On Overborrowing: Trend Shocks and Capital Controls*

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Abstract

Sudden Stops are characterized by large output drops, current account reversals and real exchange rate depreciation followed by a slow recovery, a pattern that has proven to be hard to capture with standard open economy models. This paper studies the role of shocks to international lending, domestic demand and domestic supply in generating the proper dynamics in a small open economy with endogenous borrowing limits. We find that permanent income changes play an important role in generating a Sudden Stop followed by a slow recovery. This type of economy generates overborrowing during bad times, but also during good times due to the existence of permanent shocks, making the optimal tax less procyclical. However, due to precautionary savings, the size of optimal capital controls tends to decrease with trend volatility.

Keywords: Borrowing constraints; trend shocks; Sudden Stops; optimal capital controls.

JEL Classification: F32, F34, F41.

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1 Introduction

Macro-financial crisis in small open economies, usually called "Sudden Stops", became frequent episodes during the last 30 years. The distinguishing features of these crisis are large output drops, sudden and sizable current account reversals and real exchange rate depreciation that has usually been followed by a slow recovery, i.e. a highly asymmetric dynamic where the crisis unravels quickly affecting financial and real variables, with sluggish recovery.

Even though understanding these dynamics has been of first order importance, these data patterns have proven to be hard to capture with standard open economy models. A promising line of research has been developed by Mendoza (2010) and Bianchi (2011), following the seminal work of Mendoza (2001), where they model small open economies subject to collateral constraints with endogenous borrowing limits.[1] However, these models have not been able to generate the observed persistence and sluggishness in the recovery after the crisis.[2]

In this paper, we study the role of shocks to international lending, domestic demand and domestic supply in generating Sudden Stops in a model where the collateral constraint depends on the tradable value of domestic income. We find that transitory supply and financial shocks can generate a sizable depreciation of the real exchange rate but imply counterfactual persistence in the real exchange rate and the trade balance. Demand shocks, instead, can generate a slow recovery after a Sudden Stop but only a mild impact on the real exchange rate and a counterfactual comovement between net exports and income. On the other hand, permanent income shocks can be relevant factors for these episodes as they produce plausible Sudden Stop dynamics.

Based on these findings, we extend the baseline model to include both transitory and trend shocks as in Aguiar and Gopinath (2006). We estimate the trend and transitory shocks using Argentinean data from 1876 to 2004, and we feed the estimated parameters

[1]In this class of models, borrowing limits depend on market prices and, consequently, are subject to general equilibrium effects, usually called "pecuniary externalities". Relevant prices are the price of capital (Mendoza (2010)) or the real exchange rate (Bianchi (2011)).

[2]The lack of persistence in the recovery after a Sudden Stop is more clear in the case of endowment economy models. When the literature models endogenous production and capital accumulation the problem in generating persistence is less dramatic, however even in this case the baseline model in Mendoza (2010) greatly benefits from imported inputs in production and working capital constraints.

into the model to simulate Sudden Stops as defined in the data and we find that the model with trend shocks produces realistic Sudden Stop dynamics. This result is in line with Aguiar and Gopinath (2006) and Aguiar and Gopinath (2007) who highlight the importance of trend shocks in generating the observed business cycle in emerging economies. This result is not only important from a quantitative point of view. It has significant economic implications in the way we understand these types of crisis as trend and transitory shocks generate very different debt dynamics in small open economy models.

Besides looking at unconditional moments and the dynamics around Sudden Stops, we test our model in a key dimension. As a by-product of our estimation strategy we can recover the estimates of transitory tradable income shocks, transitory non-tradable income shocks and a common trend shock. We identify several Sudden Stops in the data. If Sudden Stops were triggered by transitory shocks, we should observe a sequence of negative transitory shocks before these events. This is not the case in the data. Instead, we find mixed evidence on this dimension and, in general, persistent technology falls do not precede Sudden Stops. On the other hand, we find that the economy is growing in the years prior to Sudden Stops, in line with the implications of the Permanent Income Hypothesis that suggests that in the event of positive permanent income shocks the economy accumulates foreign debt to smooth consumption. Moreover, all Sudden Stops in our sample are preceded by a large negative trend shock, more than two standard deviations below average in most of the cases, suggesting that Sudden Stop dynamics are mainly driven by permanent shocks.

We find that the trend shocks model can generate overborrowing compared to the constrained efficient economy for the baseline calibration and the overborrowing result tends to decrease with trend shocks volatility. The overborrowing phenomena occurs when the competitive economy issues larger levels of debt than the constrained planner. Considering trend shocks introduces a new aspect of overborrowing. In the model with only mean reverting shocks the economy tends to suffer more overborrowing during bad times, i.e. when the economy issues debt to smooth consumption. However, with trend shocks the households tend to issue debt in good times to increase consumption today on behalf of future higher income and then tend to overborrow largely during good times too. With higher trend volatility, however, there are two forces playing in opposite directions. On the one hand, the precautionary savings motive induces a lower debt and lower frequency of binding constraint when volatility is larger. However, in the neighborhood of the state space where the borrowing constraint is binding, higher volatility of the trend generates higher expansion of consumption and higher correction during Sudden Stops relative to the planner's problem. Whether lower volatility induces more overborrowing is a quantitative statement that holds for many measures of overborrowing that we use.

We then study optimal taxation on external debt. In line with the existing literature we also find that capital controls are procyclical, meaning a high (low) tax on foreign debt issuance when output growth is low (high). However, a simple accounting exercise shows that the degree of procyclicality is lower with trend shocks than with transitory shocks. These taxes have a macroprudential property, as they are positive on average. We find that trend shocks imply higher degree of macroprudential policy as it implies consistently higher average taxes, both in goods and bad times, than with only transitory shocks.

Related literature. The positive analysis in this paper contributes to the literature on overborrowing established by Mendoza (2001), Mendoza (2002) and Bianchi (2011) by considering the role of different sources of fluctuations, in particular permanent income shocks, for the dynamics of Sudden Stops. In this way, we also relate to Aguiar and Gopinath (2006) and Aguiar and Gopinath (2007), who study the role of trend shocks in emerging economies in the contexts of sovereign default and business cycle analysis, respectively. We contribute to a recent debate about the importance of trend shocks in emerging economies between these authors and García-Cicco, Pancrazi, and Uribe (2010) by focusing on the importance of these shocks on the dynamics around Sudden Stops while all these papers focused on the impact of these shocks on the business cycle of emerging economies. In this point, an implication of our model is that the dynamics of the crisis require revisions of permanent income, driven by permanent income shocks.

Our normative analysis contributes to the literature on optimal capital controls such as Bianchi (2010), Benigno, Chen, Otrok, Rebucci, and Young (2011), Benigno, Otrok, Rebucci, Young, and Chen (2012), Bianchi (2011), Jeanne and Korinek (2010), Korinek (2010a), Korinek (2010b), Korinek (2011), Ottonello (2012), Uribe (2006) and Schmitt-Grohé and

Uribe (2016) by considering the implications of trend shocks in optimal policy design in the presence of overborrowing. On the empirical side there has been a renewed interest on the determinants and properties of observed capital controls, for instance Fernández, Rebucci, and Uribe (2015) and Fernández, Klein, Rebucci, Schindler, and Uribe (2015) study the behavior of capital controls over the business cycle. These streams of literature intend to shed light on the role of policymaking in preventing overborrowing cycles and mostly focus on the role of macroprudential policies. As such, one key aspect of our analysis is the identification of macroprudential policies and to quantify how important are permanent vis-a-vis transitory shocks in their design.

This paper also relates to recent literature that studies Sudden Stops in endogenous growth models. Articles in this literature such as Ates and Saffie (2016), Guerron-Quintana, Saffie, and Gornemann (2016), can provide a rationalization for the importance of permanent shocks in open economies subject to collateral constraints as these papers analyze the way transitory shocks, technological or interest rate spreads, can have permanent effects in productivity growth. Our point instead is wider, suggesting that other disturbances such as permanently perceived fiscal policy changes, changes in trade policies or political cycles that are likely to have major impact on the permanent income can affect the dynamics around Sudden Stops in a plausible way.

The remainder of the paper goes as follows. In Section 2, we document the main features of Sudden Stop episodes for various economies around the world. In Section 3, we introduce the model. In Section 4, we study the Sudden Stops implied by the model and discuss its various shortcomings. In Section 5, we evaluate how various additional features can help the baseline model account for the observed Sudden Stop features. We present our preferred calibration of the model in Section 6 and study its implications for the Sudden Stops. In Section 7, we focus on the implied overborrowing by our preferred model, and discuss the role of the trend shock volatility for the corresponding results and the features of optimal policy. We conclude in Section 8.

2 Empirical findings

As pointed out by Mendoza (2010) and Calvo, Izquierdo, and Talvi (2006) there are three main empirical regularities that are often used to identify Sudden Stop episodes. The first regularity is a sudden reversal in the dynamics of international capital flows, i.e. economies under a Sudden Stop tend to experience trade balance and current account deficits before the crisis and the reversal in international capital flows occurs as a counterpart of the capital account of the balance of payment to a sudden change to trade balance and current account positions. The second one is a drop in output. Finally, the third regularity is a fall in asset prices and peaks in spreads. In sum, the term "Sudden Stops" refers to the type of a financial crisis that occurs together with a deep recession, that is in fact the key denominator of most of the crisis in emerging economies over the last forty years. Defining Sudden Stops as episodes of at least 2% output fall jointly with a net export to output ratio reversal of at least 2 percentage points, the following stylized facts emerge.

