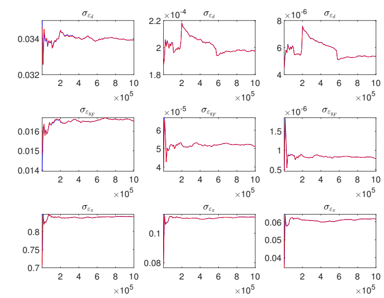

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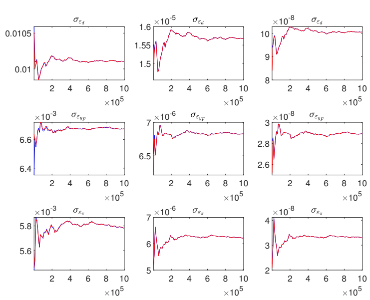

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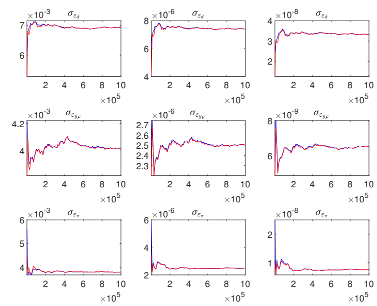

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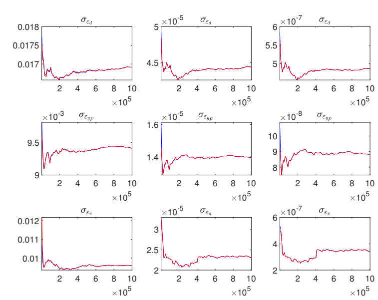
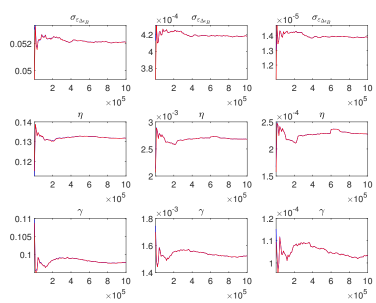
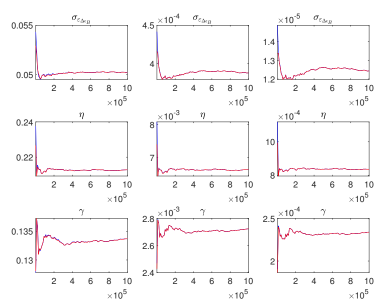


(f) AL Messy Sample Part 1



(g) RE Full Sample Part 2



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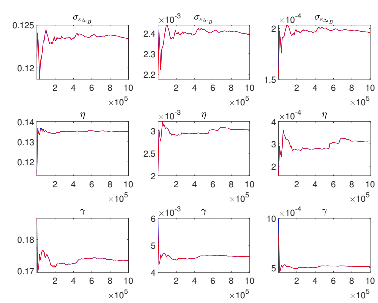

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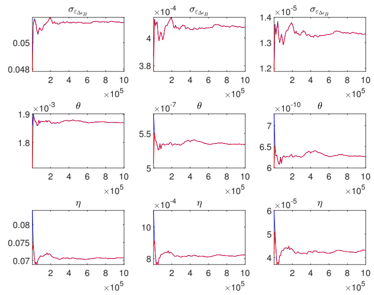

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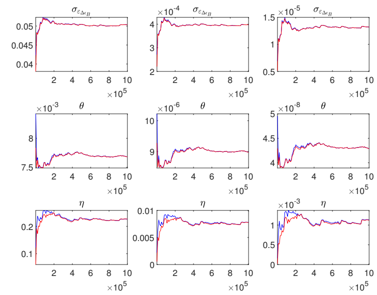

