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# The Trend-cycle Connection

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# The trend-cycle connection*

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**Abstract**

Long-run growth in Latin America over the last 50 years has been low and volatile in the presence of frequent Sudden Stops. We develop a theory that links long-run growth, financial frictions, and Sudden Stops in Emerging countries. Our theory exploits the fact that reversals in trade balance during Sudden Stops occur through sharp declines in imports, particularly of imported investment, rather than increases in exports. Imported investment, in turn, has a permanent impact on economic growth. We find that trend growth deteriorates during Sudden Stops and, even though trend shocks play a crucial role, financial frictions and shocks have a significant impact on its dynamics. We apply our model to the Sudden Stops in Argentina since the 1950s and find that financial crises have a strong permanent effect on the trend. Hence, to a large extent, the trend is the cycle.

**Keywords:** Emerging markets; Real business cycle; trend shocks; Financial Frictions.

**JEL Classification**: F32, F34, F41.

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# 1 Introduction

This paper develops a theory of the business cycle of Emerging Countries that exploits the interaction between endogenous growth and the cycle in the context of recurrent Sudden Stops with financial frictions. Our hypothesis is that the frequent Sudden Stops combined with financial frictions generate the excess volatility of the business cycle that, in turn, translates into the long-run stagnation of Latin American countries. In our framework, imported investment and its contribution to long-run growth is a key piece of the connection between the business cycle and the trend.

We design a DSGE model for a small open economy with three main features: (1) endogenous growth together with trend shocks, (2) financial frictions in the corporate sector, (3) imported investment goods. Financial frictions affect the capability of importing investment goods. During a financial crisis, imports of investment goods decrease, which drags down long-run growth at the same time as improving the trade-balance. This mechanism generates the dynamics of Aguiar and Gopinath (2007) endogenously and captures a relatively unexplored stylized fact: Sudden Stops are characterized by a drop in imports rather than an increase in exports, that goes in line with the empirical results from Alessandria et al. (2015) and Gopinath and Neiman (2014).

We contrast our theory to the data. We estimate our model using data from Argentina during the period 1951-2015. This sample is rich in terms of macroeconomic dynamics since it includes large and persistent macroeconomic swings and multiple Sudden Stops. We show that the model generates a good fit of the data and fits the standard business cycle facts as well as the financial crisis episodes. As in the data, a fall in imported capital which, in turn, deteriorates future output growth, plays a key role in the trade balance increase during Sudden Stops.

We use the model to decompose the role of real and financial shocks as well as financial frictions during normal times and Sudden Stops. We find that productivity shocks (transitory and permanent) are important for the business cycle in Argentina, but they are far from being the only source of variability. Solely these shocks are unable to generate the right comovement observed in the business cycle of emerging countries when endogenous growth and financial frictions are taken into account. The financial aspects of the economy are also relevant transmission channels.

Focusing on Sudden stops, we find that technology shocks and entrepreneurial risk play a central role in the development of the average crisis. On top of this, financial frictions explain part of the slow recovery of the trend after a Sudden Stop. The recovery operates strongly through the endogenous trend. We analyze the dynamics implied by the model around various Sudden Stops. Our model suggests that the financial crisis have strong and persistent impact on the trend of the economy.

Our paper contributes to the literature on the business cycle in emerging countries. Aguiar and Gopinath (2007) shows that the trend in emerging economies is more volatile than in developed economies and in their stylized real business cycle model, this explains the excess volatility of the former ones. Garcia-Cicco et al. (2010) challenged these findings by claiming that emerging economies tend to be subject to higher financial frictions than developed ones. These papers opened a literature that includes Akinci (2014), Chang and Fernández (2013), Miyamoto and Nguyen (2017) and Seoane (2016), among others, that try to assess the importance of trend shocks and financial frictions for emerging economies. In most of these papers, with the notable exception of Akinci (2014), the degree of financial frictions is measured as a reduced form function of the debt, output, or terms of trade. Moreover, in all these papers the trend growth is fully exogenous. The contribution of our paper to this branch of the literature is to evaluate the importance of financial factors in the dynamics of the trend, i.e. in the long-run growth of the economy. In other words, we consider economies where the trend is not independent of the degree of financial frictions.

Our paper also relates to the literature on medium-term macroeconomics analyzed by Comin (2004) and Comin and Gertler (2006), among others. This literature, however, has not focused on the macroeconomics of emerging economies from the viewpoint we draw here. In particular, studying the impact of financial frictions and imported inputs to the business cycle and the trend represents our novel contributions to this strand of the literature.

Two recent articles relate closely to our approach. Guerron-Quintana and Jinnai (2019) studies whether the financial crisis in the US had a permanent impact level of output. Besides focusing on the US, the model is substantially different from the setting we develop here as the authors consider a Kiyotaki and Moore (1997) financial constraint in a closed economy setting. Yet, we share with the authors the interest in addressing the long-term impact of financial crises. The second related reference is Queralto (2019) who study the impact of financial crises on output, innovation, and productivity. The objective of the paper is, however, different to ours. The paper does not focus on the trend, but on how financial crisis can have a persistent economic impact. It abstracts from the role of permanent shocks and imported investment and focuses exclusively on the 1997 Korean crisis. Additionally, we consider the dynamics during normal times as well as during crisis, with a contribution to the study of the main drivers of business cycle in the context of endogenous growth. We see the two papers as complements.

Our paper is also related to the literature that studies business cycle dynamics and endogenous growth, both in emerging markets, as in Ates and Saffie (2016), Benguria et al. (2020), and Matsumoto et al. (2018); and in the US, as in Bianchi et al. (2019) and Anzoategui et al. (2019). Our contribution to this branch of the literature is that we provide a quantitative decomposition on the sources of variability of growth and the importance that financial crisis may have in the long run dynamics of Emerging Economies.

The remainder of the paper goes as follows. In the next section, we review the data to introduce our working hypotheses. In section 3 we introduce the theoretical model. Section 4 discusses our data and empirical approach. Section 5 presents the main estimation results and model fit. In section 6 we discuss the main quantitative findings, with focus on the analysis of the impact of shocks and transmission channels in normal times. Section 7 explores the dynamics during Sudden Stops and disentangle the roles of shocks and friction in the trend dynamics. In section 8 we conclude.

## 2 Some facts during Sudden Stops

The typical financial crisis in small open emerging economies is a Sudden Stop. As studied in Calvo et al. (2006), Mendoza (2010), Kaminsky et al. (2004) and Seoane and Yurdagul (2019), among others, a Sudden stop of international capital flows tend to occur together with output falls, asset prices crash and increases in sovereign spreads, and a reversal of trade balance, from deficit to surplus. A key feature of the adjustment that has not been studied so far relates to the sources of the trade balance reversal. If the trade balance turns to a surplus from competitiveness gains the Sudden Stop could represent the start of a new growth cycle. Instead, if it comes from a fall in imports it could contribute to lower output growth in the medium and long run. In this section we study Sudden Stops dynamics for different groups of countries with a focus on the dynamics of the trade balance and its components.[1]

## 2.1 Emerging Economies

Table 1 presents some growth statistics for Developed and Emerging Economies.

Table 1: Growth and Sudden Stop statistics (1960-2018)

| | **Mean growth rate (%)** | **Growth volatility (%)** | **Number of sudden stops** |
|---|---|---|---|
| **Emerging SOE** | 1.96 | 4.20 | 137 (4) |
| **LA countries** | 1.72 | 3.70 | 66 (6) |
| **Developed SOE** | 2.21 | 2.39 | 23 (2) |
| **US** | 1.96 | 1.97 | 1 |
| **UK** | 1.96 | 2.03 | 2 |
| **Japan** | 3.00 | 3.36 | 1 |
| **China** | 6.37 | 6.88 | 5 |
| **India** | 3.19 | 3.03 | 2 |

Notes: The statistics for Emerging SOE, LA countries and Developed SOE are the cross-sectional population weighted average among the statistics of each country (for the number of Sudden Stops, in parenthesis we present the average per country). *Developed SOE:* Australia, Austria, Belgium, Canada, Switzerland, Denmark, Spain, Finland, Iceland, Netherlands, Norway, New Zealand, Portugal, Sweden. *Emerging SOE:* Albania, Argentina, Antigua and Barbuda, Bulgaria, Belize, Bolivia, Brazil, Barbados, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Algeria, Ecuador, Egypt, Grenada, Guatemala, Guyana, Honduras, Iran, Jordan, St. Lucia, Morocco, Mexico, Panama, Peru, Paraguay, El Salvador, Tunisia, Turkey, Uruguay, Venezuela. *LA countries:* Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Paraguay, Uruguay, Venezuela.

During the period 1960-2018, the weighted average annual growth rate in Latin America (LA) was 1.7%. Instead, developed small open economies have grown 2.2% per year on

[1]The data is annual and from the World Bank's World Development Indicators (WDI) dataset. The sample period starts in 1960; however, the data availability varies across countries. To construct the statistics, we keep only data from selected countries for which we have at least 30 uninterrupted observations for output, exports, and imports.

average. Output growth has been almost 80% more volatile in Emerging economies, despite its worst performance. The table also shows the number of Sudden Stop episodes in the data for each country and region.

We define a Sudden Stop episode as a year in which the country presents a 2% fall in the GDP and 2 p.p. increase in net exports to output ratio, following Seoane and Yurdagul (2019). As we can see in Table 1, emerging countries, and especially Latin American countries suffered, on average, this type of crisis more often than developed countries. Not surprisingly, Emerging and Latin American economies have also experienced the lowest average growth with the highest output volatility over the postwar sample. This last stylized fact suggests a persistent effect of Sudden Stops on economic development, affecting the output growth rate for several periods.

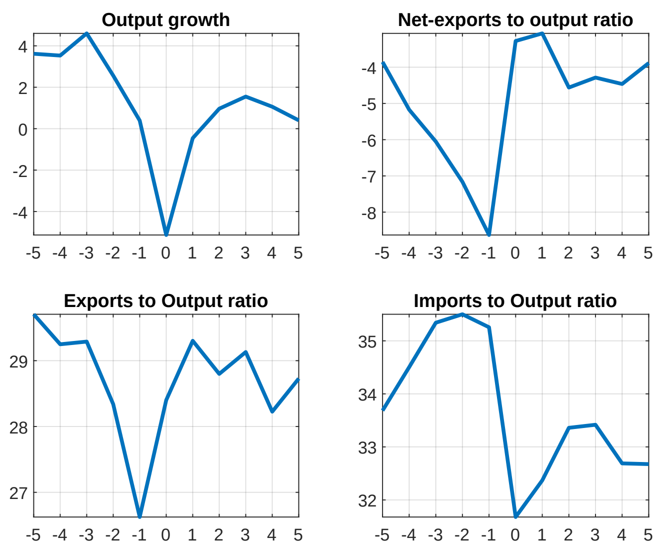


Figure 1: Sudden stops dynamics in Emerging Countries

Note: The period 0 identifies the year of a Sudden Stop episode. The figure presents mean values of variables, in a sample of 64 Sudden Stops. Output growth is in percentages.

To study the dynamics during these events we construct a database of Sudden Stop episodes in emerging countries. We identify the year of the Sudden Stop as period $t = 0$ and keep the values of output growth, net exports to output ratio, exports and imports to output ratio during the five years before and after the episode. If the five years before and after were not contained in the sample period, or if another Sudden stop occurred less than five years before, the event was discarded. With that methodology, we obtained 64 Sudden Stops. The figures 1 and 2 present the mean of the variables described before across these episodes.

As seen in Figure 1, both the increase of the net-exports deficit, from -4p.p. to almost -9p.p. in terms of GDP, before the Sudden Stop and the increase in the trade balance to output ratio at the Sudden Stop is mainly driven by the dynamics of imports. Exports seem to drop before and slowly increase after the Sudden Stop, but the changes in this variable are smaller and smoother than those of imports, as can be seen by the scale in the bottom pictures of Figure 1. This is more clearly in Figure 2, that reinforces this feature of Sudden Stops: it presents imports and exports as deviations from a linear trend. As can be seen in the figure, before the Sudden Stop, imports are 12% above trend and fall to 8% below trend in 1 year. The evolution of exports is an order of magnitude less volatile. This is not a surprise, indeed, the trade literature has already highlighted that increasing exports may not be too easy as becoming an exporter may take time. The key features of Sudden Stops are driven to a large extent by rapid expansion and sudden contraction of imports, which is, of course, the real counterpart of the rapid expansion and contraction of capital inflows.

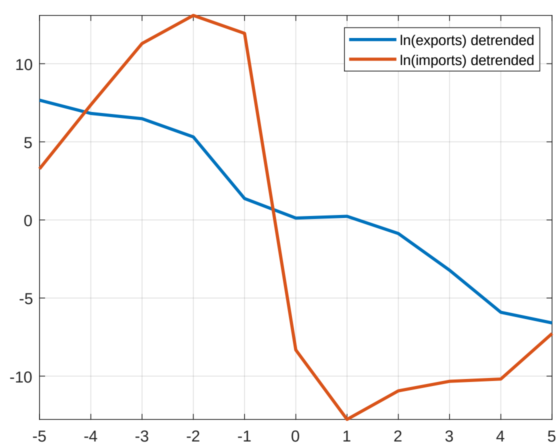


Figure 2: Detrended exports and imports during a sudden stop in Emerging Countries

Note: The period 0 identifies the year of a Sudden Stop episode. The figure presents mean values of percentage deviations of imports and exports from a linear trend, in a sample of 64 Sudden Stops.

In figure 3, we plot the behavior of imported investment during Sudden Stops. This plot shows the average growth rate (in %), from a sample of 25 Sudden Stops in Emerging Countries, in the period 1976-2018.[2] As seen in the plot, imported capital collapses during Sudden Stops. Its growth starts ameliorating four periods before the crisis, and its growth rate falls around 30 p.p. at the Sudden Stop. Since this variable represents between 13% and 27% of total imports in emerging countries during the sample period, we argue it plays a fundamental role in the reverse of the trade balance during Sudden Stops.

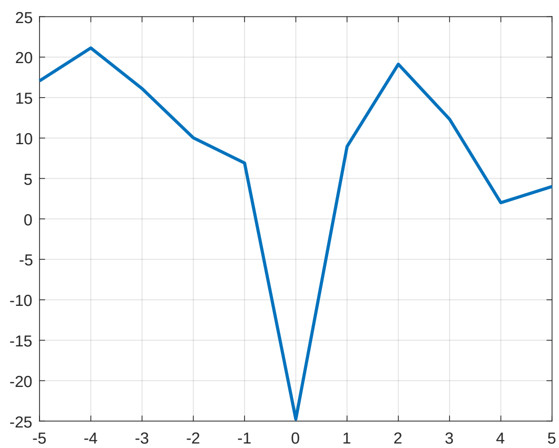


Figure 3: Sudden stops dynamics in Emerging Countries

Note: The period 0 identifies the year of a Sudden Stop episode. The figure presents mean values of variables, in a sample of 25 Sudden Stops, in the period 1976-2017. Imported capital growth rate is in percentage. Details of the data used in this figure is available in the appendix.

## 2.2 Argentina's stylized facts

Argentinean data allow us to dig deeper into our working hypothesis. This section uses data from *Instituto Interdisciplinario de Economía Política de Buenos Aires*, IIEP (2018). In particular, our data measures separately investment in domestic transport and equipment goods, and investment in imported transport and equipment goods. The sum of both variables constitutes total imported investment. Figure 4 presents the main dynamics around

[2] In this figure, imported investment goods is the sum of imports in capital goods (except transport equipment), and industrial transport equipment, according to Broad Economic Categories (BEC). For this variable, data is annual and comes from the World Integrated Trade Solution (WITS), from the World Bank. The sample period is more limited due to data availability, as we explain in the section 10.1 in the appendix. To construct this figure, we followed the same methodology that for the rest of the variables.

Sudden Stops for the episodes in Argentina for the period 1951-2015. Following the methodology previously described, we identified 9 Sudden Stop episodes in Argentina. However, to isolate the effect one sudden stop may have in the following episode when we identify two events with less than 5 years of difference, we keep only with the first one. Then, the statistics are obtained from 5 sudden stops.[3]

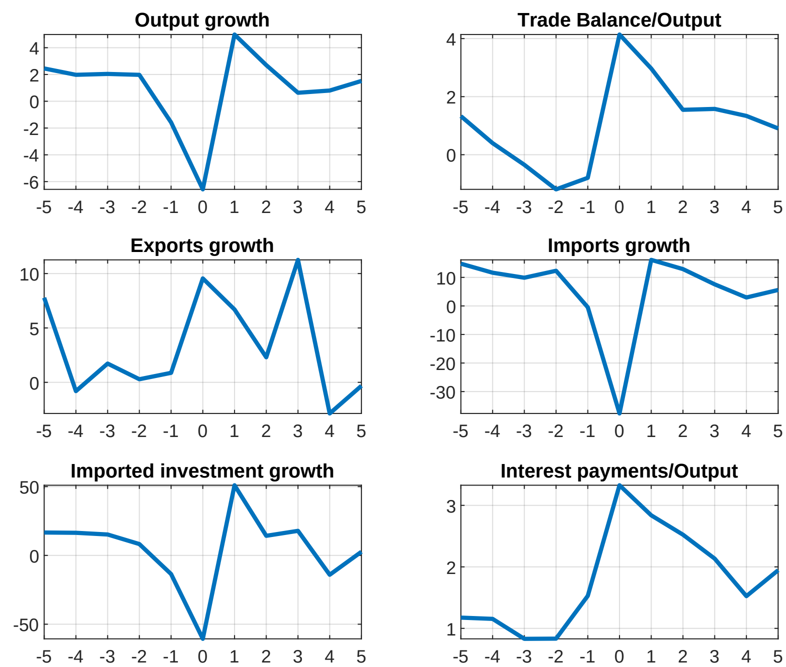


Figure 4: Sudden Stop dynamics in Argentina

Note: The period 0 identifies the year of a Sudden Stop episode. The figure presents mean values of variables, in a sample of 5 Sudden Stops in the last 50 years. Output, exports, imports, and imported investment growth are in percentages. Trade balance to output and interest payments to output are in percentage points.

The dynamics of a Sudden Stop episode in Argentina share many of the features of the typical Sudden Stop episode in Emerging Economies, but imports seem to increase more quickly after the Sudden Stop than in Figure 1. The dynamics of imported investment, that collapses around 60 p.p. in the crisis, appears to be a main driver of the fall in imports during the Sudden Stop. An additional feature we observe from Argentinian data relates to interest payments to output ratio. This variable presents an abrupt increase at the year of the crisis,

[3]The identified Sudden Stop episodes in Argentina took place in: 1959, 1963, 1976, 1982, 1985, 1988, 1989, 1995, 2002. Plots and statistics come from Sudden Stops in: 1959, 1976, 1982, 1995, 2002.

playing an important role in the reverse of the trade balance. Furthermore, this variable is of vital importance for two reasons. First, and differently from Calvo et al. (2006), our definition of a Sudden Stop does not include the behavior of interest rate due to not availability of interest rate data before the eighties. Thus, the behavior of this variable provides suggestive evidence that we are identifying the correct events. Second, as we explain in more detail in the estimation section, this variable is key in our analysis as it gives information regarding the financial sector in the economy, allowing us to identify financial frictions and shocks.