Figure 1 plots the main features of Sudden Stop episodes discarding any episode that happens within a 3 year window. We consider 22 economies during the period 1960-2016 and identify 28 Sudden Stops. As seen in the figure, net exports to output ratio starts deteriorating as early as five years before the Sudden Stop takes place. This deterioration of the current account is positively correlated with high output growth rates and strong appreciation of real exchange rate. During this period, there is also foreign debt accumulation for the economy as a whole at a similar rate to output growth, leading to a fairly constant debt to output ratio.

The Sudden Stop episodes in our database replicate the features highlighted by the existing literature. The trade balance to output ratio switches from a 2% of GDP deficit to a 4% surplus and only starts deteriorating slowly, remaining larger than zero for up to 5 years after the crisis. In fact, the strength of this correction impacts the unconditional correlation between trade-balance to output ratio with output in emerging economies that is widely recognized by the literature. Additionally, output growth rate accelerates before the Sudden Stop and is dramatically negative at the moment of the financial crisis. This strong output fall affects the debt to output ratio that increases substantially compared to

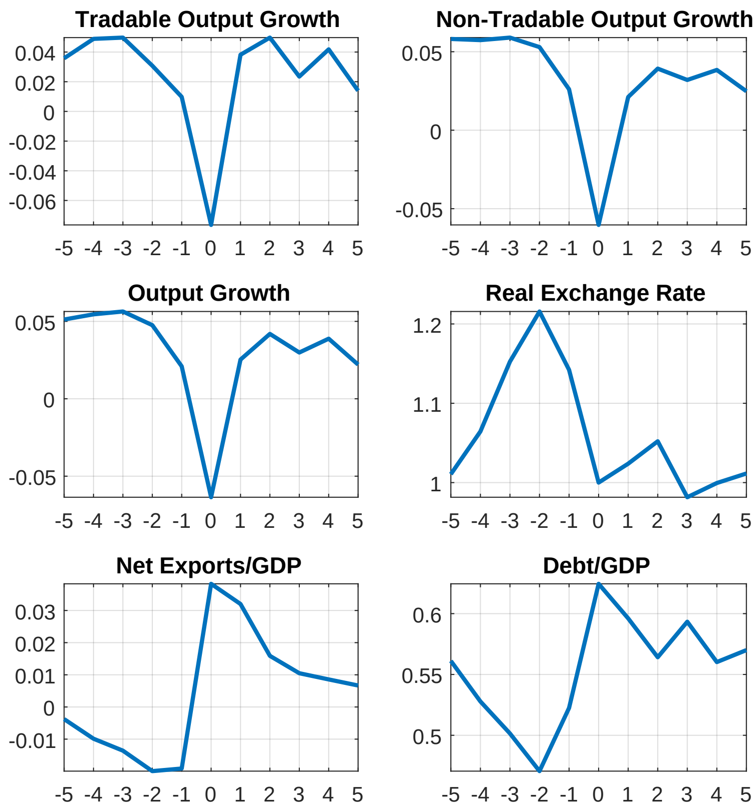


Figure 1: Sudden Stops

Note: The figure plots average of Sudden Stop episodes dynamics for an unbalanced panel of 22 emerging economies during the period 1960-2016 summing up to 28 episodes. We give the countries and sample years in Appendix A. The period 0 dates the Sudden Stop event and the figures plot the ten years interval around this period. The real exchange rate is normalized to 1 in period 0. Tradable output is agriculture and manufacture value added and non-tradable output is the remainder of GDP. Debt is total external debt stocks.

the pre-crisis period. Importantly, the deleverage of the economy with international investors is also slow and after five years, the debt to output ratio does not return to the pre-crisis period. The real exchange rate depreciates substantially and does not recover in the short run.[3]

The empirical features of the Sudden Stops highlighted here have proved to be very hard

[3]These dynamics do not change when Sudden Stops are defined in terms of changes in current-account to output ratio, instead of the trade balance to output ratio.

to replicate with DSGE models in the business cycle literature because of the difficulties to capture asymmetries around the crisis. As pointed out by Mendoza (2010), Sudden Stop literature that puts credit frictions as the key transmission channel amplifying technology shocks has more chances of generating the observed dynamics but its strongly dependent on the type of borrowing constraint. In particular, Mendoza (2010) assumes a stock borrowing constraint that depends on the market price of capital and the capital stock but includes also a working capital constraint and in that way is able to partially capture the persistence of some of the variables. In contrast, flow borrowing constraints with collateral tradable and non-tradable income as in Bianchi (2011) have a hard time in generating persistence while accurately capturing the strong real exchange rate depreciation.

In what follows, our task is to build our framework upon a standard model to understand the importance of different demand, supply or foreign markets conditions in these dynamics.

3 Small open economy with collateral constraints

Consider a small open endowment economy populated by a representative agent that derives utility from the consumption of tradable and non-tradable goods. The economy is stochastic and the household has access to international asset markets that can be used for lending and borrowing at a fix rate. The household is subject to a borrowing constraint and international investors are risk neutral, deep pocket agents. The representative household maximizes the present discounted value of utility given by,

$$\max_{\{b_{t+1}, c_t^T, c_t^N\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^T, c_t^N)$$

subject to

$$\begin{aligned} b_{t+1} + c_t^T + p_t^N c_t^N &= b_t(1+r) + p_t^N y_t^N + y_t^T \\ b_{t+1} &\geq -\kappa \left(y_t^T + p_t^N y_t^N \right) \end{aligned}$$

Here, c_t^T and c_t^N denote the household's consumption of tradable and non-tradable goods, respectively, in period t; y_t^N and y_t^T denote the exogenous and stochastic endowment of the non-tradable and tradable goods. Non-tradable goods are consumed only domestically but tradable goods can be consumed domestically or by the rest of the world. The collateral constraint that limits the household's borrowing decisions is occasionally binding and depends on the value of total income measured in tradable goods and limits the maximum debt to output ratio that can be issued to κ. As is standard in the literature, we assume that the preferences are represented by

$$u(c_t, c_n) = \frac{\left[\omega \left(c_t^T\right)^{-\eta} + (1-\omega)\left(c_t^N\right)^{-\eta}\right]^{\frac{-(1-\sigma)}{\eta}} - 1}{1-\sigma}.$$

The first order conditions for the households' problem are:

$$u_1(c_t^T, c_t^N) = \lambda_t \tag{1}$$

$$p_t^N = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1} \tag{2}$$

$$\lambda_t = \beta(1+r)E_t[\lambda_{t+1}] + \mu_t \tag{3}$$

$$b_{t+1} + c_t^T + p_t^N c_t^N = b_t(1+r) + p_t^N y_t^N + y_t^T \tag{4}$$

$$\mu_t\left[b_{t+1} - \kappa\left(y_t^T + p_t^N y_t^N\right)\right] = 0; \quad \mu_t \geq 0 \tag{5}$$

Periods with binding borrowing constraints exhibit positive μ_t, which affects intertemporal consumption decisions. The endogeneity of the value of the collateral comes from the fact that p_t^N affects total output measured in terms of tradable goods. In periods of real depreciation, when the price of domestic non-tradable goods become cheaper in terms of tradable goods, the value of the collateral is smaller and, everything else equal, the constraint is more likely to bind. The real depreciation will endogenously drive the Sudden Stop episodes and its persistence depends on the persistence of the real exchange rate, hence on that of the tradable to non-tradable consumption ratio.

3.1 The recursive formulation

We can write the problem of the representative household in recursive form, which is convenient in order to clearly present our notion of equilibrium. Here, we use primes to denote future variables, V denotes the value function of the households, and upper case B denotes the aggregate level of debt. The recursive representation of the representative households problem is then,

$$V(b, B, y^N, y^T) = \max_{b', c^T, c^N} u(c^T, c^N) + \beta E[V(b', B', (y^N)', (y^T)')]$$

$$\begin{aligned}
\text{s.t.} \qquad\qquad & b' + c^T + \tilde{p}^N c^N = b(1+r) + \tilde{p}^N y^N + y^T \\
& b' \geq -\kappa(y^T + \tilde{p}^N y^N) \\
& \tilde{p}^N = p^N(B, y^N, y^T) \\
& B' = \Gamma_B(B, y^N, y^T)
\end{aligned}$$

With this notation we are ready to present the Recursive Competitive Equilibrium.