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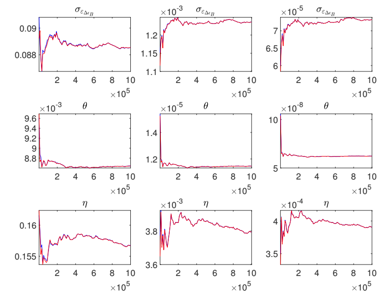
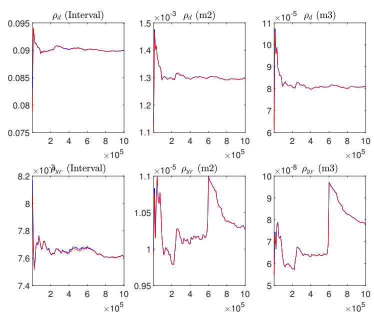
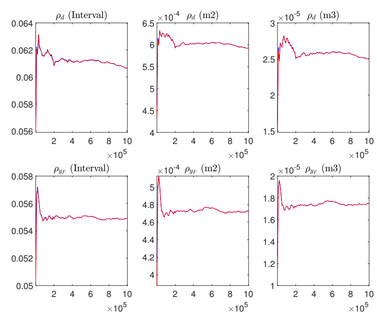


(l) AL Messy Sample Part 2



(m) RE Full Sample Part 3



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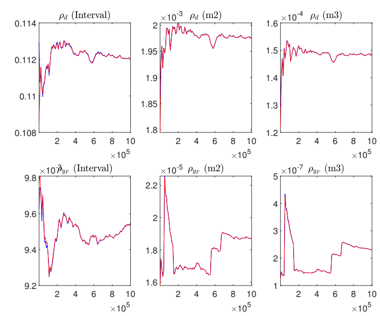
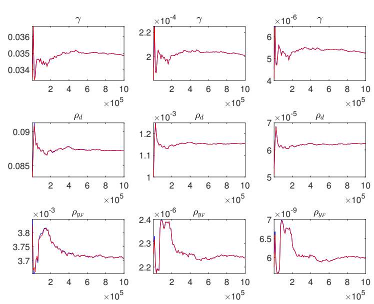
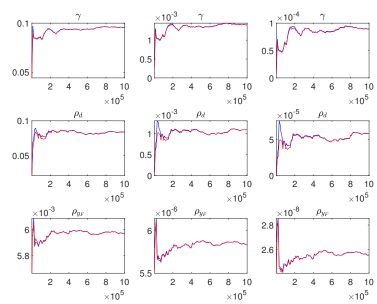


(o) RE Messy Sample Part 3



(p) AL Full Sample Part 3



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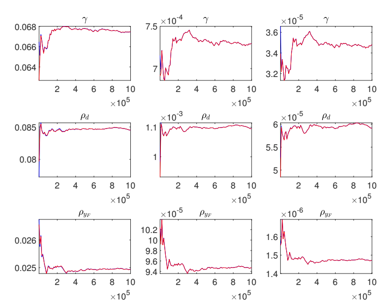
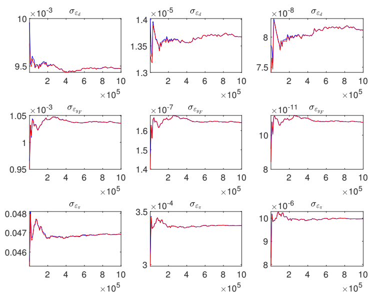
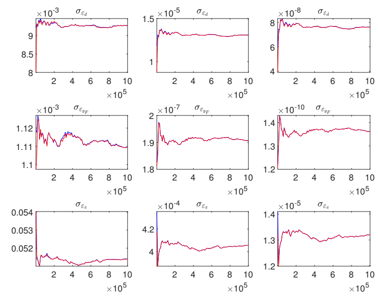


(r) AL Messy Sample Part 3

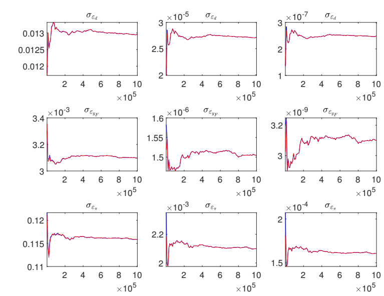
Figure 20: Venezuela Univariate convergence diagnostics for the Metropolis-Hastings. The first, second, and third columns are the criteria based on the eighty percent interval, the second and third moments.