### 2.3 Taking stocks

Both international data for Emerging Economies and Argentinean data point to a few stylized facts. First, in Emerging economies output tend to be more volatile and on average grows less than in developed economies. Second, Sudden Stops tend to be a more frequent phenomenon in Emerging countries than in developed countries. Third, a distinctive feature of Sudden Stops is that the trade-balance dynamics seem to be dominated by the dynamics of imports, and in particular, imported investment.

In the following section, we develop a theory that is consistent with these facts and use it to measure the importance of domestic and foreign shocks in a context of financial frictions and endogenous output growth, as well as the main drivers of Sudden Stops. This theory allows endogenizing the hypothesis of Aguiar and Gopinath (2007). The cycle is the trend in emerging countries, but the trend is largely affected by Sudden Stops. In this way, our theory explains the business cycle as well as the medium run in the terminology of Comin et al. (2009). The model in this paper makes clear that growth and cycle are interrelated and affected by Sudden Stops due to its impact on the financing of firms that import investment goods. In what follows we present the theory and describe the strategy to take it to the data.

## 3 The model

The model is a small open economy augmented with financial frictions and endogenous growth. The economy is populated by households, final good producers, capital goods producers, domestic investment goods producers, entrepreneurs, and the government. We assume two symmetric productive sectors for intermediate input producers and entrepreneurs: imported and domestic capital sectors. Capital goods producers only sell the intermediate product to entrepreneurs in the corresponding sector. Entrepreneurs of both sectors rent the capital to final goods producers. On top of this, the rest of the world is populated by consumers and financial intermediaries that lend to entrepreneurs.

## 3.1 Households

Households own the firms in the economy. Every period, they maximize the present discounted value of lifetime utility given by GHH preferences introduced by Greenwood et al. (1988) augmented with habit formation:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \nu_t \beta^t \left[ \left( C_t - \alpha \tilde{C}_{t-1} - X_{t-1} \frac{h_{f,t}^{\omega_f}}{\omega_f} - X_{t-1} \frac{h_{d,t}^{\omega_d}}{\omega_d} \right)^{1-\sigma} \frac{1}{1-\sigma} \right],$$

subject to an infinite set of budget constraints, ∀ t,

$$C_t + D_t R_t = W_{d,t} h_{d,t} + W_{f,t} h_{f,t} + D_{t+1} + \Lambda_t \tag{1}$$

Households choose consumption $C_t$, external borrowing $D_{t+1}$ and labor supply $h_{d,t}$, $h_{f,t}$. They do not internalize habit formation, characterized by parameter $\alpha$. We assume specific labor supply for domestic investment sector, $h_{d,t}$, and final goods sector, $h_{f,t}$, with their corresponding wages $W_{d,t}$ and $W_{f,t}$. Parameters $\omega_d$, and $\omega_f$ characterize the labor supply elasticity. $R_t$ is the domestic interest rate. $X_{t-1}$ is the trend of the economy, that we explain in detail in the following sections. $\Lambda_t$ are transfers and profits received by households every period t:

$$\Lambda_t = \Pi_{ki,t} + \Pi_{kd,t} + \Pi_{Id,t} + T_{i,t} + T_{d,t} - S_t$$

Here $\Pi_{ki,t}$, $\Pi_{kd,t}$, $\Pi_{Id,t}$ denote profits of imported and domestic capital and investment good producers. $T_{i,t}$ and $T_{d,t}$ are net real transfer to new and from old entrepreneurs of imported and domestic capital. $S_t$ are lump sum taxes paid to the government. We provide a detailed description of profits and transfers in the following section. Finally, $\nu_t$ is a preference shock, that follows an AR(1) process:

$$\ln \nu_{t+1} = \rho_\nu \ln \nu_t + \epsilon_{t+1}^\nu; \quad \epsilon_t^\nu \sim N\left(0, \sigma_\nu^2\right); \quad |\rho_\nu| < 1. \tag{2}$$

As discussed by the existing literature, the country interest rate is subject to shocks and endogenous spread. The exogenous components include risk-free interest rate shocks $R_{f,t}$, and spreads shocks, $\mu_t$. The later represents exogenous variations in the interest rate that the domestic economy has to pay for its debt, and are independent of its fundamentals. The timing for the debt and spread shocks follows the timing in Justiniano and Preston (2010), where spread shocks affect contemporaneously the cost of repaying the debt. The interest rate is $R_t = R_{o,t-1}e^{\mu_t - 1}$, with

$$R_{o,t} = R^* + \exp\left(R_{f,t} - 1\right) + \psi_D\left[\exp\left(\frac{\tilde{D}_{t+1} + \tilde{B}_{t+1}}{X_t} - (\bar{d} + \bar{b})\right) - 1\right] + \\ \psi_Y\left[\exp\left(\frac{Y_t}{X_{t-1}} - \bar{y}\right) - 1\right]. \tag{3}$$

We assume the endogenous spread has two parts: the first one depends on deviations of detrended debt to the average debt level. The parameter that measures this debt elasticity of interest rate is $\psi_D$ and it is assumed to be positive since a higher debt level is associated with higher default risk. The second depends on deviations of detrended output to the average output in the economy. The parameter $\psi_Y$ allows to capture the fact that interest rate may fall when output is growing. The representative household does not internalize the effect of her decisions on the country interest rate.

$R^*$ is the average interest rate and $\bar{d}, \bar{b}, \bar{y}$ are steady state values. We assume $R_{f,t}$ and $\mu_t$ follow zero mean AR(1) process in logs.

$$\ln R_{f,t+1} = \rho_{R_f} \ln R_{f,t} + \epsilon_{t+1}^{Rf}; \qquad \epsilon_t^{Rf} \sim N\left(0, \sigma_{R_f}^2\right); \qquad |\rho_{R_f}| < 1, \tag{4}$$

$$\ln \mu_{t+1} = \rho_\mu \ln \mu_t + \epsilon_{t+1}^\mu; \qquad \epsilon_t^\mu \sim N\left(0, \sigma_\mu^2\right); \qquad |\rho_\mu| < 1. \tag{5}$$

### 3.2 Capital goods producers

The capital goods production is divided into two symmetric, perfectly competitive, productive sectors. A representative firm in the sector I imports installed capital, $K_{i,t}$ and adds new investment $I_{i,t}$ to generate new capital stock for next period and sell it to an entrepreneur in sector I. The price of imported capital at time t is $q_{i,t}$ and the relative price of imported capital investment is $P_{i,t}$. The relative price of imported investment to domestic goods has a clear trend in the data, for this reason, we assume $P_{i,t} = p_{i,t}\Xi_{t-1}$, where $p_{i,t}$ is stationary and $\Xi_{t-1}$ is a deterministic trend. $p_{i,t}$ follows an AR(1) process with mean $\bar{p}$.

A producer in the second sector, sector D, buys installed capital $K_{d,t}$ and adds investment $I_{d,t}$ to generate a new capital stock for next period, $K_{d,t+1}$, and sell it to entrepreneurs in sector D. The price of domestic capital at time t is $q_{d,t}$ and the price of the investment is $p_{d,t}$. Domestic investment price does not grow, so we have $P_{d,t} = p_{d,t}$. All producers take prices as given and pay capital adjustment costs.

For $j = \{i, d\}$, the optimization problem of a representative producer is:

$$\max_{K_{j,t+1}, I_{j,t}} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\tilde{\lambda}_t}{\tilde{\lambda}_0} \Big( \Pi_{kj,t} = q_{j,t} K_{j,t+1} - q_{j,t} K_{j,t}(1-\delta_{kj}) - P_{j,t} I_{j,t} \Big)$$

subject to

$$K_{j,t+1} = K_{j,t}(1-\delta_{kj}) + I_{j,t} - \Phi_j\Big(\frac{K_{j,t+1}}{K_{j,t}}\Big) K_{j,t}. \tag{6}$$

We follow Garcia-Cicco et al. (2010) and assume quadratic capital adjustment costs. For domestic sector it takes the following functional form:

$$\Phi_d\Big(\frac{K_{d,t+1}}{K_{d,t}}\Big) = \frac{\phi_d}{2}\Big(\frac{K_{d,t+1}}{K_{d,t}} - \bar{g}\Big)^2.$$

while for the imported investment capital, it is given by the following expression:

$$\Phi_i\Big(\frac{K_{i,t+1}}{K_{i,t}}\Big) = \frac{\phi_i}{2}\Big(\frac{K_{i,t+1}}{K_{i,t}} - \frac{\bar{g}}{\bar{g_\Xi}}\Big)^2.$$

Here $\bar{g}$ is the average growth rate of the economy, and $\bar{g_\Xi}$ is the average growth rate of the imported investment price. The difference is that the price of domestic investment is stationary, while $P_{i,t}$ is allowed to grow in the model, to replicate the data. The different growth rates in investment prices generate different growth rates in investment among sectors and then, in capitals, as we show in the in the section 10.2 in the appendix.

### 3.3 Entrepreneurs

There are two types of entrepreneurs, $j = \{i, d\}$, the ones who buy imported capital $K_{i,t+1}$ to intermediate input producers in the sector I and the ones who buy domestic capital $K_{d,t+1}$ to producers in sector D. We assume there is a large number of entrepreneurs of each type, and both types are symmetric in their behavior. However, in the empirical strategy, we allow the data to determine the quantitative differences through the estimation of parameters. Throughout this section, we describe the behavior of an entrepreneur N of type $j$, following Christiano et al. (2014) closely.

Every period t, an entrepreneur $N_j$ buys capital $K^N_{j,t+1}$ to a capital producer in sector $j$, refurbishes it using a stochastic linear technology and sells it to the final producer good. In order to purchase the capital, entrepreneurs can use their net worth, $N_{j,t+1}$ or issue defaultable debt $B^N_{j,t+1}$, lent by an international financial intermediary. Hence,

$$q_{j,t}K^N_{j,t+1} = N_{j,t+1} + B^N_{j,t+1}, \tag{7}$$

The effective capital the entrepreneur obtains is $\omega^N_{j,t+1}K^N_{j,t+1}$, where $\omega^N_j$ is an idiosyncratic shock for each entrepreneur N, type j. This shock is independently drawn across time, type and entrepreneurs.

We assume the shock $\omega^N_j$ follows a log-normal distribution $F(\omega^N_j)$ with parameters $\mu_{\omega_j,t}$ and $\sigma^j_{\omega,t}$ such that $E_t(\omega^N_{j,t+1}) = 1$ for all $t$, for $j = \{i, d\}$. Given the properties of log-normal distributions:

$$\mathbb{E}_t\omega^N_{j,t+1} = e^{\mu_{\omega_j,t+1}+\frac{1}{2}\sigma^{2,j}_{\omega,t+1}} = 1.$$

Hence, $\mu_{\omega_j} = -\frac{1}{2}\sigma^{2,j}_{\omega,t+1} = \mu^j_{\omega,t+1}$. Assume, following Christiano et al. (2014) and Fernández-Villaverde (2010) that the dispersion $\sigma^j_{\omega,t}$ varies stochastically over time and follows:

$$log(\sigma^j_{\omega,t}) = (1 - \rho^j_\sigma)log(\mu^j_\sigma) + \rho^j_\sigma log(\sigma^j_{\omega,t-1}) + \eta^j_\sigma\epsilon_{\sigma^j,t}, \quad \epsilon_{\sigma^j,t} \sim N(0, 1).$$

The shock to the dispersion of $\omega_j^N$ can be interpreted as a financial shock. A higher dispersion implies riskier entrepreneurs and then, a higher premium on external financing.

The transformation of raw capital into effective units takes one period. Then, entrepreneurs buy $K_{j,t+1}^N$ at period $t$, but rent the capital services at period $t+1$, at rate $r_{j,t+1}$. At the end of period $t+1$, entrepreneurs are left with $(1-\delta_{kj})\omega_{j,t+1}^N K_{j,t+1}^N$ and sell it to a capital producer in sector $j$.

The entrepreneur's return per unit of capital purchased in $t$ is $R_{j,t+1}\omega_{j,t+1}^N$ and the average return per unit invested in period $t$ and sector $j$ is:

$$R_{j,t+1} = \frac{r_{j,t+1} + q_{j,t+1}(1-\delta_{kj})}{q_{j,t}}. \tag{8}$$

The foreign lender is risk neutral. Hence, the optimal contract determines a return that implies that expected returns equal the cost of funds. Define $R_j^{N,l}$ as the return on the loan, that gives expected zero profits to financial intermediaries. This return takes into account that entrepreneurs with low enough productivity may default, and those with high productivity will repay. However, since the idiosyncratic shock is private information of the entrepreneur, under default the lender pays a monitoring cost to verify the actual state of business. Then, it takes all remaining assets. The zero-profit condition is

$$[1-F(\bar{\omega}_{j,t+1}^N)]R_{j,t}^{N,l}B_{j,t+1}^N + (1-\mu_{kj})\int_0^{\bar{\omega}_{j,t+1}^N} \omega_j^N dF(\omega_j^N)R_{j,t+1}q_{j,t}K_{j,t+1}^N = R_{t+1}B_{j,t+1}^N, \tag{9}$$

where $1-\mu_{kj}$ is the fraction of the return that can be captured by the financial intermediate in case of default after screening, in sector $j$. On the right-hand side, we have the cost of raising $B_{j,t+1}^N$ funds. This cost comes from the gross interest rate, $R_{t+1}$, that financial intermediary pays.

Define $\bar{\omega}_{j,t+1}^N$ as the productivity threshold below which the entrepreneur N in sector $j$ defaults:

$$R_{j,t+1}^{N,l}B_{j,t+1}^N = \bar{\omega}_{j,t+1}^N R_{j,t+1}q_{j,t}K_{j,t+1}^N.$$

That is, for all realizations below $\bar{\omega}^N_{j,t+1}$, the returns of having purchased $K^N_{j,t+1}$ will not be enough to repay the loan. We can rewrite 9 and characterize the debt contract in terms of $\bar{\omega}^N_{j,t+1}$ rather than in terms of $R^{N,l}_{j,t+1}$.

Define $\Gamma(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t})$ as the share of entrepreneurial earnings that are used to pay financial intermediaries per unit of investment:

$$\Gamma(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t}) = \bar{\omega}^N_{j,t+1}\left(1 - F(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t})\right) + G(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t}),$$

with

$$G(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t}) = \int_0^{\bar{\omega}^N_{j,t+1}} \omega^N_j \, dF(\omega^N_j, \sigma^j_{\omega,t}).$$

Here, $\Gamma(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t})$ is the sum of the average return for those entrepreneurs that repay, plus the conditional mean of productivity of those that default. Moreover, using $\Theta$ for the CDF of a Normal distribution, we can rewrite $G(\cdot)$ as

$$G(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t}) = 1 - \Theta\left(\frac{\frac{1}{2}\sigma^{2,j}_{\omega,t} - \log \bar{\omega}^N_{j,t+1}}{\sigma^j_{\omega,t}}\right).$$

The zero profit condition is rewritten as

$$\frac{R_{j,t+1}}{R_{t+1}}\left[\Gamma(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t}) - \mu_{kj} G(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t})\right] q_{j,t} K^N_{j,t+1} = B^N_{j,t+1}. \tag{10}$$

Define the loan to net worth ratio as $\varsigma^N_{j,t} = B^N_{j,t+1}/N_{j,t+1}$. The problem of an entrepreneur is to pick the ratio $\varsigma^N_{j,t}$ and a cut-off for default to maximize its expected net worth given the zero-profit condition of the intermediary.

$$\max_{\varsigma^N_{j,t}, \bar{\omega}^N_{j,t+1}} \mathbb{E}_t \left\{ \frac{R_{j,t+1}}{R_{t+1}} \left(1 - \Gamma(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t})\right)(1 + \varsigma^N_{j,t}) \right.$$
$$\left. + \eta_{j,t}\left[\frac{R_{j,t+1}}{R_{t+1}}\left[\Gamma(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t}) - \mu_{kj} G(\bar{\omega}^N_{j,t+1}, \sigma^j_{\omega,t})\right](1 + \varsigma^N_{j,t}) - \varsigma^N_{j,t}\right]\right\}.$$

Notice since the idiosyncratic shock $\omega^N_j$ is independent of all other shocks and across time, and it is identical across entrepreneurs in sector $j$, all entrepreneurs in sector $j$ will make the same decisions. Then, we can define the solutions of the entrepreneurs problem as $(\varsigma_{j,t}, \bar{\omega}_{j,t+1})$ and remove the dependencies of variables on $N$, working with aggregate variables $B_j, K_j$.

From the first order conditions, we get:

$$\mathbb{E}_t \frac{R_{j,t+1} q_{j,t} K_{j,t+1}}{R_{t+1} N_{j,t+1}} \left(1 - \Gamma\left(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}\right)\right) = \mathbb{E}_t \left( \frac{1 - F\left(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}\right)}{1 - F\left(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}\right) - \mu_{kj} \bar{\omega}_{j,t+1} F_\omega \left(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}\right)} \right). \tag{11}$$

Given such a contract, the law of motion of entrepreneurial net worth is given by

$$N_{j,t+1} = \frac{1}{1 - e^{\bar{\gamma}^e}} \left[ R_{j,t} q_{j,t-1} K_{j,t} - R_t B_{j,t} - \mu_{kj} \int_0^{\bar{\omega}_{j,t}} \omega dF(\omega) R_{j,t} q_{j,t-1} K_{j,t} \right] + w^e_j X_{t-1}. \tag{12}$$

where $\bar{\gamma}^e$ regulates the survival rate of entrepreneurs. Exiting entrepreneurs transfer their net worth to households and these fund incoming entrepreneurs by transferring $w^e_j$. The net of these operations is reflected in the term $T_{j,t}$ observed in the households' budget constraint, which is given by:

$$T_{j,t} = \left(1 - \frac{1}{1 - e^{\bar{\gamma}^e}}\right) V_{j,t} - w^e_j X_{t-1}. \tag{13}$$

Here $V_{j,t}$ is the net worth before the fraction of $\bar{\gamma}^e$ firms leaves the market and is given by:

$$V_{j,t} = R_{j,t} q_{j,t-1} K_{j,t} - R_t B_{j,t} - \mu_{kj} \int_0^{\bar{\omega}_{j,t}} \omega dF(\omega) R_{j,t} q_{j,t-1} K_{j,t} \tag{14}$$

Notice we are imposing the same survival rate for entrepreneurs in the sector of domestic and imported capital.

## 3.4 Domestic investment producer

Domestic investment goods $I_{d,t}$ are produced using labor $h_{d,t}$ with a decreasing returns to scale technology:

$$I_{d,t} = \tilde{a}_t^d (h_{d,t})^\rho$$

with $0 < \rho < 1$ and $\tilde{a}_t^d = \bar{a}_d a_t^d X_t$. $\bar{a}_d$ is a constant that determines the average productivity level, and $a_t^d$ is a specific TFP shock that follows and AR(1) in logs, and is correlated with TFP shock in the final goods' production function. Notice we assume that the TFP in the domestic investment sector follows the same growth trend as in the final good production. The optimization problem of this firm is the following:

$$\max_{h_{d,t}} \Pi_{Id,t} = p_{d,t} a_t^d (h_{d,t})^\rho - W_{h,t} h_{d,t}$$

The firm pays wages equal to its marginal product and profits are distributed to the households.