Recursive Competitive Equilibrium. A RCE for this economy is a collection of price functions for non-tradable goods, $p^N(B, y^N, y^T)$, perceived law of motions $\Gamma_B(B, y^N, y^T)$, policy and value functions $\hat{b}(b, B, y^N, y^T)$, $V(b, B, y^N, y^T)$, $\hat{c}^j(b, B, y^N, y^T)$ for $j \in \{N, T\}$ for the household, such that:

- Policy and value functions solve the household problem given price functions.
- Perceived law of motions are consistent with the policy functions of the household:

$$\hat{b}(B, B, y^N, y^T) = \Gamma_B(B, y^N, y^T)$$

- Markets clear:

$$\begin{aligned}
\hat{c}^N(b, B, y^N, y^T) &= y^N \\
\hat{c}^T(b, B, y^N, y^T) &= y^T - \Gamma_B(B, y^N, y^T) + B(1+r)
\end{aligned}$$

Note the equilibrium price of the non-tradable good as a function of the aggregate states:

$$p^N(B, y^N, y^T) = \left\{ p : p = \tfrac{1-\omega}{\omega} \left[\tfrac{y^T + B(1+r) - \Gamma_B(B, y^N, y^T)}{y^N} \right]^{\eta+1} \right\},$$

where Γ_B denote the next period aggregate assets, given the current states of the economy.

4 Dissecting the baseline model

We study the features of this off-the-shelf model around Sudden Stops. Accordingly we use the standard calibration in Bianchi (2011). We set the discount factor, β, to 0.91; risk aversion, σ, to 2; the relative weight of the tradable goods in preferences, ω, to 0.31; and the elasticity of substitution between the tradable and non-tradable goods, η, to $1/0.83-1$. The interest rate is set at 4 percent, and the parameter for the tightness of the borrowing constraint, κ is set at 0.32. We approximate the income process with 16 grid points following the Tauchen algorithm for mimicking bivariate autoregressive processes, using the parametrization also from Bianchi (2011).[4] Table 1 summarizes the calibration of this model.

Table 1: Calibration

Parameter	Value
Risk aversion, σ	2
Consumption share of tradables, ω	0.31
Elasticity of subs. N and T, η	1/0.83-1
Risk free interest rate, r	0.04
Discount factor, β	0.91
Borrowing constraint, κ	0.32

Note: This calibration is based on Bianchi (2011).

Figure 2 presents the model and data dynamics around Sudden Stops. Given that the income process is calibrated to Argentina, we construct Sudden Stop dynamics for the model and compare them to the average Sudden Stop in Argentina from 1900 to 2004.

The figure shows that the Sudden Stops implied by the model differ in two key dimensions

[4] This corresponds to a bivariate process represented by $\log \mathbf{y}_t = \rho \log \mathbf{y}_{t-1} + \epsilon_t$, with $\mathbf{y} = [y^T\ y^N]'$, $\epsilon = [\epsilon^T\ \epsilon^N]'$, where $\epsilon \sim N(\mathbf{0}, \mathbf{V})$, and

$$\rho = \begin{bmatrix} 0.901, & 0.495 \\ -0.453, & 0.225 \end{bmatrix}, \quad \mathbf{V} = \begin{bmatrix} 0.00219, & 0.00162 \\ 0.00162, & 0.00167 \end{bmatrix}.$$

from the type of crisis documented in the empirical literature and described in Section 2.[5] First, output dynamics that give rise to a Sudden Stop in the model are counterfactual. The picture plots the aggregate output, tradable and non-tradable output growth. In the data, the five years previous to the Sudden Stop, the economy is growing overall, but also in the tradable and non-tradable sectors. The growth rates of the aggregate and sectoral outputs only become negative at the period of the Sudden Stop (and one period before for the tradable sector). On the other hand, in the model, the output dynamics that give rise to a Sudden Stop is a sequence of negative shocks that accumulate over a five years window. This is indeed non-trivial as the model implies that the economy starts to increase its foreign debt issuance in order to smooth transitory negative shocks until the borrowing level becomes unsustainable. This is not observed in the data.

Second, the correction after the crisis in the model takes a short time, i.e. only lasts for the period of the Sudden Stop, while the effects of the crisis in the data are much more persistent. To begin with, the model generates only one period deterioration in the trade-balance to output ratio before the Sudden Stop, and an immediate reversal of it after the Sudden Stop. Instead, the data shows that trade balance to output ratio deteriorates for about 5 years and after the Sudden Stop there is a strong persistent correction in the trade-balance. Moreover, even though the model can replicate the immediate real exchange rate depreciation that is one of the common denominators of these types of crisis, it cannot generate the right persistence of any macroeconomic variable of focus. The reason is that when the economy hits the borrowing limit and repays the outstanding debt, the ex-post deleveraging of the economy allows households to increase consumption of tradable goods, pushing up the price of non-tradable goods and implying an instantaneous relaxation of the borrowing limit. That is, the crisis and the tightening of the borrowing constraint in these types of model last for only one period.

[5]To compute the model dynamics around a Sudden Stop we simulate the economy for 2000 samples of 500 periods each and identify the Sudden Stop episodes according to our definition, compute the average behavior around the Sudden Stop event which happens at period 0.

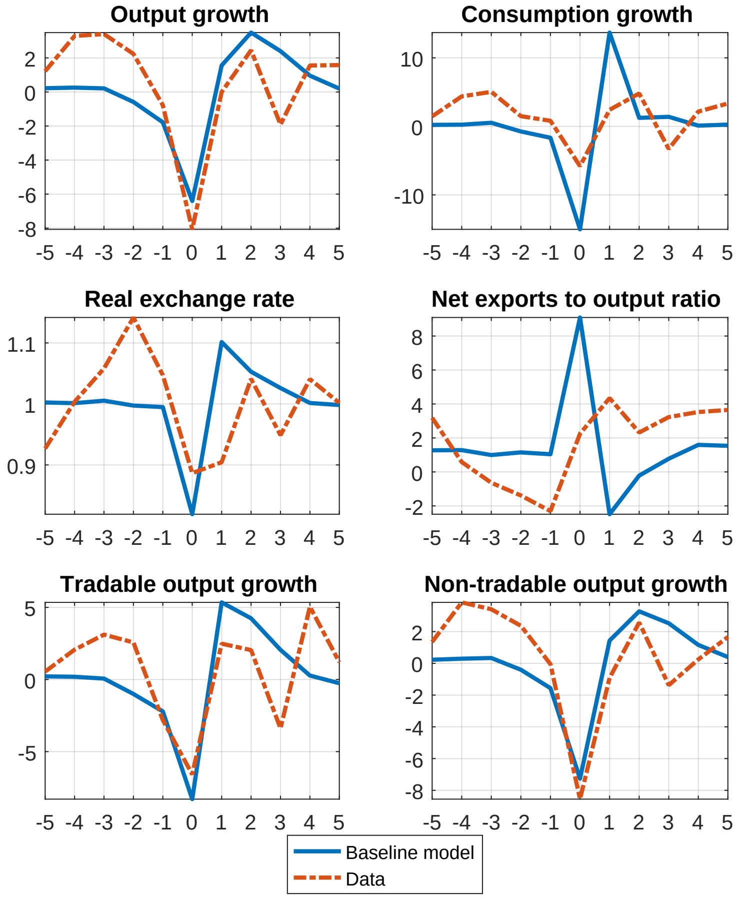


Figure 2: Sudden Stops in the model and the data
Note: The figure plots averages across Sudden Stop episodes for Argentina since 1900.

5 Time-varying wedges

Our take from the previous section is that the standard model with collateral constraints and transitory income shocks do not capture the essential dynamics around Sudden Stops, even though it is able to generate the real exchange rate depreciation in the time of the crisis. This section inquires which drivers of the business cycle are missing in the model. Our strategy is to introduce to the model three key wedges related to (1) demand factors, (2) foreign factors, and (3) permanent supply factors, studying the role of each wedge separately. In turn, this exercise provides information on the relevant channels in the supply and demand sides of the model as well as the role of international markets. Then we calibrate a preferred economy and study its implications in terms of the dynamics around a Sudden Stop.

5.1 Demand-driven crisis

The first extension we study is one with a wedge in domestic demand of tradable goods. In order to introduce a demand shock with minor deviations from the baseline model in the literature, we assume that households can suffer shocks to their preference of tradable goods over non-tradable goods, by modeling ω_t as a mean reverting AR(1) process. This device will allow us to understand how plausible is it that the dynamics after a demand shock give rise to a Sudden Stop episode.

The model allows for at least two alternative ways of introducing demand shocks in the baseline economy. First way would be to allow for shocks to the discount factor, β, but under this formulation, a demand shock that triggers a sudden-stop-like crisis would imply that households become more patient, increase savings inducing a sudden current account reversal, which is unlikely to be behind the dynamics around a Sudden Stop identified in the data.[6] The second way would be shocks to the complementarity between tradable and non-tradable consumption given by η, which has a less direct and clean effect in the demand for tradable goods than those arising from ω changes.

Consequently, focusing on ω_t shocks, the pricing of non-tradable goods can be written as

$$p_t^N = \frac{1-\tilde{\omega}}{\omega_t}\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1}. \tag{6}$$

Here, we assume that only the coefficient in front of tradable goods in the consumption aggregation function is time-varying but we keep the one of non-tradable goods fixed to $\tilde{\omega}$ that is not time-dependent.

[6]A more detailed explanation follows. In particular, shocks to β will make the households more patient (if β increases) or more impatient (if β decreases). In the case in which β increases, people will be more patient, generating savings incentive and a trade balance and current account improving. This would lead to a drop in the the price of non-tradable, reducing the value of output measured in tradable goods and potentially inducing a binding of the borrowing constraint. In this cases, the crisis starts with individuals being more patient which is unlikely in the neighborhood of a Sudden Stop and also non-testable. If instead β decreases inducing a large increase in the desire to issue debt, this would trigger a deterioration of the trade balance and is not consistent with Sudden Stop dynamics. The shocks to η are more subtle and less transparent as changes in η affects the complementarity and substitutability between tradable and non-tradable consumption and is likely to have a more indirect effect in the evolution of non-tradable prices.