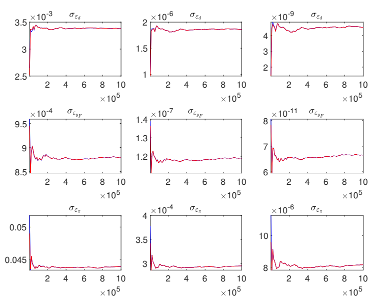
(a) RE Full Sample Part 1



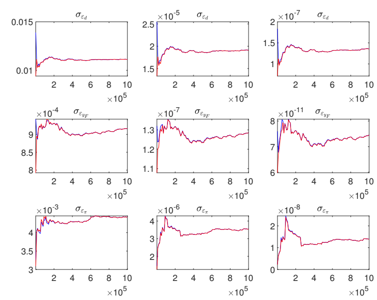
(b) RE Calm Sample Part 1



(c) RE Messy Sample Part 1



(d) AL Full Sample Part 1



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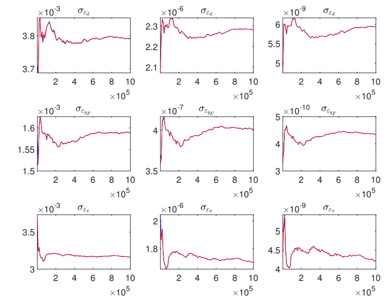

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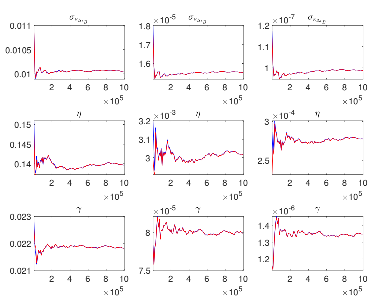
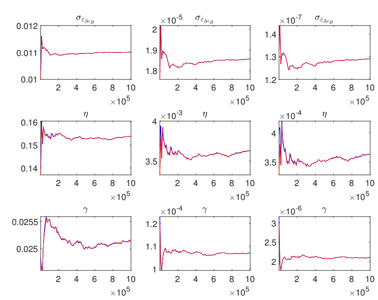


(g) RE Full Sample Part 2



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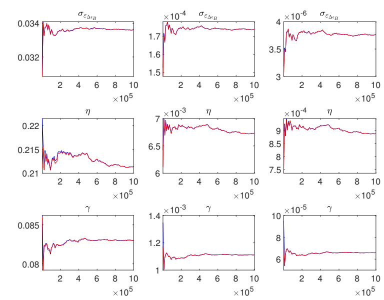

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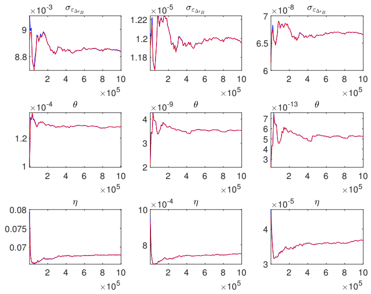

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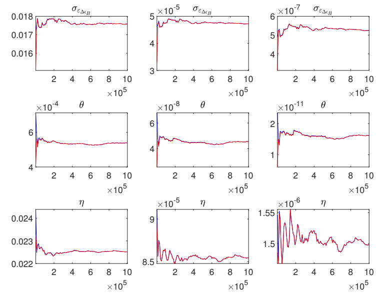

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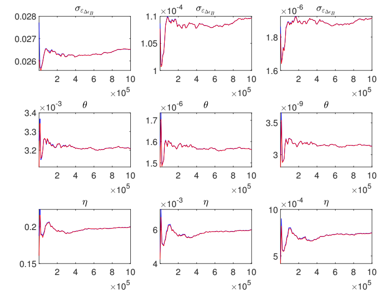

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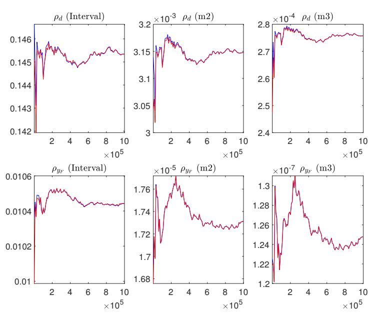

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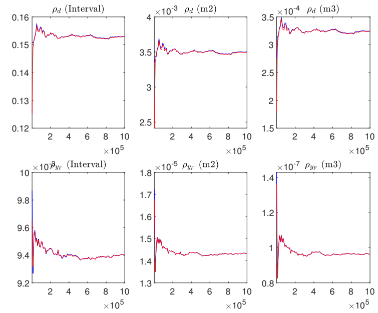
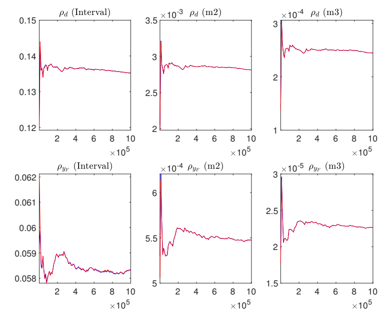