## 3.5 Final good producer

The final good production sector is competitive and operated by a representative firm that rents labor, imported, and domestic capital to produce the final consumption, and exporting/importing goods. The profit function of this firm is:

$$\Pi_{f,t} = Y\left(K_{i,t}, h_{f,t}, K_{d,t}, a_t, X_t\right) - r_{d,t} K_{d,t} - W_{f,t} h_{f,t} - r_{i,t} K_{i,t}$$

This firm solves an intratemporal problem and pays to each input its marginal cost.

The production function is the following

$$Y_t = a_t (X_t h_{f,t})^\gamma K_t^{1-\gamma}, \tag{15}$$

where $K_t$ represents the total capital services. The Armington aggregator for capital is given by:

$$K_t = \left(a_1 K_{d,t}^{\mu_1} + (1 - a_1)\left(\Xi_{t-1} K_{i,t}\right)^{\mu_1}\right)^{\frac{1}{\mu_1}}.$$

The CES specification implies imperfect substitutability between domestic and imported capital, and it is similar to the one used in Mendoza and Yue (2012) and Park (2017).

As discussed before, $\Xi_{t-1}$ is the deterministic trend in imported investment price $P_{i,t}$. The previous expression implies that the aggregate capital $K_t$ grows at the trend of the economy $X_{t-1}$. $X_t$ is given by:

$$X_t = \Gamma_t^{\eta}\left[\left(a_1 \tilde{K}_{d,t}^{\mu_1} + (1 - a_1)\left(\Xi_{t-1}\tilde{K}_{i,t}\right)^{\mu_1}\right)^{\frac{1}{\mu_1}}\right]^{1-\eta} \tag{16}$$

and the growth rate of the trend is $g_{x,t} = \frac{X_t}{X_{t-1}}$. $\Gamma_t$ is an exogenous stochastic trend such that $\frac{\Gamma_t}{\Gamma_{t-1}} = g_t$, that follows an AR(1),

$$\ln\left(g_{t+1}/\bar{g}\right) = \rho_g \ln\left(g_t/\bar{g}\right) + \epsilon_{t+1}^{g}; \qquad \epsilon_t^{g} \sim N\left(0, \sigma_g^2\right); \qquad |\rho_g| < 1, \tag{17}$$

while $\tilde{K}_{d,t}$ and $\tilde{K}_{i,t}$ are aggregate (non-internalized) capital inputs, that drive the endogenous component of the trend. In contrast to the literature, the economy in our model grows at a trend that results from the combination of an exogenous shock, the constant negative trend of imported investment, and the endogenous component.

The productivity $a_t$ is a mean reverting productivity shock and follows an AR(1) process in logs:

$$\ln a_{t+1} = \rho_a \ln a_t + \rho_{a,ad}\epsilon_{t+1}^{a,ad} + \epsilon_{t+1}^{a}; \qquad \epsilon_t^{a} \sim N\left(0, \sigma_a^2\right); \qquad |\rho_a| < 1. \tag{18}$$

where $\epsilon_{t+1}^{a,ad}$ is a shock that affects both the TFP in the production of domestic investment and the production of consumption goods sector. That is, this shock allow us to account for a potential correlation between mean reverting component of TFPs.

### 3.6 Government

We follow Garcia-Cicco et al. (2010) and model government consumption as a domestic spending shock $s_t$ that follows an AR(1) process:

$$s_{t+1} = (1-\rho_s)\bar{s} + \rho_s s_t + \epsilon^s_{t+1}; \quad \epsilon^s_t \sim N\left(0, \sigma^2_s\right); \quad |\rho_s| < 1$$

where $s_t = \frac{S_t}{X_{t-1}}$. This government spending is financed from households through lump sum taxes. We include this shock to be in line with the existing literature and in order to make our definition of output in line with that of the data. After estimation we find that this shock plays a minor role in model dynamics.

### 3.7 Balance of payments

From the definitions for the net-worth of entrepreneurs 12 together with 13 and 14 we get:

$$T_{i,t} = V_{i,t} - N_{i,t+1},$$
$$T_{d,t} = V_{d,t} - N_{d,t+1}.$$

Using these equations, definition 7, the definition of intermediate input producers' profits, optimality conditions for final goods producer and the household budget constraint 1 we get:

$$GDP_t = C_t + p_{d,t}I_{d,t} + P_{i,t}I_{i,t} + S_t + TB_t, \tag{19}$$

where $TB_t$ is the trade balance:

$$TB_t = R_t D_t - D_{t+1} + R_t(B_{i,t} + B_{d,t}) - (B_{i,t+1} + B_{d,t+1}).$$

and $GDP_t$, that is the variable we observe in the data is:

$$GDP_t = Y_t + p_{d,t}I_{d,t} - \mu_{ki}G(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t})R_{i,t}q_{i,t-1}K_{i,t-1} - \mu_{kd}G(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t})R_{d,t}q_{d,t-1}K_{d,t-1} \tag{20}$$

Moreover, we define the net interest rate payments to the rest of the world as follows:

$$rby_t = (R_t - 1)\frac{D_t + B_t}{GDP_t}$$

Notice in this setting we have two types of foreign debt, household debt ($D_t$), and corporate debt ($B_t$). Each of them has a different role: the former one is used to smooth consumption. The latter is used to buy capital to intermediate capital producers, either imported or domestic.

We present the complete set of equilibrium equations in the appendix.

# 4 Empirical strategy

We log-linearize the stationarized equilibrium conditions of the model and estimate it with a Bayesian strategy using annual data for Argentina for the period 1951-2015 from IIEP (2018). We calibrate some of the parameters to match first-order moments of the data and to standard values in the existing literature. We estimate the remainder of the parameters with Metropolis-Hastings and informative priors.

Table 2 presents the value of constrained parameters with their corresponding source or target. The CRRA coefficient, $\sigma$, that defines the curvature of the period utility function, is set to 2 and the depreciation rates ($\delta_{ki}$, $\delta_{kd}$) to 8%. The discount factor $\beta$ is set equal to 0.94 to target an annualized interest rate of 8% in the steady state. We set $\bar{g} = 1.01$, the average gross growth rate of output per-capita, and the one of imported investment price, $\bar{g_{\Xi}}$, to 0.9756. The average trade balance to output ratio is equal to 1.4%, like in Argentina in the period under study. $\gamma$ and $\rho$, the coefficients of labor in the production function of the final good and domestic investment, are set equal to 2/3. We set the Armington weight of domestic capital, $a_1$, to 0.62, in line with Mendoza and Yue (2012)'s calibration for imported inputs. The preference parameter $\omega_d$ is set equal to 1.2, as in Akinci (2014).[4]

[4]We also tried to estimate this parameter, in most of the trials the chain of this parameter approached 1. In order to avoid convergence issues, we decided to fix it to a low value in line with the literature.

We set the ratio $B/N$ in each sector to the average leverage ratio in industrial investment for firms in Argentina in the period 2007-2016.[5] We fix $\bar{\gamma}^e$ to match the average percentage of survival firms per year, equal to 89% in Argentina during period 2007-2016.

Finally, we set the relative price of imported investment in steady state to the average value in the data, $\bar{p} = 1.22$.

Table 2: Calibrated parameters

| | Value | Definition | Source or target |
|---|---|---|---|
| $\sigma$ | 2 | Risk aversion | Standard |
| $\gamma$ | 2/3 | Labor coef. in final good | Standard |
| $\rho$ | 2/3 | Labor coef. in dom. Investment | Standard |
| $\beta$ | 0.94 | Discount factor | 8% average interest rate |
| $\delta_{kj}$ | 0.08 | Depreciation rate $j = \{i, d\}$ | Standard |
| $\bar{\gamma}^e$ | 2.068 | Survival rate of entrepreneurs | 10% year firm exit, Arg. 2007-2016 |
| $w_d^e$ | 0.038 | Entrepreneurs transfer | $(B/N)_d = 0.6$ Arg. 2007-2016 |
| $w_i^e$ | 7.24e-04 | Entrepreneurs transfer | $(B/N)_i = 0.6$ Arg. 2007-2016 |
| $\bar{p}$ | 1.22 | Av. relative price of imp. investment | Arg. 1951-2015 |
| $\bar{g_\Xi}$ | 0.9756 | Av. grow rate of imp. investment price | Arg. 1951-2015 |
| $\bar{g}$ | 1.01 | Av. growth rate output per capita | Arg 1951-2015 |
| $a_1$ | 0.62 | Armington weight of domestic capital | Mendoza and Yue (2012) |
| $\omega_d$ | 1.2 | Preference parameter | Akinci (2014) |

We include eight observables: GDP growth ($gy$), private consumption growth ($gc$), domestic investment growth ($gi_d$), imported investment growth ($gi_i$), trade balance to output ratio ($tby$), the relative price of imported capital investment goods to GDP deflator, in growth rates ($gp_i$), the real risk free rate ($R_f$) and the net interest rate service on the foreign net asset position to output ratio ($rby$). In all the cases we work in per-capita terms and take natural logs, except for $tby$ and $rby$. We incorporate the latter variable together with $R_f$ in order to identify financial frictions and shocks in the estimation.[6]

In the estimation, we added measurement errors to all observables. We plot the described time series in the appendix. There we can see the variable $gp_i$ has a negative mean equal to

[5] To the best of our knowledge, information about this ratio is only available since 2007.

[6] Due to data availability, our price deflators are Fisher chained indexes. Our original data for the NIPA accounts are nominal, so we can be consistent with the model and deflate output and consumption by the GDP deflator, we deflate domestic and imported investment by their own deflator. We provide a full description of the data treatment in the appendix.

-0.024 during the period, showing the negative trend in imported capital investment prices, as in the model.

The estimated parameters and the prior distributions are in Table 7. We consider loose priors in all the cases because, given the complexity of the likelihood function, the estimation with flat priors tends to work poorly as many estimates would hit the parameter bounds.

# 5 Estimation results

Table 7 presents the prior information, the posterior mean and median, and high probability density intervals (HPDI) of 10% and 90% of each estimated parameter. Posterior distributions are in similar orders of magnitude as in the existing literature. The HPDI of the debt elasticity to interest rate, $\psi_D$, ranges from 0.02 to 0.14, smaller than the posterior mean in Garcia-Cicco et al. (2010), yet large enough to be quantitatively relevant for the dynamics. The model includes two features that explain the lower interest rate debt elasticity: first, the role of $\psi_Y$ (absent in Garcia-Cicco et al. (2010)) and second, the existence of additional financial frictions. The elasticity of interest rate to output, $\psi_Y$, has a negative posterior mean, equal to -1.31, supporting the hypothesis that financial frictions tend to relax during the expansive part of the cycle. Our estimates suggest that the imported investment is subject to higher screening costs, indeed, about 2 times the standard calibration for this parameter in the case of US,[7] with a posterior mean of 0.27 for $\mu_{ki}$. On the other hand, there seems to be a lower degree of financial frictions in the domestic investment sector, where $\mu_{kd}$ takes a posterior mean of 0.03.

A key parameter in our analysis is $\eta$ as it characterizes the importance of the endogenous component in the growth rate of this economy: the lower this parameter is, the more important is the endogenous component of the trend, and less important is the shock. The estimation places substantial mass around mild to large values of this parameter, its posterior mean equals 0.69 and has a high probability density interval of 0.46 and 0.96.

[7] See Bernanke et al. (1999) and many other that calibrate this parameter to a number around .12.

Table 3: Priors and estimation results

| | Prior | | | | | Posterior | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Dist.** | **LB** | **UB** | **Mean** | **s. d.** | **Mean** | **Median** | **10%** | **90%** |
| $\mu_\sigma^i$ | IG | | 1.00 | 1.00 | 0.25 | 0.82 | 0.81 | 0.66 | 0.97 |
| $\mu_\sigma^d$ | IG | | 1.00 | 1.00 | 0.25 | 0.89 | 0.86 | 0.59 | 1.18 |
| $\sigma_G$ | IG | | | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 | 0.04 |
| $\sigma_A$ | IG | | | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 | 0.02 |
| $\sigma_{A^d}$ | IG | | | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 | 0.02 |
| $\sigma_\mu$ | IG | | | 0.02 | 0.03 | 0.07 | 0.07 | 0.06 | 0.08 |
| $\eta_\sigma^i$ | IG | | | 0.60 | 1.00 | 1.64 | 1.49 | 0.71 | 2.54 |
| $\eta_\sigma^d$ | IG | | | 0.60 | 1.00 | 0.42 | 0.36 | 0.16 | 0.69 |
| $\sigma_{R^f}$ | IG | | | 0.02 | 0.03 | 0.02 | 0.02 | 0.01 | 0.02 |
| $\sigma_\nu$ | IG | | | 0.02 | 0.03 | 0.08 | 0.08 | 0.05 | 0.13 |
| $\sigma_p$ | IG | | | 0.02 | 0.03 | 0.21 | 0.21 | 0.18 | 0.24 |
| $\sigma_s$ | IG | | | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 |
| $\rho_G$ | Beta | | | 0.30 | 0.10 | 0.41 | 0.41 | 0.24 | 0.58 |
| $\rho_A$ | Beta | | | 0.30 | 0.10 | 0.47 | 0.47 | 0.34 | 0.60 |
| $\rho_A^d$ | Beta | | | 0.30 | 0.10 | 0.50 | 0.50 | 0.36 | 0.64 |
| $\rho_\mu$ | Beta | | | 0.30 | 0.10 | 0.30 | 0.30 | 0.20 | 0.40 |
| $\rho_\sigma^i$ | Beta | | | 0.30 | 0.10 | 0.54 | 0.55 | 0.38 | 0.70 |
| $\rho_\sigma^d$ | Beta | | | 0.30 | 0.10 | 0.30 | 0.30 | 0.14 | 0.46 |
| $\rho_{R^f}$ | Beta | | | 0.30 | 0.10 | 0.48 | 0.48 | 0.36 | 0.59 |
| $\rho_\nu$ | Beta | | | 0.30 | 0.10 | 0.34 | 0.33 | 0.15 | 0.52 |
| $\rho_p$ | Beta | | | 0.50 | 0.10 | 0.71 | 0.71 | 0.62 | 0.79 |
| $\rho_s$ | Beta | | | 0.20 | 0.10 | 0.29 | 0.28 | 0.12 | 0.46 |
| $\rho_{a,ad}$ | Normal | | | 0.20 | 0.50 | 0.02 | 0.02 | 0.01 | 0.03 |
| $\rho_{ad,a}$ | Normal | | | 0.20 | 0.50 | 0.04 | 0.04 | 0.03 | 0.06 |
| $\phi_{k^i}$ | Gamma | | | 3.00 | 2.00 | 6.78 | 6.67 | 5.10 | 8.36 |
| $\phi_{k^d}$ | Gamma | | | 3.00 | 2.00 | 5.48 | 5.43 | 3.16 | 7.69 |
| $\psi_D$ | Normal | 0.0 | 10.0 | 1.50 | 2.00 | 0.08 | 0.08 | 0.02 | 0.14 |
| $\psi_Y$ | Normal | -5.0 | 0.0 | -1.00 | 0.25 | -1.31 | -1.31 | -1.59 | -1.04 |
| $\mu_{ki}$ | Normal | 0.0 | 1.0 | 0.12 | 0.10 | 0.27 | 0.27 | 0.13 | 0.41 |
| $\mu_{kd}$ | Normal | 0.0 | 1.0 | 0.12 | 0.10 | 0.03 | 0.03 | 0.00 | 0.07 |
| $\omega_f$ | Normal | 1.0 | 7.0 | 2.00 | 1.00 | 2.96 | 2.88 | 2.03 | 3.87 |
| $\mu_1$ | Normal | | 0.9 | 0.50 | 2.00 | 0.80 | 0.80 | 0.72 | 0.91 |
| $\alpha$ | Beta | | | 0.25 | 0.10 | 0.13 | 0.13 | 0.06 | 0.19 |
| $\eta$ | Beta | | | 0.50 | 0.25 | 0.69 | 0.70 | 0.46 | 0.96 |

Note: Posterior distributions from Random Walk Metropolis Hasting algorithm of 1,000,000 draws, with 500,000 burn-in draws.

The Armington curvature parameter $\mu_1$ takes a posterior mean of 0.80, correspondent to an imperfect, but quite high elasticity of substitution between domestic and imported capitals, equal to $1/(1-\mu_1) = 5$. The fact that imported and domestic inputs are substitutes goes in line with the results of Mendoza and Yue (2012), Park (2017), among others.

Table 4: Second order moments

| | $g_y$ | $g_c$ | $g_{i_d}$ | $g_{i_i}$ | $tby$ | $rby$ | $gp$ | $R_f$ |
|---|---|---|---|---|---|---|---|---|
| **Standard deviations (in %)** | | | | | | | | |
| Model | 5.3 | 6.1 | 12.5 | 45.9 | 4.3 | 2.7 | 23.0 | 2.0 |
| Data | 5.2 | 6.8 | 12.9 | 41.3 | 3.2 | 2.1 | 21.4 | 2.3 |
| **Correlation with** $gy$ | | | | | | | | |
| Model | 1.00 | 0.91 | 0.94 | 0.23 | -0.18 | -0.11 | 0.00 | -0.07 |
| Data | 1.00 | 0.91 | 0.92 | 0.62 | -0.20 | -0.35 | -0.39 | -0.20 |
| **Correlation with** $tby$ | | | | | | | | |
| Model | -0.18 | -0.26 | -0.16 | -0.07 | 1.00 | 0.71 | 0.00 | 0.22 |
| Data | -0.20 | -0.28 | -0.22 | -0.22 | 1.00 | 0.59 | 0.19 | -0.01 |
| **Serial correlations** | | | | | | | | |
| Model | -0.16 | -0.09 | -0.21 | -0.21 | 0.80 | 0.76 | -0.15 | 0.48 |
| Data | 0.08 | -0.04 | 0.07 | 0.02 | 0.69 | 0.79 | -0.05 | 0.73 |

Note: Theoretical moments obtained evaluating the parameters at their posterior means, imposing measurement errors' standard deviation equal to zero.

From Table 4 we see the model does a good job reproducing main second-order moments from the data, in particular, the main stylized fact observed in Emerging economies as described in Aguiar and Gopinath (2007). The model produces the right order of magnitude and relative variability for all variables. This is a test for the model given that none of the numbers in the table are targeted during the estimation. It also generates the right volatility of the novel variables, the growth rates of imported investment and its price, the risk free rate and the interest rate payments to GDP ratio. [8]

Given the results in this section, we consider this model is an adequate laboratory to study the anatomy of the business cycle dynamics and Sudden Stops in Emerging countries.

# 6 Quantitative results

This section studies the main quantitative features of the model. We start by revisiting the business cycle drivers in Emerging Markets. Then we focus on the way financial frictions operate as transmission channels of the shocks.