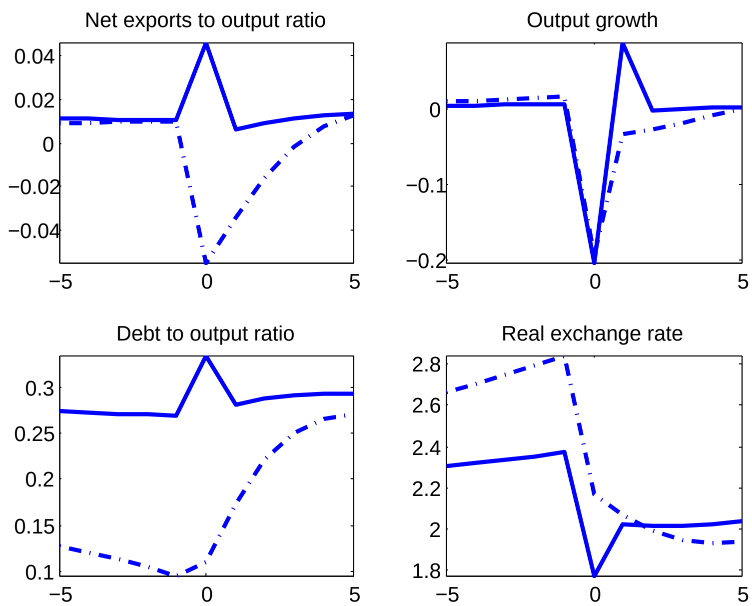


Figure 3: Dynamics after a ω_t increase

Note: The figure shows the average dynamics around positive shocks to ω_t at period 0 for 2000 samples of 500 periods each. Solid line denotes parametrization (1) and dashed line parametrization (2).

With this formulation, there is a direct effect of changes in ω_t on the price of non-tradable goods. If this wedge is relevant and persistent we would expect that Sudden Stops are driven by increases in the preferences of domestic agents over tradable goods. Figure 3 presents the dynamics after an increase in the demand wedge for two calibrations for the ω_t process, parametrization (1) that assumes $\omega = \{0.9 \times 0.31, 1.1 \times 0.31\}$ and (2) that assumes $\omega = \{0.75 \times 0.32, 1.25 \times 0.32\}$, in both cases with persistence of 0.95 for each state.

An increase in ω_t triggers remarkably different dynamics depending on the size of the demand change. For a mild increase in ω_t, there is a mild transitory fall in p^N due to the substitution between tradable and nontradable goods. This reduces wealth measured in tradable prices inducing a drop in tradable consumption and contributing to an improvement in the trade balance and due to the output fall measured in tradable goods, debt to output ratio increases. On the other hand, if the change in demand is large enough to overcompensate for the wealth effect, the drop in consumption has a persistent effect on the price of non-tradable goods, a more persistent impact on output and deterioration in the debt dynamics.

A take-away of this section is that if the crisis were triggered by a small change in the demand side of the economy (a change in preference towards consumption of tradable goods), there would be a correction in the price of non-traded goods as a real exchange depreciation, but it would not be accompanied by a correction in the trade balance to output ratio as we should find in the case of a Sudden Stop. Instead if the demand change is large enough to generate a correction in the trade balance to output ratio, this correction is only lasting one period and is not able to replicate the persistence observed in the data and more importantly is not preceded by a deterioration of the trade balance position.

5.2 Lending-driven crisis

A possibility is that the Sudden Stop crisis are triggered by international investors' behavior that have a direct impact on the level of borrowing limit. A reduced form way to capture this possibility is to allow for a wedge in the borrowing limit, assuming that κ is time-varying. Under this assumption, a drop in κ will trigger a debt crisis by limiting the possibility of roll-over debt. For this formulation, the borrowing limit can be written as,

$$b_{t+1} \geq -\kappa_t \left(y_t^T + p_t^N y_t^N \right).$$

This is indeed an appealing model as it implies that a persistent tightening in the borrowing limit can potentially be able to explain the persistence of the net exports to output ratio after a Sudden Stop. Figure 4 presents the dynamics after a drop in the borrowing limit for two calibrations of the κ_t process, parametrization (1) that assumes $\kappa = \{0.9 \times 0.32, 1.1 \times 0.32\}$ and (2) that assumes $\kappa = \{0.75 \times 0.32, 1.25 \times 0.32\}$, in both cases with persistence of 0.95 for each state.

Figure 4 presents the dynamics after a negative shock to the borrowing limit. In particular, it shows that even a persistent shock to κ_t does not generate the empirically-observed sluggishness following a Sudden Stop. The reason is that when the borrowing limit tightens, the economy suffers a large correction in net exports to meet the new borrowing limit but after one period, the borrowing limit does not bind anymore, even with a low κ_{t+1} as the debt level has been repaid, the burden of interest payments of debt is lower and tradable consumption recovers. With the recovery of tradable consumption, there is a recovery of the

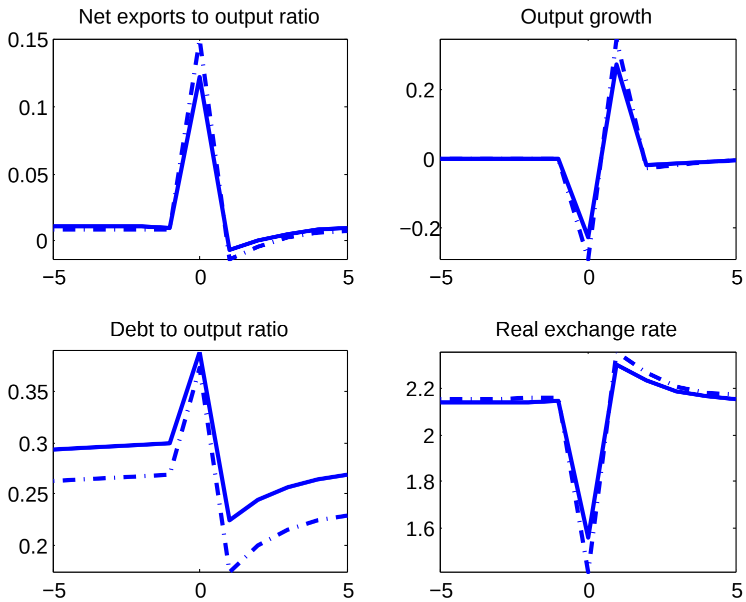


Figure 4: Dynamics after a κ_t drop

Note: The figure shows the average dynamics around negative shocks to κ_t at period 0 for 2000 samples of 500 periods each. Solid line denotes parametrization (1) and dashed line parametrization (2).

real exchange rate and output which relaxes the borrowing limit even further.

5.3 Trend-driven crisis

As implied by the Permanent Income Hypothesis and pointed out in Aguiar and Gopinath (2007), the dynamics following transitory shocks are fundamentally different from dynamics induced by permanent changes to the income process. Here, we allow for a wedge in the supply side of the economy that has permanent impact on the tradable and non-tradable income processes. This type of permanent wedges in the income processes, as suggested by Aguiar and Gopinath (2007), can be coming from regime switches of fiscal and monetary policy rules, persistent changes in trade or capital control policies or persistent market or financial frictions, all of which are likely to affect the trend growth of emerging economies prone to Sudden Stops. In this section, we assume that the baseline model with endogenous borrowing limit is such that sectoral output is a combination of stationary TFP shocks given by z_t^j for $j = \{T, N\}$ and a common trend shock, Γ_t,

$$y_t^j = z_t^j \Gamma_t.$$

The trend is stochastic and its growth rate follows an AR(1) process as in Aguiar and Gopinath (2007), $\frac{\Gamma_t}{\Gamma_{t-1}} = g_t$ with:

$$\log g_t = (1 - \rho_g) \log \mu_g + \rho_g \log g_{t-1} + \nu_t, \; \nu_t \sim N(0, \sigma_g).$$

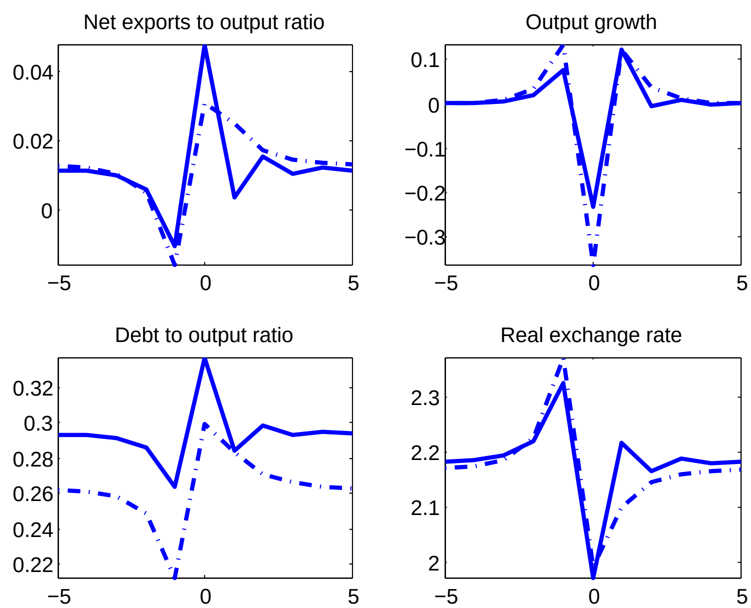


Figure 5: Dynamics after a g_t drop

Note: The figure shows the average dynamics around negative shocks to g_t at period 0 for 2000 samples of 500 periods each. Solid line denotes parametrization (1) and dashed line parametrization (2).