(n) RE Calm Sample Part 3



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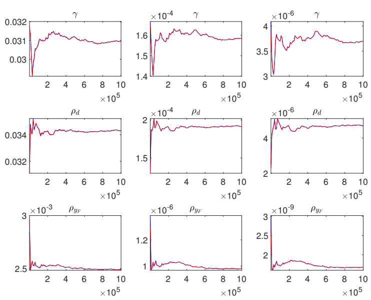
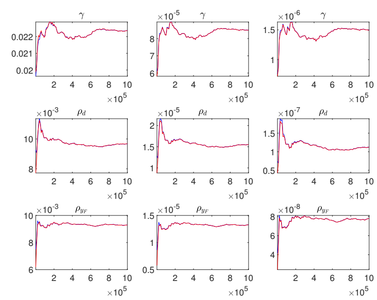


(p) AL Full Sample Part 3



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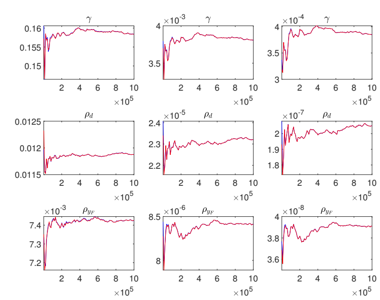
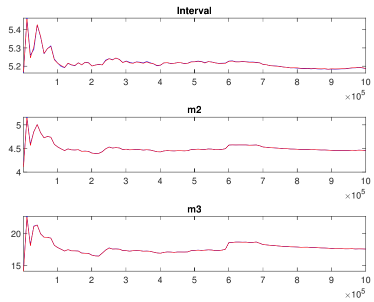


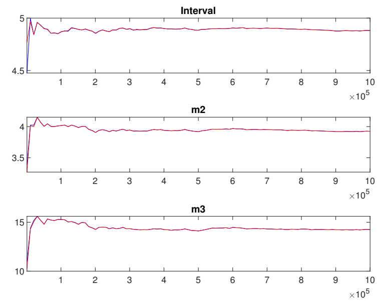
(r) AL Messy Sample Part 3

Figure 21: Argentina Univariate convergence diagnostics for the Metropolis-Hastings. The first, second, and third columns are the criteria based on the eighty percent interval, the second and third moments.