## 6.1 Drivers of the business cycle

Table 8 presents the variance decomposition analysis of the observables, classifying shocks as productive, financial, or other shocks. Our results suggest that exogenous shocks to the trend, however important, play a secondary role as a driver of consumption, output and investment but are the main driver of the trade balance and the debt service to output ratio.[9] These results are in line with Garcia-Cicco et al. (2010) and Akinci (2014), where the transitory shock tends to explain the largest part of the output, consumption, and domestic investment growth. [10] Financial shocks (including, spread, risk free rate and risk shocks) as well as imported investment prices mainly explain the imported investment, and to a lesser extent the trade balance to output ratio, interest payments to output, and consumption dynamics but do not affect output. Preference shock plays no role in the decomposition of

[8] In contrast to standard approach in the literature, for instance those of Aguiar and Gopinath (2007) and Garcia-Cicco et al. (2010), and even Chang and Fernández (2013) or Akinci (2014), our framework imposes a new set of identifying restrictions to the estimation exercise as we include domestic and imported investment and imported investment price data as observables. Dynamics of these variables over the business cycle and during Sudden Stops are virulent, and allow us to characterize better the trade balance adjustment during Sudden Stops. Producing the right moments is, hence, challenging.

[9] Being a key driver of debt service to output ratio is an important feature of trend shocks because it suggests that this shock can play a central role in over-borrowing and external default phenomena, both of which are outside the scope of this paper but are considered in Seoane and Yurdagul (2019) and Aguiar and Gopinath (2006), respectively.

[10] In this table, the contribution of the transitory productivity shocks to variance decomposition is the sum of TFP shocks in the final production good ($a_t$), the one in domestic investment sector ($ad_t$) and the covariance between them, that absorbs the greater share of the explained variance. In the appendix we present the desegregated contribution of each shock.

output growth, but we find that the shock explains around 10% of consumption growth and the trade-balance to output ratio, and also helps to generate the observed co-movement and volatility rank of the observables.

Table 5: Variance decomposition (%)

| Shock | $g_y$ | $g_c$ | $g_{i_d}$ | $g_{i_i}$ | $tby$ | $rby$ |
|---|---|---|---|---|---|---|
| **Production** | | | | | | |
| Transitory ($a_t$, $a_{d,t}$, $\epsilon^{a,ad}$) | 80.0 | 58.1 | 72.2 | 3.3 | 28.6 | 19.6 |
| Trend ($g_t$) | 15.2 | 10.9 | 10.5 | 0.9 | 39.8 | 44.8 |
| **Financial** | | | | | | |
| Spread ($\mu_t$) | 2.8 | 8.1 | 4.9 | 2.3 | 13.2 | 31.5 |
| Risk ($\sigma_t^d, \sigma_t^i$) | 0.6 | 0.2 | 0.3 | 69.5 | 0.5 | 0.1 |
| Risk free ($R_{f,t}$) | 1.2 | 3.9 | 2.6 | 0.4 | 5.9 | 1.8 |
| **Other** | | | | | | |
| Gov. spending ($s_t$) | 0.0 | 0.2 | 0.0 | 0.0 | 3.0 | 0.4 |
| Preference ($\nu_t$) | 0.1 | 9.8 | 0.1 | 0.0 | 8.9 | 1.6 |
| Investment price ($p_{i,t}$) | 0.0 | 0.0 | 0.0 | 23.5 | 0.1 | 0.1 |
| **Measurement error** | 0.0 | 8.8 | 9.4 | 0.0 | 0.0 | 0.2 |

In our model, the trend has an endogenous component. What is the role of endogenous growth in our context? We recompute the second-order moments for a counterfactual economy where the trend does not depend on the stock of capital. Table 6 presents the ratio of moments for the model without endogenous growth divided by the baseline model.

Endogenous growth does not explain the excess volatility phenomenon. It does, however, exacerbate the cyclical properties of consumption, output, and investment growth with the trade balance to output ratio. The second row of the table presents the ratio between the correlation of the variables with the trade balance to output ratio in the economy without endogenous growth to the one in the baseline model, i.e. the negative correlation between output growth and the trade balance to output ratio without endogenous growth is 50% smaller than in the model with endogenous growth. The negative comovement of these variables with the trade balance is a feature stressed by recurrent Sudden Stop episodes. Hence, endogenous trend augments the drop in output, consumption, and domestic investment growth in Sudden Stops. This finding implies that the cycle affects the trend, exacerbating its response during Sudden Stops which, in turn, affects the cyclical feature of the economy. In other words, feedback effects between cycle and trend matter.

Table 6: Relative second order moments

| | $g_y$ | $g_c$ | $g_{i_d}$ | $g_{i_i}$ | $tby$ | $rby$ |
|---|---|---|---|---|---|---|
| **Relative standard deviations** | | | | | | |
| | 1.004 | 0.974 | 0.994 | 0.997 | 1.058 | 1.007 |
| **Relative correlations with** $tby$ | | | | | | |
| | 0.52 | 0.70 | 0.58 | 0.74 | - | 0.98 |
| **Relative correlations with** $gy$ | | | | | | |
| | - | 0.99 | 1.00 | 0.96 | 0.52 | 0.64 |

Note: Theoretical moments in the counterfactual economy relative to the baseline estimation. For the baseline we use the moments implied by the model evaluated at its posterior mean. For the counterfactual economy we fix all parameters in their posterior means except $\eta$ and $\sigma_g$ that we set to 1 and 0.0205, respectively. We choose the value of $\sigma_g$ that generates the same volatility of the trend growth rate ($gx_t$) in both scenarios, baseline and counterfactual.

## 6.2 The interaction between the trend and financial factors

Do financial factors have persistent effects on the economy through the trend dynamics? This is one of the key questions we want to address in this paper. Figure 5 plots the response of the trend growth ($g_{x,t}$) to a one standard deviation increase in the spread ($\mu_t$), risk free interest rate ($R_{f,t}$) and productivity dispersion shocks ($\sigma_t^i$, $\sigma_t^d$).

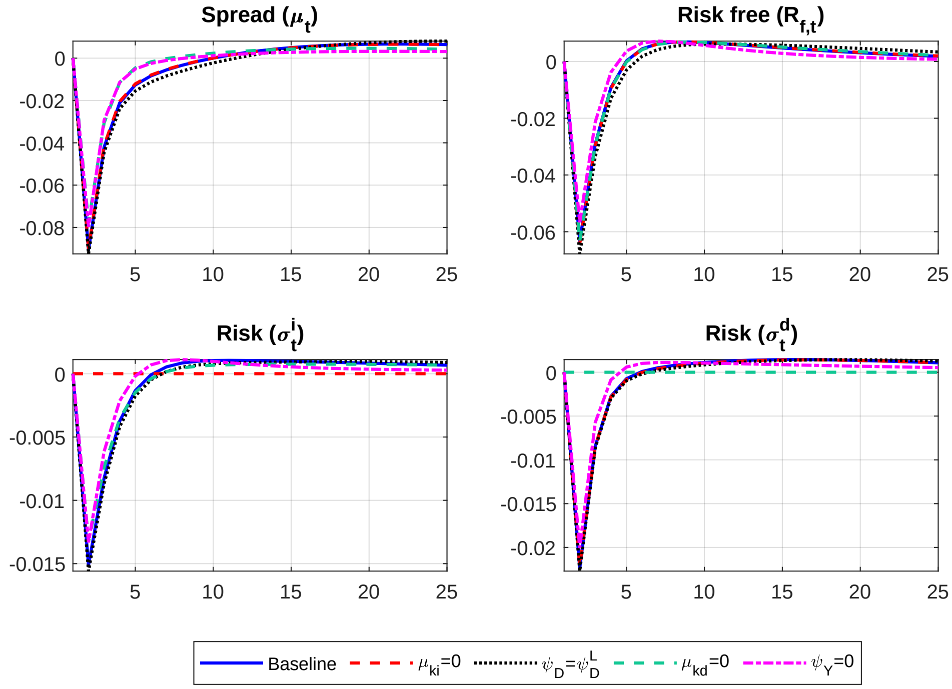


Figure 5: IRF (in %) for the growth rate of the trend

Note: $g_x$ impulse response function as percentage deviations in % from the steady state to a one standard deviation shock in $\mu_t$, $R_{f,t}$, $\sigma_t^i$, $\sigma_t^d$.

The blue solid line shows the results under the baseline model. Financial shocks have a permanent effect since they drive down the growth rate of the economy $g_{x,t}$. All financial shocks have a similar order of magnitude impact on the trend growth, with idiosyncratic productivity being slightly smaller.

In this case, the trend growth remains below its steady state value for around 6 years. The transmission mechanism of this shock is the following. The increase in firms' productivity dispersion increases the cost of funding for private firms, with a very negative impact on imported and domestic investment and then, in output. As the domestic and the foreign capital decrease, this drags down the spillover effects making the output drop larger than in a model without these effects.

The figure also presents sensitivity analysis for the trend growth response to the aforementioned shocks under different financial frictions. Notice the trend response to all shocks is stronger when the debt elastic interest rate coefficient ($\psi_D$) is set equal to $\psi_D^L = 0.041$, a value 50% smaller than its posterior mean. In that case, all shocks are also more long-lasting. Here as firms reduce investment, they also reduce their leverage. But the cost of funding does not fall with low $\psi_D$ as much as with the baseline $\psi_D$, leading to more adjustment in investment.[11] The screening cost in the imported capital sector also matters, if they are zero the productivity dispersion shock in the corresponding sector has no longer an effect on the trend. Hence, the risk shock materializes through the corporate debt channel. If the corporate risk increases, the impact on the cost of funding is increasing in the degree of financial friction, as it is more costly to screen firms, and this cost is internalized in the cost of funds. Hence, the larger the risk, the larger is the cost of funds driving down investment incentives. The output elasticity of the interest rate ($\psi_Y$) has the opposite effect $\psi_D$ has. A positive $\psi_Y$ slightly amplifies the effect of financial shocks trough the interest rate, and then, on the trend.

It is important to stress that, even if in the figure the role of financial transmission channel looks mild, they can produce large differences in the actual trend of the economy. Figure 6 translates the dynamics of $g_x$ into dynamics of $(\ln(X_t) - \ln(X_{ss,t})) \times 100$ normalizing the initial value of $X$ to one and defining $X_{ss,t} = g_{ss} \times t$.

[11] There is yet some heterogeneity in the responses across investment sectors: for instance, risk and spread shocks with the baseline estimation of $\mu_{ki}$ have virtually the same impact on imported investment with $\psi_D$ and $\psi_D^L$. For completeness, in the section 10.5 in the appendix we include the impulse responses of several relevant variables for the dynamics discussed in this section.

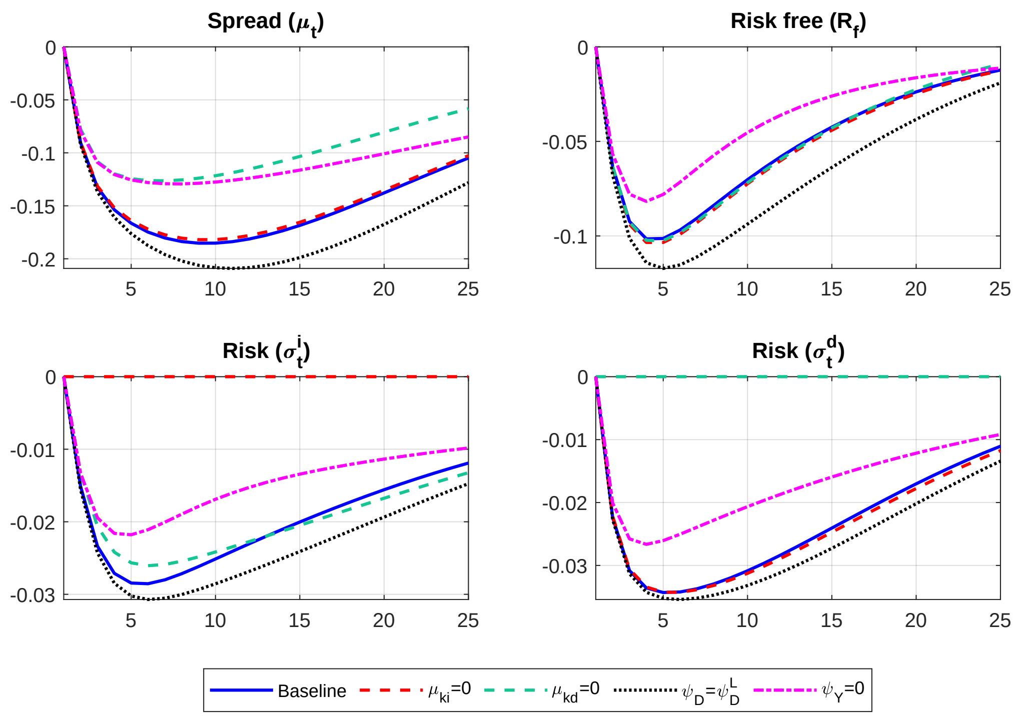


Figure 6: IRF (in %) for the trend

Note: Trend ($X_t$) impulse response function, in logarithms, as percentage deviations in % from the steady trend growth ($X_{ss,t} = g_{ss} \times t$) to a one standard deviation shock in $\mu_t$, $R_{f,t}$, $\sigma_t^i$, $\sigma_t^d$. The trend is obtained as $ln(X_t) = ln(X_{t-1}) + ln(gx_t)$.

The figure plots the impact of each shock, conditional on different assumptions about the financial frictions, in comparison to the trend that would have happened in the absence of the shock. This picture makes clearer that there are persistent effects in the economy. As can be seen, the effect of financial shocks is very persistent, lasting from more than 20 years in most of the cases. The shortest live shock is the one of the risk-free rate while the technology dispersion and the spread shock have the most persistent effect on the trend.

To complete the characterization of the dynamics of the model we can study the impact of productivity shocks and how the transmission channels operate. We do this as technology shocks play a major role. Figure 7 shows the response of the interest rate, debt, and the endogenous growth rate of the economy to a negative mean-reverting productivity shock (in the upper block of the figure) and trend shock (in the lower block). Under the baseline calibration both shocks have negative permanent effects in the economy since the endogenous trend growth falls below its steady state value. The interest rate response differs significantly in both cases and under different financial frictions' assumptions because of the different dynamics followed by the accumulation of debt at the household and corporate levels.

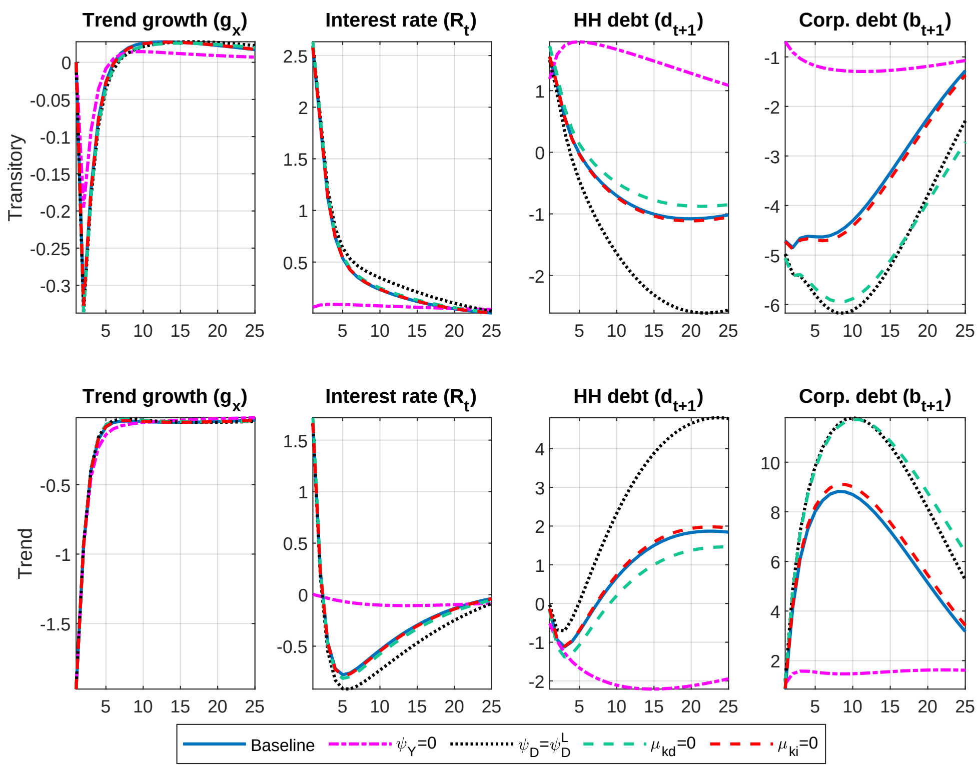


Figure 7: IRF (in %) to negative productivity shocks

Note: $g_x$, $R_t$, household debt ($d_{t+1}$) and corporate debt ($b_{t+1}$) impulse response function as percentage deviations in % from the steady state to a negative one standard deviation shock in $\epsilon^{a,ad,t}$ and $g_t$.

Consider first the baseline model. When the productivity shock is mean-reverting, and it affects TFP in the final good and domestic investment goods production sectors, the interest rate increases. Output falls because technology worsens, labor does not react to wealth effects and both capitals are fixed for that period. This induces a negative output growth. Households borrow more to smooth consumption, but firms borrow less because they plan to invest less. Overall, the impact is an increase in the interest rate because negative output growth dominates the interest rate dynamics. After that period, the output starts recovering, which pushes interest rates down. In the subsequent periods, households' debt decreases, following the return of interest rate to its steady state value.

If we decrease the interest rate debt elasticity financial friction, the behavior of the interest rate mimics the behavior of the growth rate of output with opposite sign, as seen by the dotted black line. On the other hand, if we shut down the interest rate elasticity to output growth, the dashed purple line exhibits the hump-shaped behavior of total debt, without the initial spike of the interest rate.

When the productivity shock is permanent, the increase in the interest rate is smaller and from period 1 falls and remains below its steady state value for around 20 periods. The role of households' debt is key here as, given that the economy is permanently poorer, the household does not have incentives to borrow to smooth consumption. Thus, households' debt decreases. This effect generates a negative pressure on the interest rate, which is dominated by the fall in detrended output. Thus, the interest rate increases in period 0. The response of corporate debt is very small on impact. As the growth rate of the trend returns to its steady state, the interest rate starts falling. Since financing cost goes down, corporate debt and then total debt increase, generating the hump shape in the interest rate. Again, if $\psi_D$ is set equal to $\psi_D^L$, the behavior of $R_t$ mimics the detrended output but with a positive sign; while if we shut down $\psi_Y$, the behavior of $R_t$ mimics the total debt.

Figure 8 allows us to study further the investment dynamics after the negative trend shock. A negative trend shock increases the interest rate and decreases both domestic and imported investment symmetrically. However, notice the financial friction operates more strongly in the imported sector than in domestic investment.

In sum, the previous figures suggest that trend dynamics strongly depend on the cost of financial frictions summarized by the interest rate dynamics. The findings in this section represent one of the main results of the paper. The dichotomy of trend shocks versus financial frictions to explain the business cycle in emerging countries represents a strong simplification given that the behavior of both of them are closely interconnected.