Figure 5 presents the dynamics after a negative permanent change in the conditions of the supply side of the economy. We assume two parametrizations for the trend shocks: (1) One that sets the variance and the persistence of the process following Aguiar and Gopinath (2007) parametrization and (2) one that doubles that variance. The dynamics after a permanent income shock are remarkably different from those of transitory supply shocks, demand or international investors' disturbances. Before a negative permanent income shock, the economy tends to be stable, subject to mild output growth, as the average growth is of 0.6% per period reinforced by a slow appreciation of the real exchange rate. Given that trend shocks are permanent, the economy before the negative trend shock is becoming permanently richer which leads to a continuous deterioration of the trade balance and debt accumulation. This is indeed the actual dynamics before Sudden Stops. After the negative output growth shock, the economy suffers a strong and persistent correction, as the negative shock is perceived as permanent by the agents, here net exports dynamics, debt and the real exchange rate behaves in a way that mimics the dynamics around a Sudden Stop.

We take this evidence as suggestive that the Sudden Stops are related to permanent supply shocks that lead to strong, permanent revisions of the income level of the economy when measured in terms of tradable goods. In the remainder of the paper we do a quantitative implementation of this type of model, evaluate the likelihood that Sudden Stops are permanent-supply driven and assess the implied policy recommendations.

6 Quantitative results with trend shocks

We introduce a model exhibiting transitory and permanent supply side changes, as described in Section 5.3 and study its quantitative implications. To keep the calibration of the model as clean as possible we omit all the other sources of uncertainty described above, which can easily be introduced to this new model. We describe now our empirical strategy and then the quantitative implications of the model.

6.1 Empirical strategy

Our empirical strategy is to fix preference parameters to existing values in the literature, calibrate the interest rate to 9% following data averages and set $\kappa = 0.4$ to match external debt to output ratio for Argentina. Table 2 gives the non-income parameter values.[7]

We estimate a model for the stochastic processes of transitory and permanent income

[7] For the interest rate we use data until 2001. After 2002 default, Argentina was driven into financial autarky, hence, the interest rate on new external debt commitments after 2001 does not reflect the market rate. Data is "Average interest on new external debt commitments (private)" for the period 1970-2001 from World Development Indicators, WDI.

Table 2: Calibration

Parameter	Value	Basis
Risk free interest rate, r	0.09	Avg. return on new commitments, WDI
Discount factor, β	0.84	Avg. debt-to-output ratio = 30%, WDI
Borrowing constraint, κ	0.40	Sudden stop frequency = 5%

Note: Targets on debt and returns are for Argentina from years 1970-2001. The rest of the parameters are as in Bianchi (2011) as described in Table 1, except for those on the income process. WDI in this table stands for "World Development Indicators" by the World Bank Data.

shocks implementing full information Bayesian strategy. The estimation of this type of models is challenging given that identifying trend shocks requires long samples. Aguiar and Gopinath (2007) show that using a direct estimation of the relative variances of the trend and mean reverting shocks as in Beveridge and Nelson (1981) is not appropriate with short samples of quarterly frequency and they need to use the identifying restrictions imposed by the DSGE model. Full estimation with more than one hundred years data is, instead, a promising strategy as discussed in García-Cicco, Pancrazi, and Uribe (2010).[8]

The model for income process with transitory and permanent components can be written in state space representation as follows: the measurement equation given by,

$$\begin{bmatrix} \log(\gamma_t^T) \\ \log(\gamma_t^N) \end{bmatrix} = \begin{bmatrix} \log(z_t^T) - \log(z_{t-1}^T) + \log(g_t) \\ \log(z_t^N) - \log(z_{t-1}^N) + \log(g_t) \end{bmatrix}$$

and the state equation is

$$\begin{bmatrix} \log(z_t^T) \\ \log(z_{t-1}^T) \\ \log(z_t^N) \\ \log(z_{t-1}^N) \\ \log(g_t) \end{bmatrix} = \begin{bmatrix} \rho_T & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & \rho_N & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho_g \end{bmatrix} \begin{bmatrix} \log(z_{t-1}^T) \\ \log(z_{t-2}^T) \\ \log(z_{t-1}^N) \\ \log(z_{t-2}^N) \\ \log(g_{t-1}) \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \sigma_T & 0 & 0 \\ 0 & \sigma_N & 0 \\ 0 & 0 & \sigma_g \end{bmatrix} \begin{bmatrix} \epsilon_t^T \\ \epsilon_t^N \\ \epsilon_t^g \end{bmatrix}$$

[8] Another possibility would be to implement a non-linear estimation of the small open economy model with occasionally borrowing constraints, which is unfeasible under a global solution method that we need for the model of this paper. Moreover, given the complexity and potential issues of Particle Filters in practice, there is no guarantee that this strategy will improve over the Bayesian estimation strategy of the bivariate model implemented in this section. Finally, our strategy imposes a great deal of discipline in our quantitative exercise as our estimates do not depend on identifying restrictions of the DSGE model we want to test.

where γ_t^T and γ_t^N denote the demeaned growth rate of per-capita tradable income and non-tradable income. This model allows us to estimate the volatilities of different shocks and the persistence of the trend and mean reverting shock and as a by-product we can recover the smoothed estimates of all innovations.

Priors for the persistence of the trend shock are based on the estimates of the two sector model in Seoane (2016), and we set all other priors for persistence of mean reverting processes to this same value. The priors for the standard deviation of technology shocks are centered around standard values and are assumed to be the same for all shocks. Figure 6 shows the prior distribution, and in particular that the support of the distribution includes a sizable part of the parameter space.

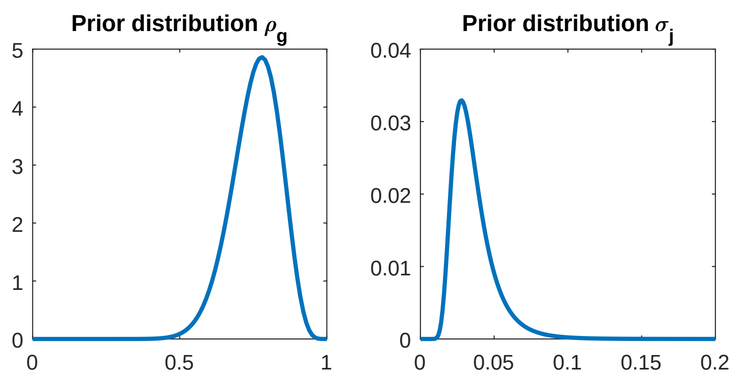


Figure 6: Prior distributions

Note: prior distributions for the persistence and standard deviations of all shocks. In the case of ρ_j is $B(0.7576, 0.0819)$ and for σ_j is $IG(0.0278, 0.0098)$. Here $B(\mu, \sigma)$ and $IG(\mu, \sigma)$ denote Beta and Inverse-Gamma distributions with mean μ and standard deviation of σ for all $j = \{z^T, z^N, g\}$.

Given that the posterior (or conditional posterior) distribution of the parameters is not of a known form and we cannot take draws directly from it, we estimate this model using a Metropolis-Hastings algorithm using data for the de-meaned log annual growth rate of tradable and non-tradable output during the period 1876-2004. We first maximize the posterior mode and then do 100,000 draws. Posterior estimates are in Table 3.

Table 3 documents that trend shocks are fairly persistent and in line with estimates of Seoane (2016) and García-Cicco, Pancrazi, and Uribe (2010) for a version of a one sector model. Also, the estimates of standard deviation of the shocks are very different depending

Table 3: Descriptive moments of the posterior distribution

Parameter	Mean	St. Deviation
ρ_g	0.5439	0.0863
ρ_{z^T}	0.7574	0.0820
ρ_{z^N}	0.7567	0.0822
σ_g	0.0351	0.0069
σ_{z^T}	0.0548	0.0046
σ_{z^N}	0.0487	0.0048

Note: The table gives the mean and standard deviation of the posterior distribution for each parameter from 100,000 draws.

on the shock, suggesting that the data contains substantial information. Finally, in line with the data we set average growth in the model to 1%, i.e. $\mu_g = 1.01$.[9]

We now feed the estimated processes into the model with transitory and permanent shocks and evaluate its quantitative implications.