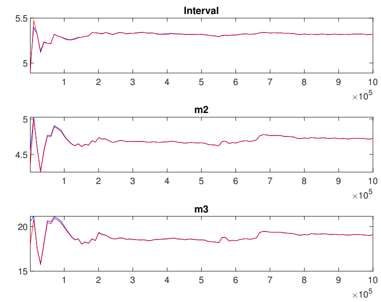
B.4 Multivariate Diagnostics



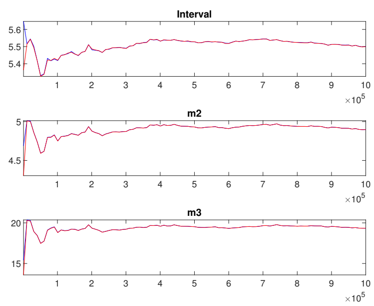
(a) RE Full Sample



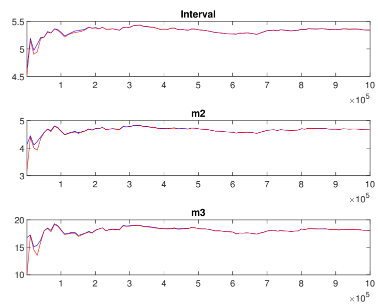
(b) RE Calm Sample



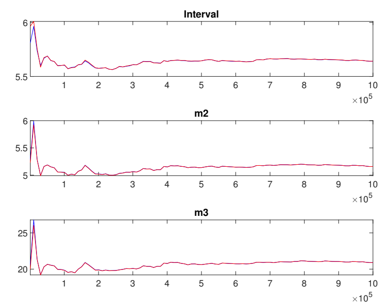
(c) RE Messy Sample



(d) AL Full Sample

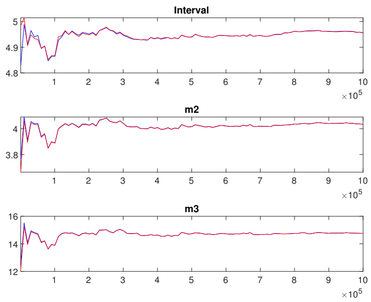


(e) AL Calm Sample

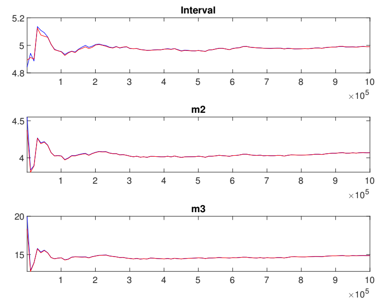


(f) AL Messy Sample

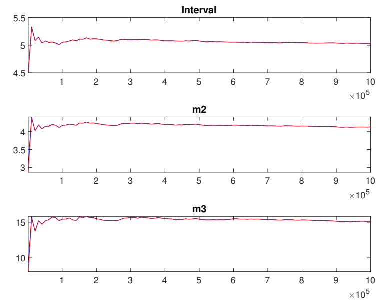
Figure 22: Venezuela Multivariate convergence diagnostics for the Metropolis-Hastings. The first, second, and third rows are the criteria based on the eighty percent interval, the second and third moments. The different parameters are aggregated using the posterior kernel.



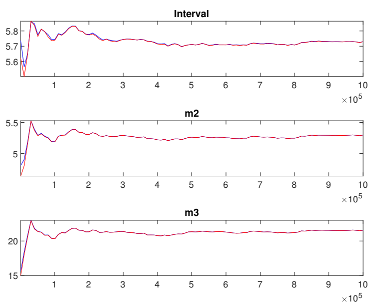
(a) RE Full Sample



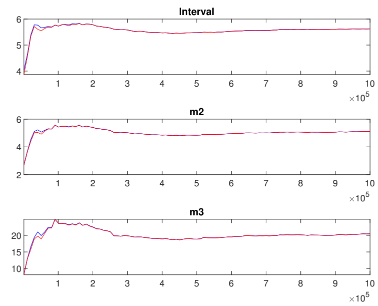
(b) RE Calm Sample



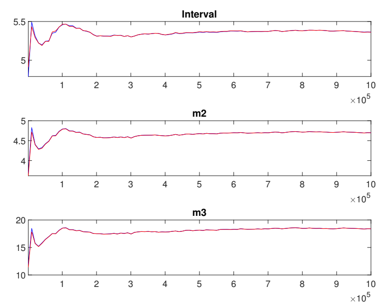
(c) RE Messy Sample



(d) AL Full Sample



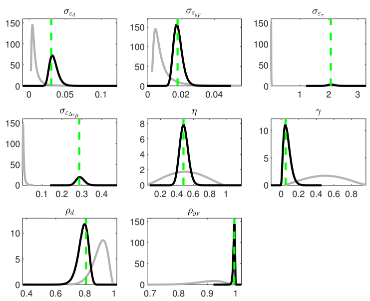
(e) AL Calm Sample



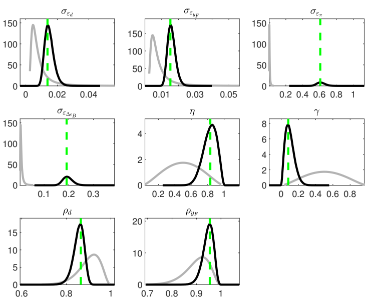
(f) AL Messy Sample

Figure 23: Argentina Multivariate convergence diagnostics for the Metropolis-Hastings. The first, second, and third rows are the criteria based on the eighty percent interval, the second and third moments. The different parameters are aggregated using the posterior kernel.