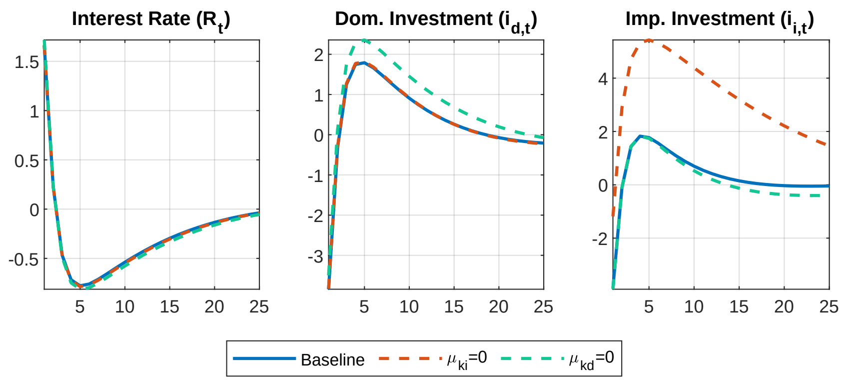


Figure 8: IRF (in %) to a negative trend shock

Note: Impulse response function as percentage deviations in % from the steady state to a negative one standard deviation shock in $g_t$.

# 7 The long run impact of Sudden Stops

Sudden stops are the most common form that a financial crisis takes in Emerging countries. As discussed in the empirical section, it is a combination of an increase in spreads, capital flow reversals, and output fall. We study here the impact of Sudden Stops in the long-run growth of the economy. We do it in two steps, first we show that the model can replicate the dynamics around Sudden Stops. Second, we study the permanent impact that the country's trend suffered around each Sudden Stop identified in the data. This question becomes relevant in order to understand the long-run implication of short-run macroeconomic volatility in Emerging countries.

## 7.1 Anatomy of Sudden Stops

This section studies the model implications for the average simulated Sudden Stop, the percentils 32 and 68, and compares it to the average in the argentinean data. As with the data, we define a Sudden Stop episode as a year in which the country presents a 2% fall in the GDP and 2 p.p. increase in net exports to output ratio. We simulate the economy for 500.000 periods, removed the first half of observations, recover the episodes that fit into our definition of Sudden Stop and compute the cross-sectional average of all episodes including the 5 years before and after. As in the data, we keep only the first event when two episodes have less than five years of difference. The frequency of Sudden stops in the data and the model are aligned, being of 6.7% in the model and of 7.8% in the data. Additionally, the model replicates the main dynamics involved in a sudden stop, both qualitatively and quantitatively.

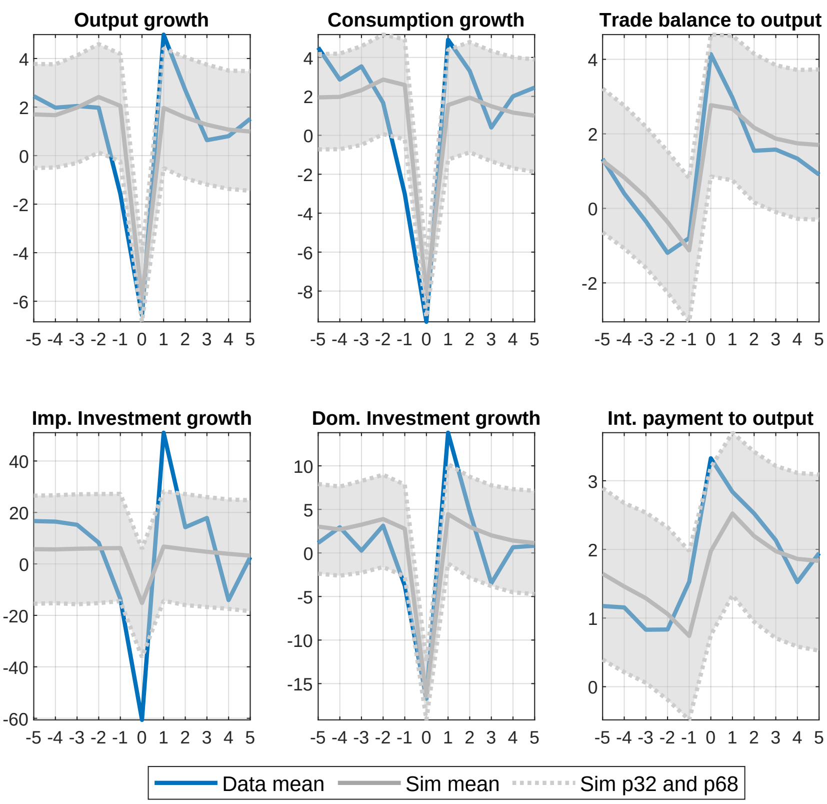


Figure 9: Av. sudden stop in the data, simulated mean, and percentiles 32 and 68.

Note: Average simulated Sudden Stop, percentils 32, and 68 (grey lines), and average Sudden Stop in the argentinean data (blue line). Simulated events come from 500.000 simulation periods with half burn-in periods, where we recover the episodes that fit into our definition of Sudden Stop and compute the cross-sectional average of all episodes including the 5 years before and after. We keep only the first event when two episodes have less than five years of difference, both in simulations and in the data.

The Sudden Stop emerges endogenously, mostly as a combination of various technological and financial shocks that affect the economy in different ways depending on the episode. Figure 10 presents in each plot the evolution of output for the baseline calibration and the counterfactual dynamics shutting down one shock at a time. The larger the difference between baseline and counterfactual, the more important is the shock that we remove.

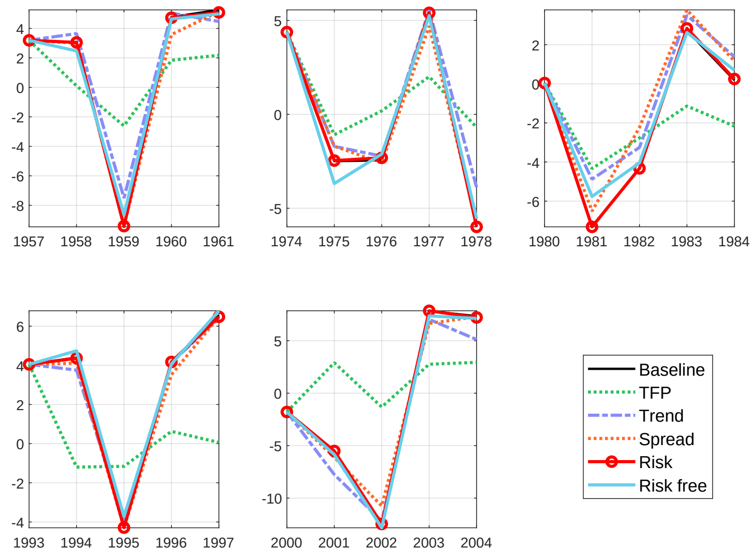


Figure 10: GDP growth around Sudden Stops: observed and counterfactuals dynamics

Note: Observed and counterfactual dynamics around Sudden Stop episodes in Argentina. The Baseline corresponds to the smoothed value of GDP growth. We define as $t = 0$ the year of the Sudden Stop. We simulate counterfactual dynamics from $t-1$ to $t+2$, taking the observed value at $t-2$ as initial condition, the baseline calibration, and removing one shock at the time. TFP stands for TFP productivity shock in final goods production ($a_t$), in domestic investment ($ad_t$) and the covariance among them. Risk shock includes the dispersion shocks in both sectors ($\sigma_t^i$, $\sigma_t^d$).

As seen in the figure, in all the episodes, trend and mean reverting shocks matter. The trend tends to matter the most when a policy change was involved in the episode, for instance 2002. For 1976 and 1982, financial factors play a very relevant role. To some extent the spreads matter also in the 2002 crisis. It can be seen that removing them would have implied a larger output growth. For the sake of space, in the main text we only include the evolution of output growth during Sudden Stops but the drivers behind the dynamics of other variables may be different. For instance, in the case of imported investment, the risk shock tends to play a crucial role in most Sudden Stops. We leave the study of the main drivers of the rest of the endogenous variables to the section 10.6 in the appendix.

## 7.2 A quantitative view of the long-run impact of Sudden Stops

Having identified the most relevant shock in each episode we want to quantify the long-run impact of Sudden Stops, i.e. the effect on the trend, for each episode. Figure 11 presents the dynamics of the logarithm of the trend for each episode decomposing it in productivity versus financial shocks. Each picture shows the logarithm of the trend in the baseline specification (blue solid line) and the counterfactual (the left column shutting down technological shocks and the right one shutting down financial shocks).

As seen in the plots, in the absence of the technology and financial drivers, the trend of the economy would have been different from the smoothed one. The counterfactual trend remains above the smoothed one for the 1959, 1976, and 1982 sudden stops. For 1995 and 2002, the trend decelerates in the neighborhood of the crisis but shutting down technology or financial shocks do not explain it.[12]

Financial shocks matter the most for the 1982 crisis. Removing them would have implied (persistently) a milder drop in the trend.

The 2002 crisis is a very interesting one and deserves comment. The Sudden Stop occurred at the same time as the abandonment of the convertibility plan, i.e. the currency peg. Trend shocks, in turn, are meant to capture these events that are not otherwise included in the model. Then, by removing the trend shock in this context we also remove the impact of the change in policy which in some way contributed to the recovery after 2003. For this reason, the counterfactual economy recovers at a slower pace after 2003 than the baseline economy.

The previous figure shows the importance of technology shocks in the Sudden Stops. This does not imply that the trend around Sudden Stops is determined by trend shocks. The endogenous component of the trend matters and also respond to trend shocks. We can disentangle the impact of trend shock to the role of the endogenous trend by studying the dynamics of the trend around each Sudden Stop for different values of $\eta$. Figure 12 present the baseline dynamic of the trend in the black solid line, the one with $\eta = 1$, that implies a fully exogenous trend, and fully endogenous trend, $\eta = 0$. As seen in the figure, as expected, the baseline trend is an average of both exogenous and endogenous components.

[12] In the appendix we show the historical variance decomposition showing which shocks push the trend down in those periods.

When the exogenous component is the determinant of the Sudden Stop, by construction the endogenous trend is above the smoothed estimate of the trend. This happens in all Sudden Stops except in 2002. As seen in all these cases, when the trend shock is a main driver of the Sudden Stop, it falls at the period of the crisis. The persistence of the crisis comes from the endogenous trend. This is the case in all crises. In the 2002 crisis, trend dynamics are mainly driven by the endogenous component, and the recovery is pushed by the exogenous trend after 2003. This is in line with the previous findings of this section. The behavior of the endogenous component of the trend determines the key link between the business cycle and the long run. This is our central result; the business cycle translates into persistent long-run stagnation.

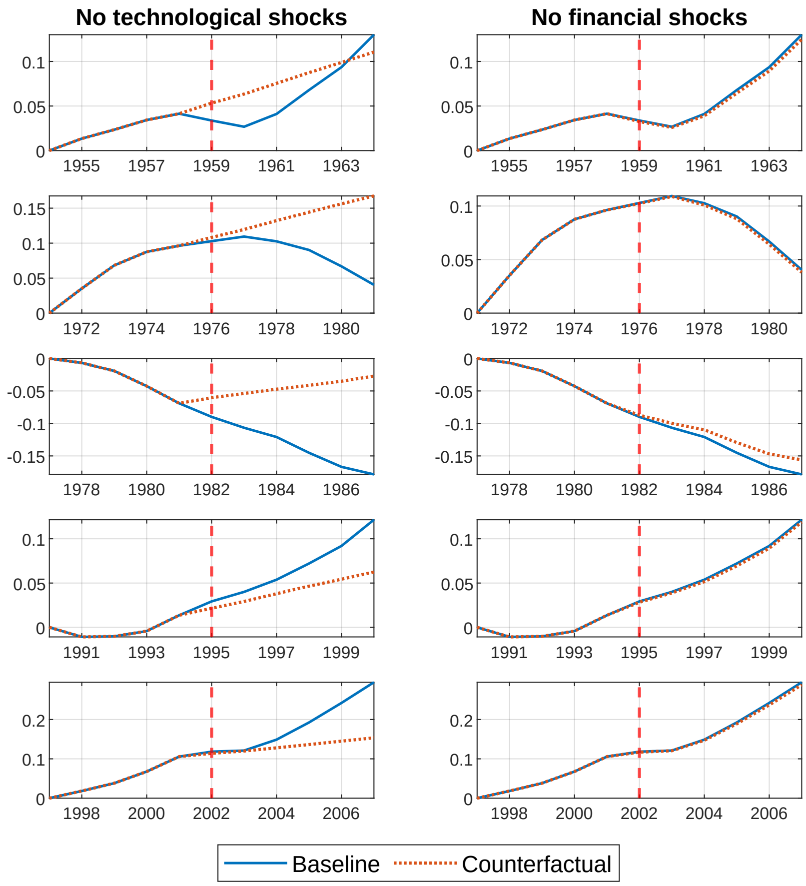


Figure 11: Observed and counterfactual trend dynamics (in logs)

Note: Smoothed and counterfactual dynamics around Sudden Stop episodes in Argentina. The plots show the log of the trend ($ln(X_t)$) calculated as $ln(X_t) = ln(X_{t-1}) + ln(gx_t)$, normalizing $X_1 = 1$. The Baseline corresponds to the smoothed value of the trend growth rate ($gx_t$). In the counterfactual dynamics, we simulate $gx_t$ from $t-1$ to $t+5$, taking the smoothed value at $t-2$ as initial condition. We remove the correspondent shocks during the simulated periods. First column sets trend shocks equal to zero, second column sets TFP in final production sector ($a_t$), in domestic investment sector ($ad_t$), and their covariance, equal to zero, and last column sets spread shocks ($\mu_t$), risk shocks ($\sigma_t$) and risk-free interest rate shocks ($R_{f,t}$) equal to zero.

Last but not least, the same analysis can be carried to disentangle the role of financial shocks. This is shown in the third column of Figure 13. There, the counterfactual economy is one without financial shocks, but $\eta$ is fixed in the posterior mean value. The picture compares them with a fully exogenous trend ($\eta = 1$) and a fully endogenous trend ($\eta = 0$). This figure highlights the interaction between the endogenous trend and the financial shocks. In most of the crises, the trend would have been stronger without financial shocks if the trend were fully endogenous. This implies that financial shocks affect the trend in a persistent way due to the endogenous component.

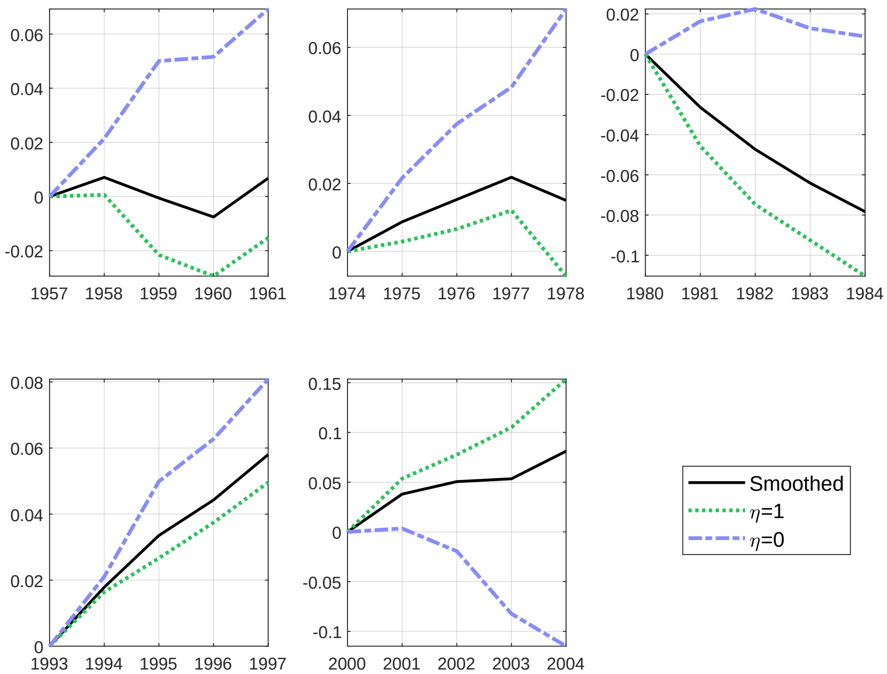


Figure 12: Smoothed and counterfactual trend dynamics (in logs)

Note: Smoothed and counterfactual dynamics around Sudden Stop episodes in Argentina. The plots show the log of the trend ($ln(X_t)$) calculated as $ln(X_t) = ln(X_{t-1}) + ln(gx_t)$, normalizing $X_1 = 1$. The Baseline corresponds to the smoothed value of the trend growth rate ($gx_t$). In the counterfactual dynamics, we simulate $gx_t$ from $t-1$ to $t+2$, changing the calibrated value of $\eta$ and maintaining the rest of parameters at their posterior mean.

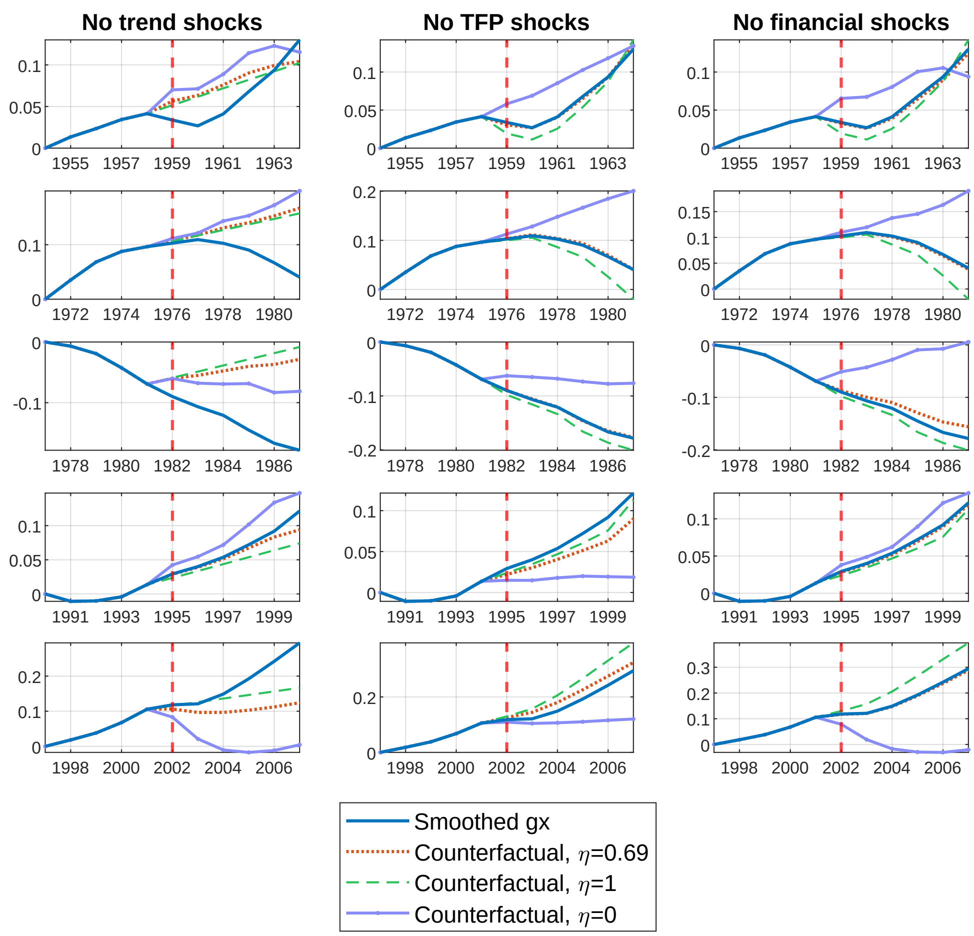


Figure 13: Smoothed and counterfactual trend dynamics

Note: Smoothed and counterfactual dynamics around Sudden Stop episodes in Argentina. The plots show the log of the trend ($ln(X_t)$) calculated as $ln(X_t) = ln(X_{t-1}) + ln(gx_t)$, normalizing $X_1 = 1$. The Baseline corresponds to the smoothed value of the trend growth rate ($gx_t$). In the counterfactual dynamics, we simulate $gx_t$ from $t-1$ to $t+5$, taking the smoothed value at $t-2$ as initial condition. We remove the correspondent shocks during the simulated periods. First column sets trend shocks equal to zero, second column sets TFP in final production sector ($a_t$), in domestic investment sector ($ad_t$), and their covariance equal to zero, and last column sets spread shocks ($\mu_t$), risk shocks ($\sigma_t$) and risk-free interest rate shocks ($R_{f,t}$) equal to zero.