6.2 Quantitative implications of the model

Figure 7 compares the dynamics around Sudden Stops for our preferred model and the data. The model with permanent income shocks exhibits dynamics around Sudden Stops that are qualitatively in line with those observed in the data. In particular, output growth, and the growth rate of tradable and non-tradable output are positive before the Sudden Stop in all the cases suggesting that the accumulation of foreign debt is not due to a sequence of negative shocks, but instead due to a sequence of positive permanent shocks that induce debt accumulation to smooth consumption. Moreover, while the baseline model in the literature implies a correction of the net exports to output ratio lasting for only one period, the model with trend shocks can capture a slow recovery of the trade deficit, lasting for three years. Additionally, the real exchange rate exhibits similar dynamics, only lasting for one period for the baseline economy but a persistent depreciated exchange rate for the model with permanent trend shocks.

Permanent supply shocks capture the role of permanently perceived changes in income that can be driven by policy changes, expectation revisions or political frictions, as discussed

[9] The average growth rate for Argentina during 1876-2004 sample for the tradable output is 1.18% while the one of the non-tradable output is 0.95%.

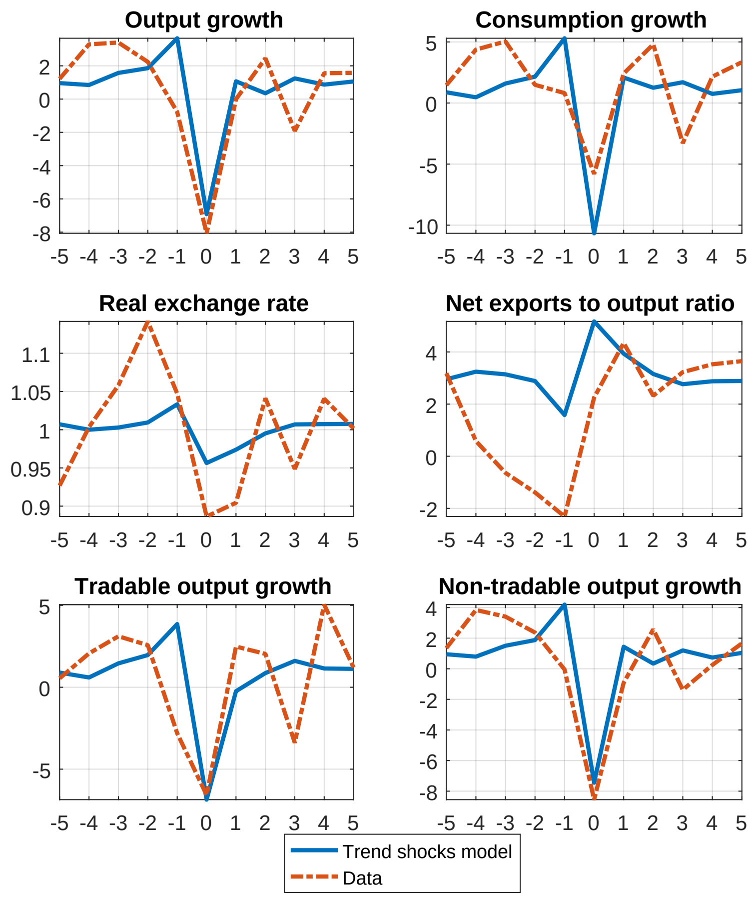


Figure 7: Sudden Stops in the model and the data

Note: Macroeconomic crisis around Sudden Stops. Average of Sudden Stop episodes dynamics for Argentina. The period 0 dates the Sudden Stop episode and the figures plot the ten years interval around this episode. Model in green lines measured in the right axis.

by Aguiar and Gopinath (2007). Large and permanent revisions in the present value of income have persistent effects in macroeconomic variables and induce the co-movement observed in the data. According to Figure 7, the crisis is triggered by a drop in permanent income after a sequence of good income shocks. This sequence of good income shocks prior to the crisis induces a persistent deterioration in the net exports balance which starts three periods before the Sudden Stop. The positive pressure in consumption, distributed between tradable and non-tradable consumption implies an appreciation in the real exchange rate.

When the negative permanent income shock hits the economy, for a given level of external debt, the drop in output forces a correction in the net exports, consumption and the real exchange rate. This contributes to a further tightening in the size of the collateral. Moreover, given that the economy is permanently poorer, there is a permanent drop in tradable consumption from the fact that households revise their permanent income down. Accordingly, in line with the Permanent Income Hypothesis, the model produces dynamics that resemble those in the data, suggesting that revisions of permanent income are key to the dynamics around Sudden Stop episodes.

As for the transmission channel of this model, it is key that the permanent shock triggers a persistent drop in tradable consumption (and a drop that is indeed larger than tradable output drop) as this keeps the real exchange rate depreciated for a longer time than in the case of a mean reverting shock model.[10]

The model is able to match qualitatively various non-targeted unconditional first and second order moments for the case of Argentina. In particular, Table 4 shows under the column labeled "Competitive Equilibrium" that the model's average current account to output ratio is negative as in the data while the net exports is positive and in both cases their relative size to output is of the same order of magnitude as in the data.

Additionally, second order moments in the data and the model are also similar, except for the case of the volatility of the real exchange rate, for which the model can generate 14.5% of volatility, as in other models in this literature, about 1/3 of the real exchange rate volatility in the data.

6.3 Testing the model implications: Sudden Stops and income shocks

This model provides testable implications, namely that if the Sudden Stops are mainly triggered by mean reverting shocks, we should observe in the data an accumulation of negative shocks before the Sudden Stop episodes. On the contrary, if Sudden Stops are mainly triggered by permanent shocks, we should observe that before the Sudden Stop episode the economy is growing.

[10]Moreover, this is also true given that non-tradable consumption falls by the same magnitude and persistence of non-tradable output.

Table 4: Model comparisons of second moments

	Data	Benchmark	
		Comp. Eq.	SP
Average (%)			
Output growth	1.0	1.0	1.0
Current account / GDP	-1.7	0.0	-0.1
Trade balance / GDP	2.2	2.9	2.8
Standard dev. (%)			
Consumption growth	6.4	10.8	9.7
Real exchange rate (log)	47	14.5	13.3
Current account / GDP	4.8	4.3	3.5
Trade balance / GDP	4.4	4.8	4.0

Note: Annual data for Argentina period 1876-2004. (*log*) denotes natural logs and the real exchange rate is computed using Argentina's GDP deflator and US CPI. "Comp. Eq." refers to the competitive equilibrium and "SP" refers to the Constrained Social Planner equilibrium.

In order to study the data we first identify the Sudden Stop episodes in Argentinean data. Figure 8 plots the smoothed estimates of trend and mean reverting shocks for the tradable and non-tradable sectors together with the Sudden Stop episodes in blue vertical lines, these shocks are obtained as a by-product of our estimation strategy and they have a direct mapping to the ones in the model. In the last 100 years of the Argentinean economy, we observe several episodes that are considered Sudden Stops according to its definition.[11] Even though there are many Sudden Stops after 1980, this type of crisis is not new and we already find them as early as in 1914. Notice that according to the figure all Sudden Stops occurred together with a strong drop in the growth rates of the common trend.

Figure 8 suggests that there is no clear pattern regarding Sudden Stop episodes and mean reverting shocks. Even though during all Sudden Stops mean reverting shocks are negative, the behavior before the crisis is heterogeneous. However, from the bottom figure it is clear that all Sudden Stops occur together with a strong correction in the trend. Moreover, in all but two episodes, the trend takes values smaller than 2 standard deviations below its mean.

Figure 9 shows a similar piece of evidence, in which we plot the five years average income before each Sudden Stop for each source of innovation. The pattern implied by the standard

[11] In the figure we plot all episodes in line with the definition of Sudden Stop even if they occur within a 3 year window of each other.

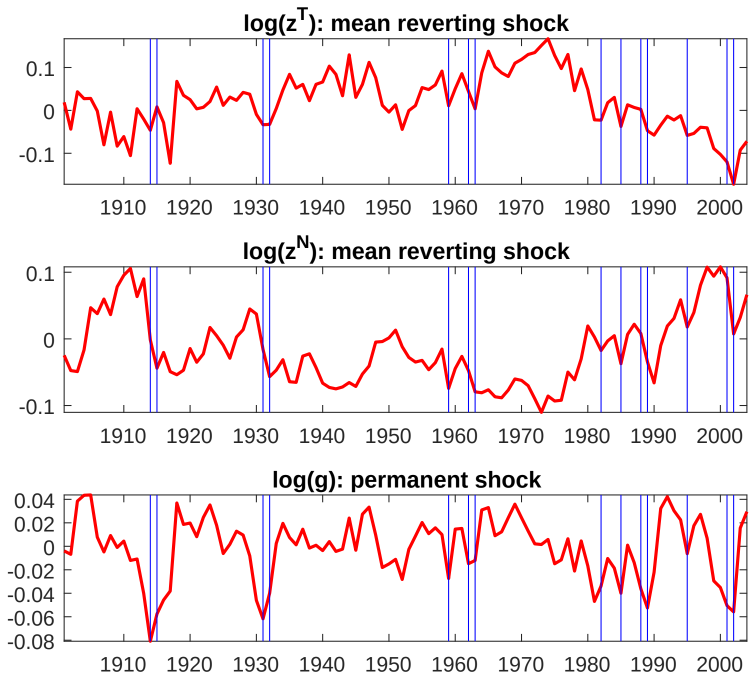


Figure 8: Sudden Stops

Note: The figure plots the unobserved smoothed estimates of tradable and non-tradable stationary shocks and the common trend together with the Argentinean Sudden Stops in blue vertical lines. As in the empirical section, Sudden Stops are defined as episodes of at least 2% output fall jointly with a net export to output ratio reversal of at least 2 percentage points.

model without trend shocks is not observed in the data. Specifically, for the Sudden Stop to favor the baseline model without trend shocks, mean reverting shocks should typically be low before the crisis as in this model the economy is borrowing because of the negative transitory shocks and the need to smooth consumption.