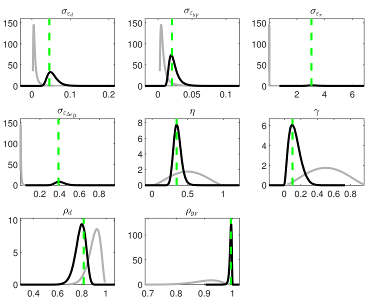
B.5 Prior and Posterior Distributions



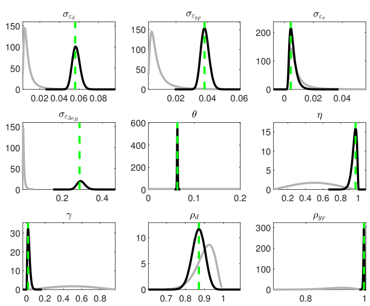
(a) RE Full Sample



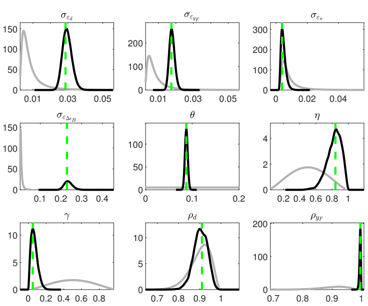
(b) RE Calm Sample



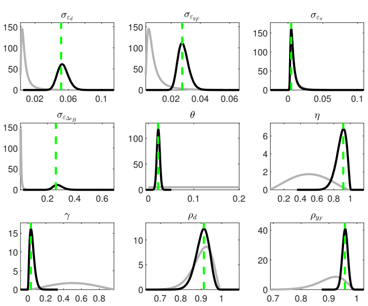
(c) RE Messy Sample



(d) AL Full Sample

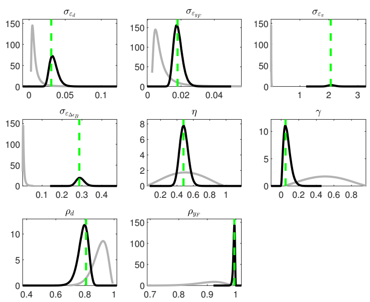


(e) AL Calm Sample

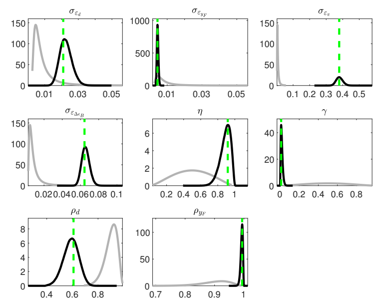


(f) AL Messy Sample

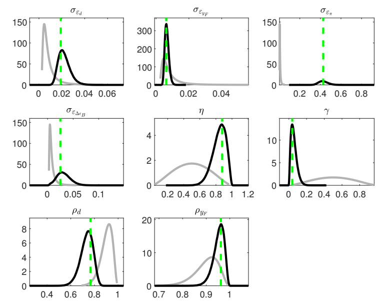
Figure 24: Venezuela Priors and Posteriors.



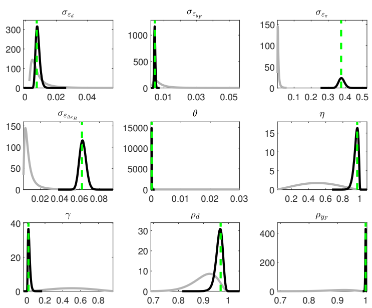
(a) RE Full Sample



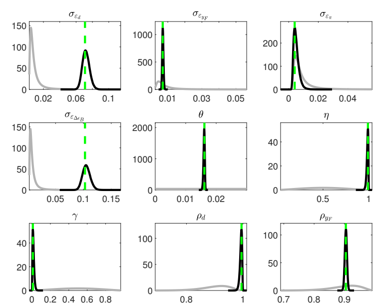
(b) RE Calm Sample



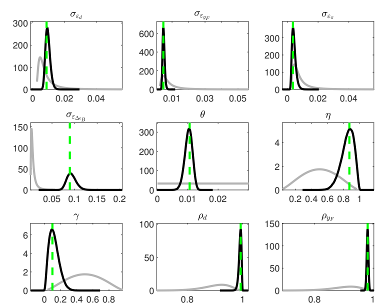
(c) RE Messy Sample



(d) AL Full Sample



(e) AL Calm Sample



(f) AL Messy Sample

Figure 25: Argentina Priors and Posteriors.