# 8 Concluding remarks

We develop a theory to understand and quantify the interaction between growth, financial frictions, and Sudden Stops in Emerging economies. We find that the dichotomy of trend shocks versus financial frictions to explain the business cycle in emerging countries is a first-order approximation. The behavior of both of them is closely interconnected.

Our theory identifies the financial constraints and financial shocks as key drivers of many features of the Emerging markets business cycle. Moreover, they are at the core of Sudden Stops. In the case of Argentina, we document that financial factors have a persistent impact on the economy through the endogenous trend. For instance, during the 1982 episode, the entrepreneurial risk, spreads, and financial constraints shaped the dynamics of the trade balance, consumption, and imported investment dynamics.

Productivity shocks, both transitory and permanent, are also of first-order importance. We do not present a theory for permanent productivity shocks. Our interpretation of these shocks, however, coincides with that of Aguiar and Gopinath (2007). Permanent shocks can capture the sudden changes in fiscal and monetary policies, changes in the trade or current account policies, or even changes in the exchange rate policy, such as abandonment of fixed exchange rate regimes. Such changes are likely to have a strong and long-lasting impact and are plausible interpretations of the trend shock if they are perceived as permanent.

In a nutshell, a finding to highlight is that the cycle and trend in emerging countries are interconnected, and crises have persistent effects at business cycles and secular frequencies due to the existence of financial constraints. Hence, modeling emerging economies without accounting for financial frictions may entail a significant simplification. Yet, our analysis highlights only one potential channel for the impact of business cycles on the trend, the endogenous growth due to capital accumulation. We leave the study of additional channels for future research.

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# 10 Online Appendix

## 10.1 Data

### 10.1.1 Estimation observables

In the estimation, we include eight observables: GDP growth ($g_y$), private consumption growth ($g_c$), domestic investment growth ($g_{i_d}$), imported investment growth ($g_{i_i}$), trade balance to output ratio ($tby$), interest rate payments over output ($rb_y$), the risk free interest rate ($R_f$) and the relative price of imported capital investment goods to GDP deflator, in demeaned growth rate ($g_{p_i}$). National account data come from IIEP (2018). Due to data availability, our price deflators are Fisher chained indexes.

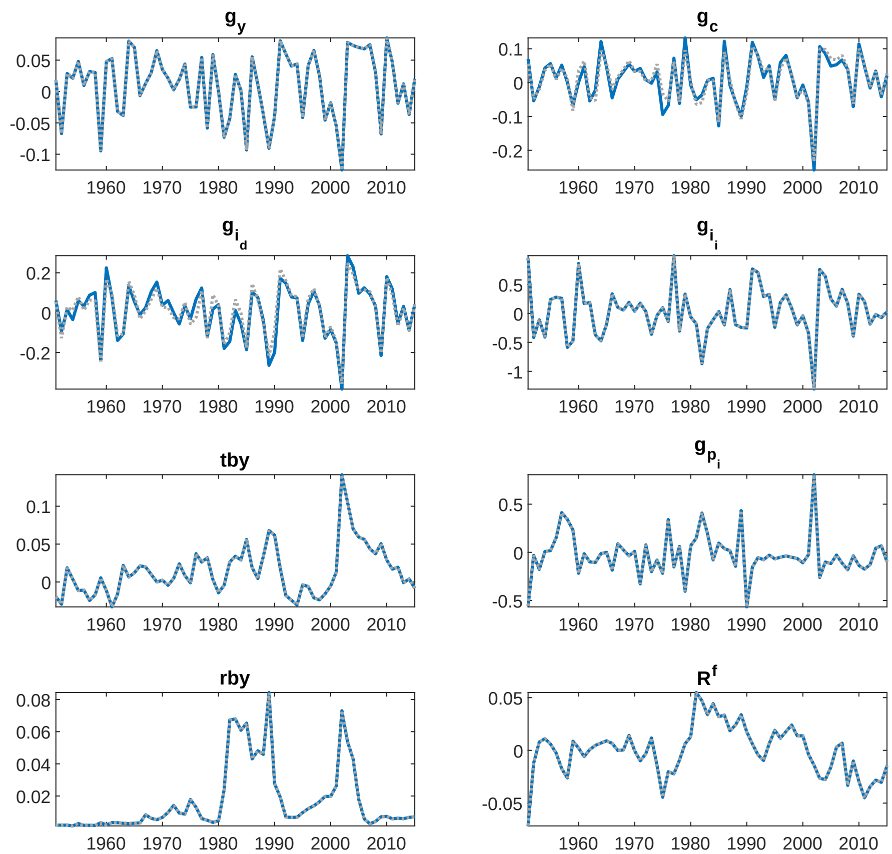


Figure 14: Observable variables and smoothed variables

Time series used in the Bayesian Estimation: output growth ($g_y$), private consumption growth ($g_c$), domestic investment growth ($g_{i_d}$), imported investment growth ($g_{i_i}$), trade balance to output ratio ($tby$), interest rate payments ($Rb_y$), the relative price of imported capital investment goods to GDP deflator, in demeaned growth rate ($g_{p_i}$), and risk free interest rate ($R^f$). Blue line is the data, grey discontinued line is the smoothed variable.

Variables definition in aggregate, nominal terms: output is the annual GDP. Consumption is private consumption. The total investment is gross fixed capital formation. In the data, gross fixed capital formation is the sum of constructions and durable production equipment. The last one is composed of imported and domestic transport material, and imported and domestic machinery and equipment. We define domestic investment as the sum of 3 variables: constructions, domestic transport material and domestic machinery and equipment. This variable is in real terms in the data. Output, consumption and government spending are deflated by the GDP deflator. We work with per capita variables, and obtain the growth rates by log-differences.

To construct the imported investment and the price of imported investment we proceed as follows. Real imported investment is the sum of real imported transports plus real imported machinery and equipment. We also have data on nominal imported investment (transports plus machinery and equipment). To compute the implicit price deflator of imported investment we divide nominal imported investment by real imported investment. To compute the relative price of imported investment in terms of domestic goods we divide this price, by the GDP deflator.

Finally, as an observable we use per-capita imported investment in growth obtained as follows: $g_{i_{i,t}} = \ln(i_{i,t}) - \ln(i_{i,t-1})$.

The trade balance in nominal terms is nominal exports minus nominal imports. Trade balance to output ratio: it is the ratio of trade balance and output, in levels.

The variable *rby* are annual net interest rate payments to the rest of the world, divided by output.

Risk free interest rate: demeaned risk free rate using the short term nominal interest rate from Jordà et al. (2019) for US in real terms, by removing US CPI current inflation.

Population data comes from World Bank and FRED.

#### 10.1.2 Stylized facts: international data

International data for capital imports come from World integrated Trade Solutions (WITS), from the World Bank. This variable is the sum of two import categories in Broad Economic Categories (BEC) classification: Capital goods (except transport equipment), category 41, and Transport equipment, industrial, category 521. Data is in thousands of dollars, and imports include the rest of the world as partner. Due to data availability, the period under consideration is 1976-2018, but differs considerably among countries. In the following table we present the sample period for each country and the average percentage of imported investment over total imports, for the correspondent period.

| Country | Sample | Imported investment/Imports |
|---|---|---|
| Argentina | 1980-2018 | 21% |
| Antigua and Barbuda | 2005-2018 | 12% |
| Bulgaria | 1996-2018 | 15% |
| Belize | 1992-2018 | 16% |
| Bolivia | 1977-2015 | 27% |
| Brazil | 1983-2018 | 16% |
| Barbados | 1980-2018 | 13% |
| Chile | 1983-2018 | 24% |
| Colombia | 1978-2018 | 24% |
| Costa Rica | 1986-2018 | 15% |
| Dominican Republic | 2001-2018 | 14% |
| Ecuador | 1980-2018 | 23% |
| Egypt, Arab Rep. | 1981-2018 | 13% |
| Guatemala | 1986-2018 | 16% |
| Guyana | 1997-2018 | 20% |
| Honduras | 1986-2018 (disc.) | 17% |
| iran | 1986-2018 (disc.) | 23% |
| Jordan | 1981-2018 | 13% |
| St. Lucia | 1981-2018 | 13% |
| Morocco | 1976-2018 | 17% |
| Mexico | 1986-2018 | 20% |
| Panama | 1986-2018 | 13% |
| Peru | 1976-2018 | 21% |
| Paraguay | 1983-2018 | 24% |
| El Salvador | 1986-2018 | 14% |
| Tunisia | 1980-2018 | 16% |
| Turkey | 1985-2018 | 20% |
| Uruguay | 1983-2018 | 16% |
| Venezuela | 1983-2018 | 24% |

## 10.2 Equilibrium conditions

### 10.2.1 Equilibrium equations

Household's problem:

$$\nu_t \left( C_t - \alpha \tilde{C}_{t-1} - X_{t-1} \frac{h_{f,t}^{\omega_f}}{\omega_f} - X_{t-1} \frac{h_{d,t}^{\omega_d}}{\omega_d} \right)^{-\sigma} = \lambda_t X_{t-1}^{-\sigma}$$

$$\nu_t \left( C_t - \alpha \tilde{C}_{t-1} - X_{t-1} \frac{h_{f,t}^{\omega_f}}{\omega_f} - X_{t-1} \frac{h_{d,t}^{\omega_d}}{\omega_d} \right)^{-\sigma} X_{t-1} h_{f,t}^{\omega_f - 1} = W_{f,t} \lambda_t X_{t-1}^{-\sigma}$$

$$\nu_t \left( C_t - \alpha \tilde{C}_{t-1} - X_{t-1} \frac{h_{f,t}^{\omega_f}}{\omega_f} - X_{t-1} \frac{h_{d,t}^{\omega_d}}{\omega_d} \right)^{-\sigma} X_{t-1} h_{d,t}^{\omega_d - 1} = W_{d,t} \lambda_t X_{t-1}^{-\sigma}$$

$$\lambda_t = \beta g_{x,t}^{-\sigma} R_{t+1} \mathbb{E}_t \left[ \lambda_{t+1} \right]$$

$$C_t + D_t R_t = W_{d,t} h_{d,t} + W_{f,t} h_{f,t} + D_{t+1} + \Lambda_t$$

$$\Lambda_t = \Pi_{ki,t} + \Pi_{kd,t} + \Pi_{Id,t} + T_{i,t} + T_{d,t} - S_t$$

Final goods producer:

$$r_{d,t} = a_t (1-\gamma)(X_t h_{f,t})^{\gamma} K_t^{1-\gamma-\mu_1} a_1 K_{d,t}^{\mu_1 - 1}$$

$$W_{f,t} = a_t \gamma K_t^{1-\gamma} (X_t h_{f,t})^{\gamma - 1} X_t$$

$$r_{i,t} = a_t (1-\gamma)(X_t h_{f,t})^{\gamma} K_t^{1-\gamma-\mu_1} (1-a_1) \Xi_{t-1}^{\mu_1} K_{i,t}^{\mu_1 - 1}$$

$$Y_t = a_t (X_t h_{f,t})^{\gamma} K_t^{1-\gamma}$$

$$K_t = \left( a_1 K_{d,t}^{\mu_1} + (1-a_1) \left( \Xi_{t-1} K_{i,t} \right)^{\mu_1} \right)^{\frac{1}{\mu_1}}$$

Imported capital producer:

$$q_{i,t} - \Lambda_{i,t} \Big[ 1 + \Phi'_{K_{i,t+1}} \Big( \frac{K_{i,t+1}}{K_{i,t}} \Big) \Big] =$$
$$\mathbb{E}_t \beta \frac{\lambda_{t+1}}{\lambda_t} g_{x,t}^{-\sigma} \left( q_{i,t+1}(1-\delta_{ki}) - \Lambda_{i,t+1} \left[ (1-\delta_{ki}) - \Phi \Big( \frac{K_{i,t+2}}{K_{i,t+1}} \Big) - \Phi'_{K_{i,t+1}} \Big( \frac{K_{i,t+2}}{K_{i,t+1}} \Big) \right] \right)$$

$$\Lambda_{i,t} = P_{i,t}$$

$$K_{i,t+1} = K_{i,t}(1-\delta_{ki}) + I_{i,t} - \Phi \Big( \frac{K_{i,t+1}}{K_{i,t}} \Big) K_{i,t}$$

$$\Pi_{ki,t} = q_{i,t}K_{i,t+1} - q_{i,t}K_{i,t}(1-\delta_{ki}) - P_{i,t}I_{i,t}$$

Domestic capital producers:

$$q_{d,t} - \Lambda_{d,t}\Big[1 + \Phi'_{K_{d,t+1}}\Big(\frac{K_{d,t+1}}{K_{d,t}}\Big)\Big] =$$

$$\mathbb{E}_t\beta\frac{\lambda_{t+1}}{\lambda_t}g_{x,t}^{-\sigma}\left(q_{d,t+1}(1-\delta_{kd}) - \Lambda_{d,t+1}\left[(1-\delta_{kd}) - \Phi\Big(\frac{K_{d,t+2}}{K_{d,t+1}}\Big) - \Phi'_{K_{d,t+1}}\Big(\frac{K_{d,t+2}}{K_{d,t+1}}\Big)\right]\right)$$

$$\Lambda_{d,t} = p_{d,t}$$

$$K_{d,t+1} = K_{d,t}(1-\delta_{kd}) + I_{d,t} - \Phi\Big(\frac{K_{d,t+1}}{K_{d,t}}\Big)K_{d,t}$$

$$\Pi_{kd,t} = q_{d,t}K_{d,t+1} - q_{d,t}K_{d,t}(1-\delta_{kd}) - p_{d,t}I_{d,t}$$

Imported capital entrepreneurs:

$$R_{i,t+1} = \frac{r_{i,t+1} + q_{i,t+1}(1-\delta_{ki})}{q_{i,t}}$$

$$\frac{R_{i,t+1}}{R_{t+1}}\Big[\Gamma(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t}) - \mu_{ki}G(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t})\Big](1+\varsigma_{i,t}) = \varsigma_{i,t}$$

$$\mathbb{E}_t\frac{R_{i,t+1}q_{i,t}K_{i,t+1}}{R_{t+1}N_{i,t+1}}\left(1-\Gamma\left(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t}\right)\right) = \mathbb{E}_t\left(\frac{1-F\left(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t}\right)}{1-F\left(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t}\right) - \mu_{ki}\bar{\omega}_{i,t+1}F_\omega\left(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t}\right)}\right)$$

$$q_{i,t}K_{i,t+1} = N_{i,t+1} + B_{i,t+1}$$

$$N_{i,t+1} = \gamma^e\left[R_{i,t}q_{i,t-1}K_{i,t} - R_tB_{i,t} - \mu_{ki}\int_0^{\bar{\omega}_{i,t}}\omega dF(\omega)R_{i,t}q_{i,t-1}K_{i,t}\right] + WE_{i,t}$$

Domestic capital entrepreneurs:

$$R_{d,t+1} = \frac{r_{d,t+1} + q_{d,t+1}(1-\delta_{kd})}{q_{d,t}}$$

$$\frac{R_{d,t+1}}{R_{t+1}}\Big[\Gamma(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}) - \mu_{kd}G(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t})\Big](1+\varsigma_{d,t}) = \varsigma_{d,t}$$

$$\mathbb{E}_t\frac{R_{d,t+1}q_{d,t}K_{d,t+1}}{R_{t+1}N_{d,t+1}}\left(1-\Gamma\left(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}\right)\right) = \mathbb{E}_t\left(\frac{1-F\left(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}\right)}{1-F\left(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}\right) - \mu_{kd}\bar{\omega}_{d,t+1}F_\omega\left(\bar{\omega}_{d,t+1}, \sigma_{\omega,t}\right)^d}\right)$$

$$q_{d,t}K_{d,t+1} = N_{d,t+1} + B_{d,t+1}$$

$$N_{d,t+1} = \gamma^e \left[ R_{d,t} q_{d,t-1} K_{d,t} - R_t B_{d,t} - \mu_{kd} \int_0^{\bar{\omega}_{d,t}} \omega dF(\omega) R_{d,t} q_{d,t-1} K_{d,t} \right] + WE_{d,t}$$

Domestic Investment producer

$$I_{d,t} = \tilde{a}_t^d (h_{d,t})^\rho$$

$$\Pi_{Id,t} = p_{d,t} a_t^d (h_{d,t})^\rho - W_{h,t} h_{d,t}$$

$$W_{d,t} = \rho p_{d,t} \frac{I_{d,t}}{h_{d,t}}$$

Exogenous shock processes:

$$\ln\left(g_{t+1}/\bar{g}\right) = \rho_g \ln\left(g_t/\bar{g}\right) + \epsilon_{t+1}^g; \qquad \epsilon_t^g \sim N\left(0, \sigma_g^2\right); \qquad |\rho_g| < 1$$

$$\ln a_{t+1} = \rho_a \ln a_t + \rho_{a,ad} \epsilon_{t+1}^{a,ad} + \epsilon_{t+1}^a; \qquad \epsilon_t^a \sim N\left(0, \sigma_a^2\right); \qquad |\rho_a| < 1.$$

$$\ln a_{d,t+1} = \rho_{ad} \ln a_{d,t} + \rho_{ad,a} \epsilon_{t+1}^{a,ad} + \epsilon_{t+1}^{ad}; \qquad \epsilon_t^{ad} \sim N\left(0, \sigma_{ad}^2\right); \qquad |\rho_{ad}| < 1$$

$$\ln \nu_{t+1} = \rho_\nu \ln \nu_t + \epsilon_{t+1}^\nu; \quad \epsilon_t^\nu \sim N\left(0, \sigma_\nu^2\right); \quad |\rho_\nu| < 1$$

$$\ln \mu_{t+1} = \rho_\mu \ln \mu_t + \epsilon_{t+1}^\mu; \qquad \epsilon_t^\mu \sim N\left(0, \sigma_\mu^2\right); \qquad |\rho_\mu| < 1$$

$$\ln R_{ft+1} = \rho_{R_f} \ln R_{ft} + \epsilon_{t+1}^{Rf}; \qquad \epsilon_t^{Rf} \sim N\left(0, \sigma_{R_f}^2\right); \qquad |\rho_{R_f}| < 1$$

$$\ln\left(p_{i,t+1}/\bar{p}\right) = \rho_p \ln\left(p_{i,t}/\bar{p}\right) + \epsilon_{t+1}^p; \qquad \epsilon_t^p \sim N\left(0, \sigma_p^2\right); \qquad |\rho_p| < 1$$

$$\ln \sigma_{\omega,t}^i = \left(1 - \rho_\sigma^i\right) \ln \mu_\sigma^i + \rho_\sigma^i \ln \sigma_{\omega,t-1}^i + \eta_\sigma^i \varepsilon_{\sigma,t}; \qquad \epsilon_t^\sigma \sim N\left(0, \sigma_\sigma^{2,i}\right); \qquad |\rho_\sigma^i| < 1$$

$$\ln \sigma_{\omega,t}^d = \left(1 - \rho_\sigma^d\right) \ln \mu_\sigma^d + \rho_\sigma^d \ln \sigma_{\omega,t-1}^d + \eta_\sigma^d \varepsilon_{\sigma,t}; \qquad \epsilon_t^\sigma \sim N\left(0, \sigma_\sigma^{2,d}\right); \qquad |\rho_\sigma^d| < 1$$

$$s_{t+1} = (1 - \rho_s)\bar{s} + \rho_s s_t + \epsilon_{t+1}^s; \quad \epsilon_t^s \sim N\left(0, \sigma_s^2\right); \quad |\rho_s| < 1$$