As seen in the figure, the smoothed estimates of different shocks imply that sectoral growth before the crisis is mainly positive regardless of the sector as well as the growth of the common trend. In other words, prior to the crisis the economy is booming and accumulating debt on behalf of future output growth, which is consistent with the previous section that points out that the role of permanent income shocks can be key to understand the Sudden Stop dynamics.

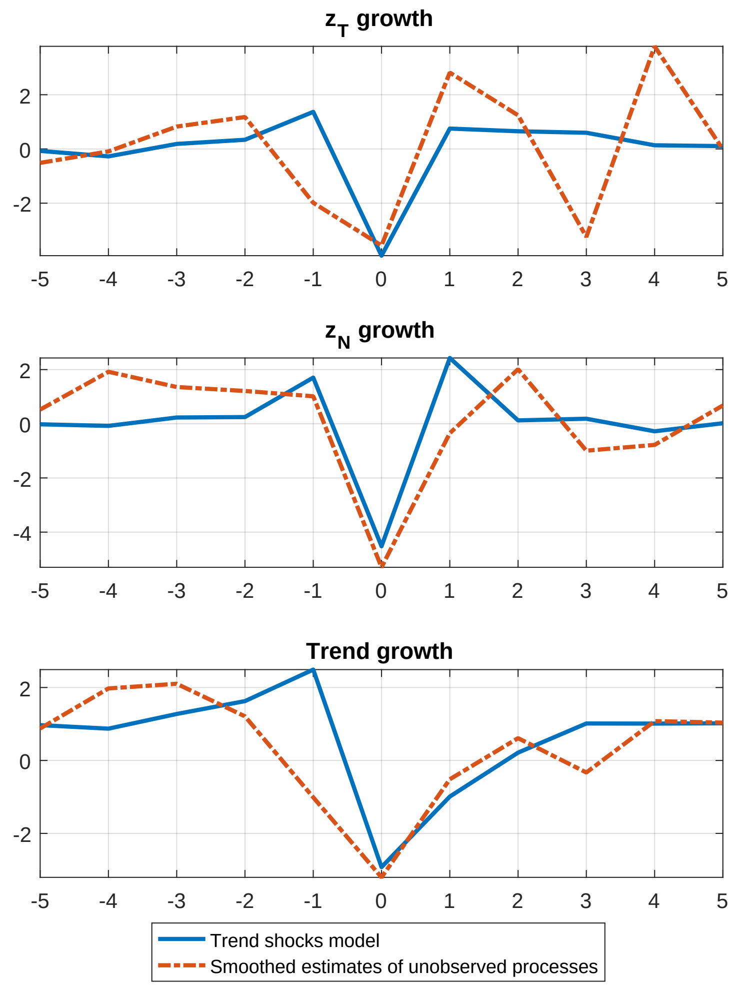


Figure 9: Sudden stops

Note: The figure plots shocks dynamics around Sudden Stop episodes in Argentina and the model.

7 Overborrowing and optimal capital controls

We turn now to study the quantitative relevance of trend shocks in the overborrowing result and the properties of optimal capital controls. We first solve the constrained efficient allocation of a benevolent planner that internalizes the consumption decisions' impact on the price of non-tradable goods, and discuss the implied taxes to sustain this solution in a competitive equilibrium. Then we show how the volatility of the trend shocks change the degree of overborrowing in the competitive equilibrium and the corresponding optimal taxation.

7.1 Overborrowing in our preferred economy

The planner maximizes the household's objective function,

$$\max_{\{b_{t+1},c_t^T\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^T, y_t^N)$$

subject to the resource constraint of the economy and the borrowing limit, fully internalizing the effects of consumption decisions on market prices and on the consequent borrowing limit,

$$\begin{aligned} b_{t+1} + c_t^T &= b_t(1+r) + y_t^T \\ b_{t+1} &\geq -\kappa \left(y_t^T + \left(\frac{1-\omega}{\omega} \left(\frac{c_t^T}{y_t^N} \right)^{\eta+1} \right) y_t^N \right). \end{aligned}$$

Table 4 shows a few key moments implied by the Social Planner allocation. Even though the current account and trade balance to output ratio are on average at similar levels compared to the competitive equilibrium allocation, the planner allocation has lower volatility for all variables by internalizing the effects of prices on the collateral constraint.

Figure 10 plots the distribution of debt for the competitive equilibrium (in red bars) and the constrained optimal allocation (in blue bars). Even though debt distributions coincide in a large share of the debt spectrum, the competitive equilibrium generates overborrowing as it allocates more mass of the distribution in higher levels of debt than the distribution under the planner's allocation. To provide a numerical measure of overborrowing we use percentile comparisons and the results are, although less stable, in line with the implications in the figure. Table 5 shows numerical measures for overborrowing for the full model and for its versions shutting down the transitory and permanent income shocks. All these versions imply some degree of overborrowing, but smaller precautionary motive increases the borrowing, hence overborrowing, in the models shutting down one type of the shocks.

An important point to highlight is that in the economy with only mean reverting shocks, overborrowing is stronger during bad times, as in those cases the households tend to issue higher levels of debt. When we introduce trend shocks, the overborrowing has a different nature as it is also strongly present during the expansion, which happens because during good times is when the households have more incentives to issue debt to smooth consumption. As

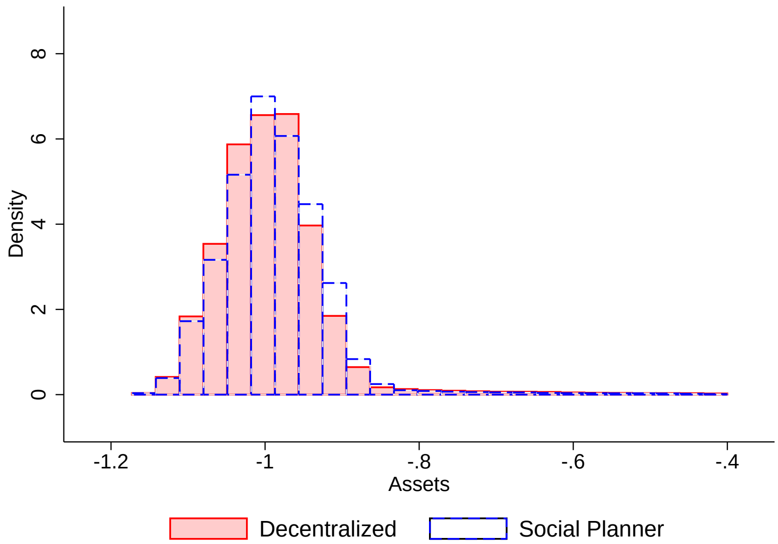


Figure 10: Debt distribution for the competitive equilibrium and the constrained optimal
Note: The debt levels in the x-axis are detrended.

we will see in the next section, this is reflected in the optimal tax schedule.

7.2 Decentralization of the contrained optimal allocation

A way to infer the degree of overborrowing is by studying the size of the optimal tax over debt issuance that would make the competitive equilibrium mimic the constrained planner equilibrium. To compute this optimal tax, we set the decentralized problem with a tax over new debt issuance, such that the budget constraint is

$$(1-\tau_t)b_{t+1} + c_t^T + p_t^N c_t^N = b_t(1+r) + y_t^T + p_t^N y_t^N.$$

Then we solve the competitive equilibrium and set the tax rate such that the solution of the decentralized economy mimics the solution of the social planner's problem. The optimal tax is given by the following expression:

$$\tau_t = \frac{\beta(1+r)g^{-\sigma}\mathbb{E}_t\left(\mu_{t+1}^{sp}\Psi_{t+1}\right) - \mu_t^{sp}\Psi_t}{u'_{T,t}},$$

where $\Psi_t = \kappa\frac{p_t^N c_t^N}{c_t^T}(1+\eta)$.

Table 5 presents results for optimal taxes. The column labeled "Full Model" documents that the optimal tax is procyclical, i.e. tax is larger during bad times and lower during good times, defined as the periods in which the economy grows at a rate lower and higher than the average growth rate of the economy. This procyclicality of the optimal tax is robust to alternative definitions of good and bad times. The reason for this result is that in this economy, the borrowing constraint is more likely to be binding during bad times and the impact of the price adjustment relaxes the constraint, and hence promotes overborrowing, in those periods. Consequently the optimal capital control should tax debt issuance during crisis times. It is important to note that the full model with trend shocks, as is the case in the literature only with transitory shock, finds it optimal to establish a macroprudential policy as the optimal tax is unconditionally positive.