Definitions:

$$R_t = R_{o,t-1} e^{\mu_t - 1}$$

$$R_{o,t} = R^* + \exp\left(R_{f,t} - 1\right) + \psi_D \left[ \exp\left(\tilde{d}_{t+1} + \tilde{b}_{t+1} - (\bar{d} + \bar{b})\right) - 1 \right] +$$
$$\psi_Y \left[ \exp\left(y_t - \bar{y}\right) - 1 \right]$$

$$B_t = B_{i,t} + B_{d,t}$$

$$F(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) = \Theta\left( \frac{log(\bar{\omega}_{j,t+1}) + \frac{1}{2}{\sigma^j_{\omega,t}}^2}{\sigma^j_{\omega,t}} \right) \text{ for } j = i, d$$

$$G(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) = 1 - \Theta\left( \frac{\frac{1}{2}\sigma^{j\,2}_{\omega,t} - \log \bar{\omega}_{j,t+1}}{\sigma^j_{\omega,t}} \right) \text{ for } j = i, d$$

$$\Gamma(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) = \bar{\omega}_{j,t+1}\left(1 - F(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t})\right) + G(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) \text{ for } j = i, d$$

$$T_{i,t} = \left(1 - \frac{1}{1 - e^{\bar{\gamma}^e}}\right) V_{i,t} - w^e \Gamma_{t-1}$$

$$T_{d,t} = \left(1 - \frac{1}{1 - e^{\bar{\gamma}^e}}\right) V_{d,t} - w^e \Gamma_{t-1}$$

$$V_{i,t} = R_{i,t} q_{i,t-1} K_{i,t} - R_t B_{i,t} - \mu_{ki} \int_0^{\bar{\omega}_{i,t}} \omega dF(\omega) R_{i,t} q_{i,t-1} K_{i,t}$$

$$V_{d,t} = R_{d,t} q_{d,t-1} K_{d,t} - R_t B_{d,t} - \mu_{kd} \int_0^{\bar{\omega}_{d,t}} \omega dF(\omega) R_{d,t} q_{d,t-1} K_{d,t}$$

$$X_t = \Gamma^\eta_t \left[ \left( a_1 \bar{K}^{\mu_1}_{d,t} + (1 - a_1)\left(\Xi_{t-1}\bar{K}_{i,t}\right)^{\mu_1} \right)^{\frac{1}{\mu_1}} \right]^{1-\eta}$$

$$TB_t = R_t D_t - D_{t+1} + R_t(B_{i,t} + B_{d,t}) - (B_{i,t+1} + B_{d,t+1})$$

$$GDP_t = Y_t + p_{d,t} I_{d,t} - \mu_{ki} G(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t}) R_{i,t} q_{i,t-1} K_{i,t-1} - \mu_{kd} G(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}) R_{d,t} q_{d,t-1} K_{d,t-1}$$

### 10.2.2 Stationary equations

There are three sources of growth in the model: the trend in imported investment price ($P_{i,t}$) given by $\Xi_t$, the trend productivity shock $\Gamma_t$ and the trend of the economy $X_t$, that depends on capital accumulation and $\Gamma_t$. The correspondent growth rates are $g_{\Xi,t}$, $g_t$ characterized by equation 17, and $g_{x,t}$.

In order to solve the model, we need to stationarize the equilibrium equations from section 10.2, dividing each variable by the corresponding trend. In general, we adopt the notation of working with capital letters for growing variables and lowercase letters for detrended variables. We make an exception for $q_{i,t}$ and $\Lambda_{i,t}$ whose detrended versions are $\tilde{q}_{i,t}$ and $\tilde{\Lambda}_{i,t}$.

First, from equation 19 we need each component of domestic absorption to grow at the same rate than output, $X_{t-1}$. In particular, $P_{i,t}I_{i,t}$ has to grow at rate $X_{t-1}g_{\Xi,t}$. This happens only if the trend of imported investment is given by $\frac{X_{t-1}}{\Xi_{t-1}}$, and the growth rate of imported investment is $\frac{g_{x,t}}{g_{\Xi,t}}$.

Notice this fact is consistent with the data. In the dataset, we see that output, consumption, domestic investment, and the trade balance have a similar growth rate, close to 1% on average in the whole period. This is $\bar{g}-1$ in the model. However, the imported investment grows at an average rate of 3.6% and imported investment price grows at $-2.4\%$. This means the gross growth rate of imported investment prices is 0.9756 on average, what we call $\bar{g_\Xi}$. Then we have $\frac{g_{\bar{x},t}}{g_{\bar{\Xi},t}} = 1.034$, very close to the empirical gross growth rate of imported investment.

Since the price of domestic investment does not grow, the trend in domestic investment, and then, the one of domestic capital, is equal to $X_{t-1}$.

We follow an analogous approach to find the trend of the rest of the endogenous variables. The complete set of stationary equilibrium equations is the following.

Household's problem:

$$\nu_t \left( c_t - \alpha \frac{\tilde{c}_{t-1}}{g_{x,t-1}} - \frac{h_{f,t}^{\omega_f}}{\omega_f} - \frac{h_{d,t}^{\omega_d}}{\omega_d} \right)^{-\sigma} = \lambda_t$$

$$\nu_t \left( c_t - \alpha \frac{\tilde{c}_{t-1}}{g_{x,t-1}} - \frac{h_{f,t}^{\omega_f}}{\omega_f} - \frac{h_{d,t}^{\omega_d}}{\omega_d} \right)^{-\sigma} h_{f,t}^{\omega_f - 1} = w_{f,t}\lambda_t$$

$$\nu_t \left( c_t - \alpha \frac{\tilde{c}_{t-1}}{g_{x,t-1}} - \frac{h_{f,t}^{\omega_f}}{\omega_f} - \frac{h_{d,t}^{\omega_d}}{\omega_d} \right)^{-\sigma} h_{d,t}^{\omega_d - 1} = w_{d,t}\lambda_t$$

$$\lambda_t = \beta R_{t+1} g_{x,t}^{-\sigma} \mathbb{E}_t \left[ \lambda_{t+1} \right]$$

$$c_t + d_t R_t = w_{f,t}h_{f,t} + w_{d,t}h_{d,t} + d_{t+1}g_{x,t} + \tilde{\Lambda}_t$$

$$\tilde{\Lambda}_t = \pi_{ki,t} + \pi_{kd,t} + \pi_{Id,t} + t_{i,t} + t_{d,t} - s_t$$

Final goods producer:

$r_{i,t}$ grows at rate $\Xi_{t-1}$. $W_{f,t}$, $K_t$ and $Y_t$ grows at rate $X_{t-1}$. $r_{d,t}$ does not grow.

$$r_{d,t} = a_t(1-\gamma)(g_{x,t}h_{f,t})^{\gamma} k_t^{1-\mu_1-\gamma} a_1 k_{d,t}^{\mu_1 - 1}$$

$$w_{f,t} = a_t \gamma k_t^{1-\gamma}(g_{x,t}h_{f,t})^{\gamma-1} g_{x,t}$$

$$r_{i,t} = a_t(1-\gamma)(g_{x,t}h_{f,t})^{\gamma} k_t^{1-\mu_1-\gamma}(1-a_1) k_{i,t}^{\mu_1 - 1}$$

$$y_t = a_t(g_{x,t}h_{f,t})^{\gamma} k_t^{1-\gamma}$$

$$k_t = \left(a_1 k_{d,t}^{\mu_1} + (1-a_1)k_{i,t}^{\mu_1}\right)^{\frac{1}{\mu_1}}$$

Imported capital producer:

Here we have: $I_{i,t}$ and $K_{i,t}$ grow at rate: $\frac{X_{t-1}}{\Xi_{t-1}}$. $p_{i,t}$, $q_{i,t}$, $\Lambda_{i,t}$ grow at rate $\Xi_{t-1}$. $\Pi_t$ grows at rate $X_{t-1}$.

$$\tilde{q}_{i,t} - \tilde{\Lambda}_{i,t}\Big[1 + \Phi'_{k_{i,t+1}}\Big(\frac{k_{i,t+1}}{k_{i,t}}\frac{g_{x,t}}{g_{\Xi,t}}\Big)\Big] =$$

$$\mathbb{E}_t \beta \frac{\lambda_{t+1}}{\lambda_t}\frac{g_{\Xi,t}}{g_{x,t}^{\sigma}}\left(\tilde{q}_{i,t+1}(1-\delta_{ki}) - \tilde{\Lambda}_{i,t+1}\left[(1-\delta_{ki}) - \Phi\Big(\frac{k_{i,t+2}}{k_{i,t+1}}\frac{g_{x,t+1}}{g_{\Xi,t+1}}\Big) - \Phi'_{k_{i,t+1}}\Big(\frac{k_{i,t+2}}{k_{i,t+1}}\frac{g_{x,t+1}}{g_{\Xi,t+1}}\Big)\right]\right)$$

$$\tilde{\Lambda}_{i,t} = p_{i,t}$$

$$k_{i,t+1}\frac{g_{x,t}}{g_{\Xi,t}} = k_{i,t}(1-\delta_{ki}) + i_{i,t} - \Phi\Big(\frac{k_{i,t+1}}{k_{i,t}}\frac{g_{x,t}}{g_{\Xi,t}}\Big)k_{i,t}$$

$$\pi_{ki,t} = \tilde{q}_{i,t}k_{i,t+1}\frac{g_{x,t}}{g_{\Xi,t}} - \tilde{q}_{i,t}k_{i,t}(1-\delta_{ki}) - p_{i,t}i_{i,t}$$

Domestic capital producers

$q_{d,t}$, $p_{d,t}$ and $\Lambda_{d,t}$ do not grow. $K_{d,t}$, $I_{d,t}$ and $\Pi_{d,t}$ grow at rate $X_{t-1}$.

$$q_{d,t} - \Lambda_{d,t}\Big[1 + \Phi'_{k_{d,t+1}}\Big(\frac{k_{d,t+1}}{k_{d,t}}g_{x,t}\Big)\Big] =$$
$$\mathbb{E}_t\beta\frac{\lambda_{t+1}}{\lambda_t}g_{x,t}^{-\sigma}\left(q_{d,t+1}(1-\delta_{kd}) - \Lambda_{d,t+1}\left[(1-\delta_{kd}) - \Phi\Big(\frac{k_{d,t+2}}{k_{d,t+1}}g_{x,t+1}\Big) - \Phi'_{k_{d,t+1}}\Big(\frac{k_{d,t+2}}{k_{d,t+1}}g_{x,t+1}\Big)\right]\right)$$

$$\Lambda_{d,t} = p_{d,t}$$

$$k_{d,t+1}g_{x,t} = k_{d,t}(1-\delta_{kd}) + i_{d,t} - \Phi\Big(\frac{k_{d,t+1}}{k_{d,t}}\Big)k_{d,t}$$

$$\pi_{kd,t} = q_{d,t}k_{d,t+1} - q_{d,t}k_{d,t}(1-\delta_{kd}) - i_{d,t}p_{d,t}$$

Imported capital entrepreneurs:

$R_{i,t+1}$ does not grow. $N_t$, $B_{i,t}$, $WE_{d,t}$ grow at rate $X_{t-1}$.

$$\frac{R_{i,t+1}}{g_{\Xi,t}} = \frac{r_{i,t+1} + \tilde{q}_{i,t+1}(1-\delta_{ki})}{\tilde{q}_{i,t}}$$

$$\frac{R_{i,t+1}}{R_{t+1}}\left[\Gamma(\bar{\omega}_{i,t+1},\sigma^i_{\omega,t}) - \mu_{ki}G(\bar{\omega}_{i,t+1},\sigma^i_{\omega,t})\right](1+\varsigma_{i,t}) = \varsigma_{i,t}$$

$$\mathbb{E}_t\frac{R_{i,t+1}\tilde{q}_{i,t}k_{i,t+1}}{R_{t+1}n_{i,t+1}g_{\Xi,t}}\left(1-\Gamma\left(\bar{\omega}_{i,t+1},\sigma^i_{\omega,t}\right)\right) = \mathbb{E}_t\left(\frac{1-F\left(\bar{\omega}_{i,t+1},\sigma^i_{\omega,t}\right)}{1-F\left(\bar{\omega}_{i,t+1},\sigma^i_{\omega,t}\right) - \mu_{ki}\bar{\omega}_{i,t+1}F_\omega\left(\bar{\omega}_{i,t+1},\sigma^i_{\omega,t}\right)}\right)$$

$$\tilde{q}_{i,t}k_{i,t+1} = \left(n_{i,t+1} + b_{i,t+1}\right)g_{\Xi,t}$$
$$n_{i,t+1}g_{x,t} = \gamma^e\left[R_{i,t}\frac{\tilde{q}_{i,t-1}k_{it}}{g_{\Xi,t-1}}\left(1-\mu_{ki}\int_0^{\bar{\omega}_{i,t}}\omega dF(\omega)\right) - R_{i,t}b_{i,t}\right] + we_{i,t}$$

Domestic capital entrepreneurs:

$$R_{d,t+1} = \frac{r_{d,t+1} + q_{d,t+1}(1-\delta_{kd})}{q_{d,t}}$$

$$\frac{R_{d,t+1}}{R_{t+1}}\left[\Gamma(\bar{\omega}_{d,t+1},\sigma^d_{\omega,t}) - \mu_{kd}G(\bar{\omega}_{d,t+1},\sigma^d_{\omega,t})\right](1+\varsigma_{d,t}) = \varsigma_{d,t}$$

$$\mathbb{E}_t \frac{R_{d,t+1} q_{d,t} k_{d,t+1}}{R_{t+1} n_{d,t+1}} \left(1 - \Gamma\left(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}\right)\right) = \mathbb{E}_t \left( \frac{1 - F\left(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}\right)}{1 - F\left(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}\right) - \mu_{kd} \bar{\omega}_{d,t+1} F_\omega\left(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t}\right)} \right)$$

$$q_{d,t} k_{d,t+1} = n_{d,t+1} + b_{d,t+1}$$

$$n_{d,t+1} g_{x,t} = \gamma^e \left[ R_{d,t} q_{d,t-1} k_{d,t} \left(1 - \mu_{kd} \int_0^{\bar{\omega}_{d,t}} \omega dF(\omega)\right) - R_{t-1} b_{d,t} \right] + we_{d,t}$$

Domestic Investment producers

$$i_{d,t} = \bar{a}_d a_{t,d} g_{x,t} (h_{d,t})^\rho$$

$$\pi_{Id,t} = p_{d,t} i_{d,t} - w_{h,t} h_{d,t}$$

$$w_{d,t} = \rho p_{d,t} \frac{i_{d,t}}{h_{d,t}}$$

Exogenous shock processes: see section 10.2.

Definitions:

$T_{i,t}$ and $T_{d,t-1}$ grow at rate $X_{t-1}$.

$$R_t = R_{o,t-1} e^{\mu_t - 1}$$

$$R_{o,t} = R^* + \exp\left(R_{f,t} - 1\right) + \psi_D \left[ \exp\left(\tilde{d}_{t+1} + \tilde{b}_{t+1} - (\bar{d} + \bar{b})\right) - 1 \right] + \psi_Y \left[ \exp\left(y_t - \bar{y}\right) - 1 \right]$$

$$b_t = b_{i,t} + b_{d,t}$$

$$F(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) = \Theta\left( \frac{log(\bar{\omega}_{j,t+1}) + \frac{1}{2} {\sigma^j_{\omega,t}}^2}{\sigma^j_{\omega,t}} \right) \text{ for } j = i, d$$

$$G(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) = 1 - \Theta\left( \frac{\frac{1}{2} {\sigma^j}^2_{\omega,t} - \log \bar{\omega}_{j,t+1}}{\sigma^j_{\omega,t}} \right) \text{ for } j = i, d$$

$$\Gamma(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) = \bar{\omega}_{j,t+1} \left(1 - F(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t})\right) + G(\bar{\omega}_{j,t+1}, \sigma^j_{\omega,t}) \text{ for } j = i, d$$

$$t_{i,t} = \left(1 - \frac{1}{1 - e^{\bar{\gamma}^e}}\right) v_{i,t} - we_{i,t}$$

$$t_{d,t} = \left(1 - \frac{1}{1 - e^{\bar{\gamma}^e}}\right) v_{d,t} - we_{d,t}$$

$$v_{i,t} = R_{i,t}\frac{\tilde{q}_{i,t-1}k_{i,t}}{g_{\Xi,t-1}} - R_t b_{i,t} - \mu_{ki}\int_0^{\bar{\omega}_{i,t}} \omega dF(\omega) R_{i,t}\frac{\tilde{q}_{i,t-1}k_{i,t}}{g_{\Xi,t-1}}$$

$$v_{d,t} = R_{d,t}q_{d,t-1}k_{d,t} - R_t b_{d,t} - \mu_{kd}\int_0^{\bar{\omega}_{d,t}} \omega dF(\omega) R_{d,t}q_{d,t-1}k_{d,t}$$

$$g_{x,t} = g_t^{\eta} g_{x,t-1}^{1-\eta}\left[\left(a_1 \bar{k}_{d,t}^{\mu_1} + (1-a_1)\left(\bar{k}_{i,t}\right)^{\mu_1}\right)^{\frac{1}{\mu_1}}\right]^{1-\eta}$$

$$tb_t = R_t d_t - d_{t+1}g_{x,t} + R_t(b_{i,t} + b_{d,t}) - (b_{i,t+1} + b_{d,t+1})g_{x,t}$$

$$gdp_t = y_t + i_{d,t}p_{d,t} - \mu_{ki}G(\bar{\omega}_{i,t+1}, \sigma^i_{\omega,t})R_{i,t}\frac{\tilde{q}_{i,t-1}k_{i,t}}{g_{\Xi,t-1}} - \mu_{kd}G(\bar{\omega}_{d,t+1}, \sigma^d_{\omega,t})R_{d,t}q_{d,t-1}k_{d,t-1}$$

## 10.3 Estimation

Table 7: Priors and estimation results: Measurement errors

| | Prior | | | | | Posterior | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Dist.** | **LB** | **UB** | **Mean** | **s. d.** | **Mean** | **Median** | **10%** | **90%** |
| $g_y$ | IG | | | 0.001 | 0.003 | 0.00 | 0.00 | 0.00 | 0.00 |
| $g_c$ | IG | | | 0.001 | 0.003 | 0.02 | 0.02 | 0.01 | 0.02 |
| $g_{i_d}$ | IG | | | 0.001 | 0.003 | 0.04 | 0.04 | 0.03 | 0.05 |
| $g_{i_i}$ | IG | | | 0.001 | 0.003 | 0.00 | 0.00 | 0.00 | 0.00 |
| $tby$ | IG | | | 0.001 | 0.003 | 0.00 | 0.00 | 0.00 | 0.00 |
| $rby$ | IG | | | 0.001 | 0.003 | 0.00 | 0.00 | 0.00 | 0.00 |
| $g_p$ | IG | | | 0.001 | 0.003 | 0.00 | 0.00 | 0.00 | 0.00 |
| $R_f$ | IG | | | 0.001 | 0.003 | 0.00 | 0.00 | 0.00 | 0.00 |

Note: Posterior distributions from Random Walk Metropolis Hasting algorithm of 1,000,000 draws, with 500,000 burn-in draws.

## 10.4 Quantitative results: variance decomposition

In the following table we present the decomposition of transitory shocks contribution to the volatility of each observable variable.

Table 8: Variance decomposition (%)

| Shock | $g_y$ | $g_c$ | $g_{i_d}$ | $g_{i_i}$ | $tby$ | $rby$ |
|---|---|---|---|---|---|---|
| $a_t$ | 16.9 | 10.0 | 3.3 | 0.7 | 2.1 | 2.4 |
| $ad_t$ | 0.1 | 0.3 | 2.8 | 0.0 | 0.9 | 0.5 |
| $\epsilon^{a,ad}$ | 63.0 | 47.8 | 66.1 | 2.6 | 25.6 | 16.7 |
| **Transitory** | **80.0** | **58.1** | **72.2** | **3.3** | **28.6** | **19.6** |

## 10.5 The interaction between the trend and financial factors: supplementary figures

In this section we present the IRF of interest rate, investment, and debt, to a one standard deviation shock in spread ($\mu_t$), risk free ($R_{f,t}$) or risk ($\sigma_t^i$, $\sigma_t^d$), to complement the analysis in section 6.2.

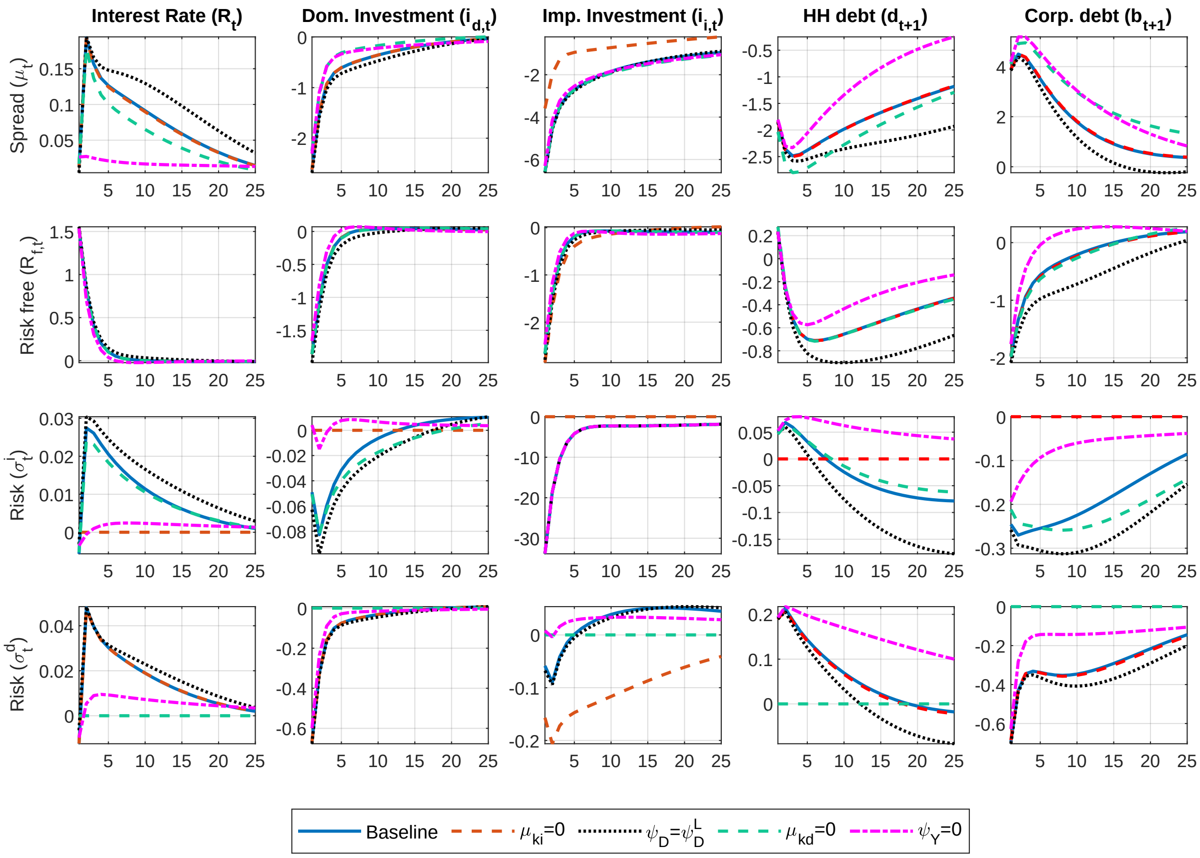


Figure 15: IRF (in %) for interest rate, investment and debt

Note: $R_t$, $i_{d,t}$, $i_{i,t}$, $d_{t+1}$, and $b_{t+1}$ impulse response function as percentage deviations in % from the steady state to a one standard deviation shock in $\mu_t$, $R_{f,t}$, $\sigma_t^i$, $\sigma_t^d$.

## 10.6 Sudden Stops: supplementary figures

In this section we present the shock decomposition for the year of the sudden stop ($t = 0$) and the year before ($t = -1$), for each episode and each main endogenous variable, in order to identify the main driver.

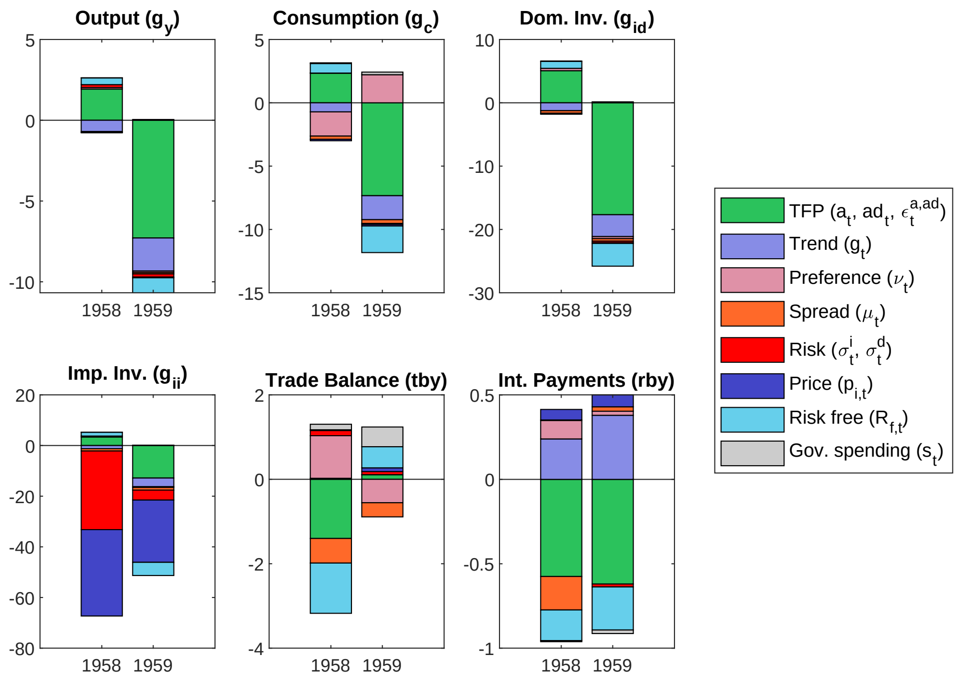


Figure 16: Sudden stop 1959: main drivers

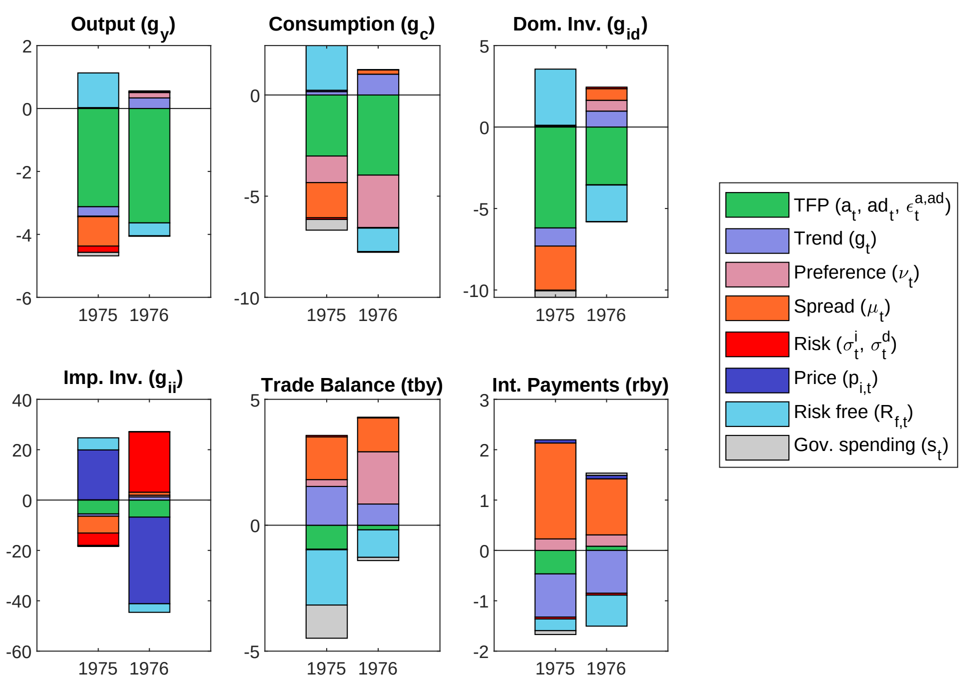


Figure 17: Sudden stop 1976: main drivers

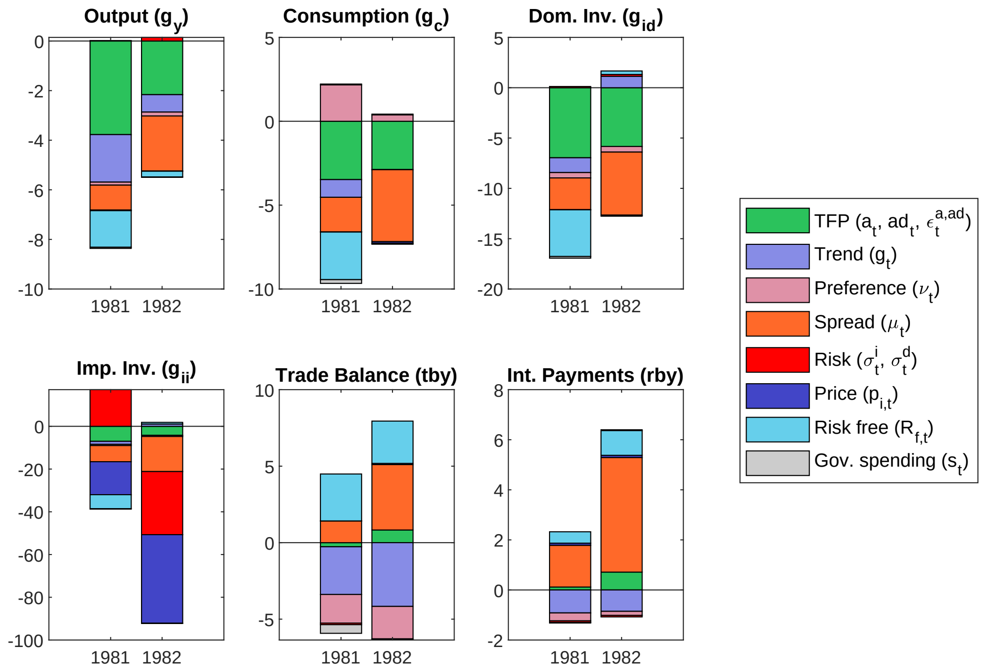


Figure 18: Sudden stop 1982: main drivers

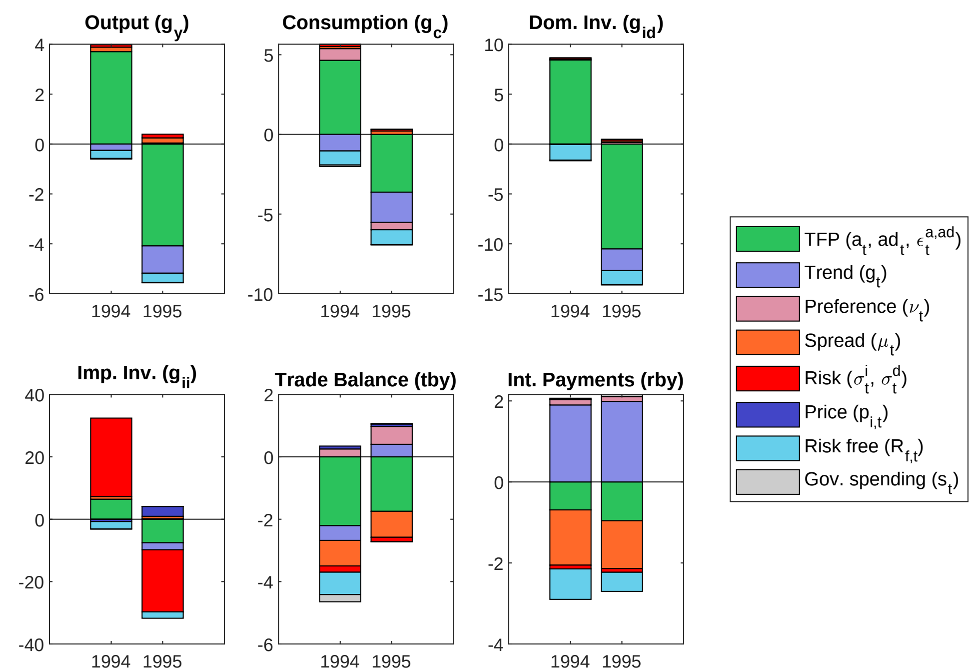


Figure 19: Sudden stop 1995: main drivers

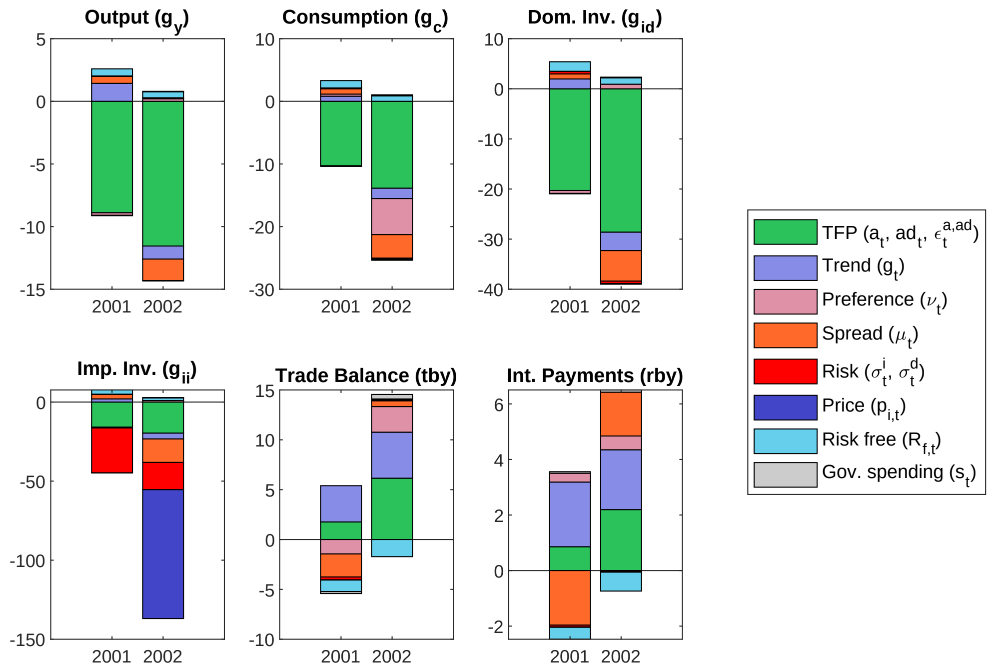


Figure 20: Sudden stop 2002: main drivers

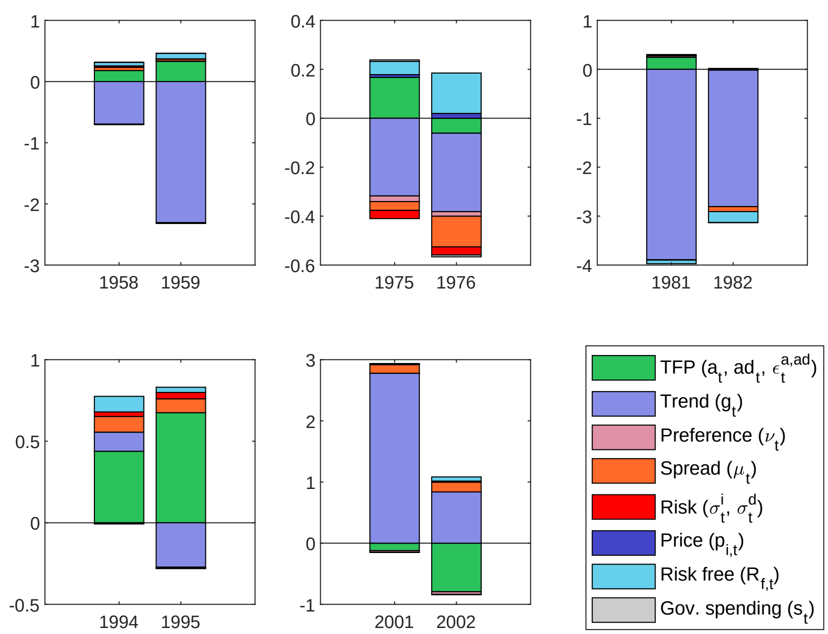


Figure 21: Trend growth (gx) historical decomposition

Note: Historical decomposition of trend growth (gx) in the five sudden stop episodes identified in the data.