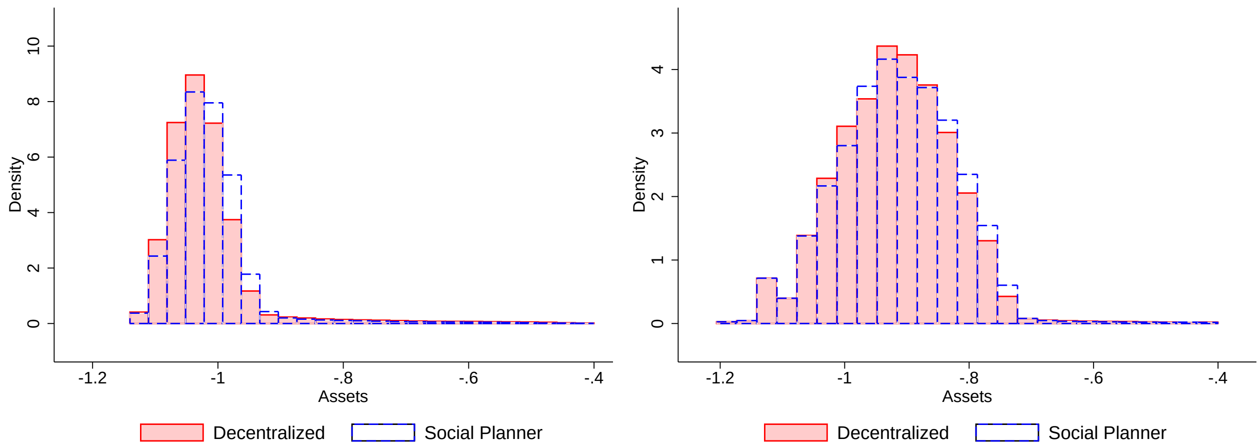
Table 5: Decomposition of overborrowing and capital controls

	Full model	Only trend shocks	Only transitory shocks
Overborrowing measures (%)			
$\frac{F^{CE}_{10pc}-F^{SP}_{10pc}}{F^{SP}_{10pc}}$	0.39	0.72	0.86
$\frac{F^{CE}_{25pc}-F^{SP}_{25pc}}{F^{SP}_{25pc}}$	0.18	1.03	0.71
Implied optimal tax (%)			
Overall, mean	3.52	4.31	3.35
Good times, mean	2.32	3.97	2.18
Bad times, mean	4.71	4.65	4.52
Good growth, mean	2.90	3.97	2.72
Bad growth, mean	4.13	4.64	3.98
Good trend shock, mean	3.40	3.96	-
Bad trend shock, mean	3.68	4.79	-
Corr. with GDP growth	-0.26	-0.15	-0.23

Note: Good/bad growth refer to the case in which the economy grows at a rate higher/lower than the average growth rate of the economy. Good/bad times refer to the case in which the detrended GDP of the economy is higher/lower than the median detrended GDP.

What is the role of mean reverting shocks and permanent shocks in the design of the optimal tax?[12] To address this question we can look at the third and fourth columns in Table 5 that compute the optimal taxes assuming that the economy only suffers trend shocks or only suffers transitory shocks, respectively.

[12] For a discussion on the properties of optimal tax in the baseline model without trend shocks, see Schmitt-Grohé and Uribe (2016).



(a) Low volatility

(b) High volatility

Figure 11: Debt distribution for the competitive equilibrium and the constrained optimal

Note: The debt levels in the x-axis are detrended. The left (right) panel corresponds to benchmark calibration with the exception of halving (doubling) the volatility parameter of the trend shocks, σ_g.

For the economy that is only hit by transitory shocks, we see that taxes are macroprudential. Moreover, optimal taxes during bad times (or bad growth) tend to double optimal tax during the expansions. The economics for this findings comes from the fact that the economy that is only hit by transitory shocks tend to issue debt during bad times, and hence, the impact on non-internalization of consumption decisions on prices affects debt dynamics more during bad times than good times.

Instead, in the economy with only trend shocks, debt accumulation tends to occur during the expansion, because those are the episodes where agents largely revise their permanent income and want to accumulate debt to smooth consumption. As seen in the table taxes during good times are much closer to taxes during bad times. In this way, trend shocks require less procyclical optimal taxes to replicate the Planner's allocation.

7.3 Trend volatility and overborrowing

Next, we study the sensitivity of our overborrowing results to the relative importance of trend shocks by halving and doubling its' volatility. Figure 11 plots the debt distribution for the competitive equilibrium and constrained optimal problem for the case of low trend volatility and high trend volatility keeping transitory shocks volatility constant. Our findings indicate a precautionary savings channel, as the economy with low volatility issues substantially larger levels of debt compared to the economy with high volatility. Accordingly, the overborrowing result is larger in the economy with low volatility than the economy with high volatility.

Table 6 shows additional results for high and low volatility scenarios, particularly that higher volatility induces lower levels of debt on average and less overborrowing for several measures. The relationship between overborrowing and trend volatility is quantitative and non-linear given that it depends on two channels that have opposite effects. On the one hand, higher volatility induces higher precautionary savings and reduces the ergodic debt level and, everything else equal would point to a less frequent crisis economy. On the other hand, higher volatility makes more frequent sudden changes in income process which, for a given level of debt, is likely to induce more frequent crisis. In our calibration, it is clear that the precautionary motive is substantial given that, as shown in the last block of the previous table, the implied taxes with high volatility are much smaller than the ones for the low volatility model.

Table 6: Overborrowing, capital controls and trend volatility

	Benchmark calibration	Low trend vol	High trend vol
	Overborrowing measures (%)		
$\frac{F^{CE}_{10pc}-F^{SP}_{10pc}}{F^{SP}_{10pc}}$	0.39	0.51	0.02
$\frac{F^{CE}_{25pc}-F^{SP}_{25pc}}{F^{SP}_{25pc}}$	0.18	0.67	0.63
	Implied optimal tax (%)		
Overall, mean	3.52	3.70	2.01
Good times, mean	2.32	2.31	1.27
Bad times, mean	4.71	5.10	2.75
Good growth, mean	2.90	3.07	1.55
Bad growth, mean	4.13	4.33	2.47
Good trend shock, mean	3.40	3.67	1.77
Bad trend shock, mean	3.68	3.75	2.34
Corr. with GDP growth	-0.26	-0.23	-0.26

Note: Good/bad growth refer to the case in which the economy grows at a rate higher/lower than the average growth rate of the economy. Good/bad times refer to the case in which the detrended GDP of the economy is at higher/lower than the median detrended GDP.

8 Final remarks

Open economy models with collateral constraints had significant success in explaining various important features of financial crisis in emerging markets. In this paper, we evaluate the performance of an endowment version of this model in replicating the behavior of macroeconomic variables around the Sudden Stops and argue that it fails to generate the right comovement and persistence of the trade balance adjustment and the real exchange rate behavior, both factors that are key to understand the dynamics and severity of macroeconomic adjustment process after periods of over-accumulation of foreign debt.

We study various features that can potentially help the model match the aforementioned features, namely international lending shocks, domestic preference shocks, and permanent supply side shocks. We show the latter is a promising candidate, given that the dynamics around Sudden Stops are similar to those related to permanent downward revisions of expectation of permanent income. We evaluate quantitatively how it can help the model account for the studied patterns around Sudden Stops and show that when the model is calibrated to match output moments of Argentina, the dynamics around the Sudden Stop replicates the qualitative behavior of the data.

We test the theory by estimating and studying the evolution of transitory and trend income shocks around Sudden Stops and we find that the corresponding behavior of these shocks is consistent with the implications of our model. Trend shocks can be key, combined with credit frictions, to model financial crisis dynamics. This result complements the findings in Aguiar and Gopinath (2007) who focus on the regular business cycle of emerging economies, by studying the dynamics around financial crisis.

In this environment, the model can generate overborrowing. Moreover, we show that for our calibration the optimal capital control tax has a macroprudential flavor while the tax is pro-cyclical. Trend shocks imply, however, less procyclical taxes compared to transitory shocks, but even higher taxes on average.

Endogenizing the permanent income dynamics is a key avenue to consider. Ates and Saffie (2016) and Guerron-Quintana, Saffie, and Gornemann (2016) are valuable steps in that direction but focus on pure technological story while the permanent income in emerging economies suffer permanent changes due to policy changes or political instability that are plausible explanations to consider in future research.

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A Data Sources

Data for the construction of Figure 1 is from the World Development Indicators (WDI). The unbalanced panel includes: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Egypt, Guatemala, Honduras, India, Indonesia, Korea, Malaysia, Mexico, Panama, Peru, Philippines, South Africa, Turkey, Uruguay and Venezuela. Table 7 gives the years for which we have the corresponding data for each country in the WDI.

For the estimation of income process for Argentina we use data from 1876 to 2004 from Ferreres (2010). Tradable sector includes Farming, livestock, hunting, fishing, mining and forestry and manufacturing; and non-tradable sector includes production of energy, gas and water, construction, transportation, financial intermediation and other services.

Table 7: Samples from the World Development Indicators

Country	Sample	Country	Sample
Argentina	1965-2016	Indonesia	1960-2016
Bolivia	1970-2016	Korea	1960-2016
Brazil	1990-2016	Malaysia	1970-2016
Chile	1960-2016	Mexico	1965-2016
Colombia	1965-2016	Panama	1970-2016
Costa Rica	1965-2016	Peru	1960-2016
Ecuador	1965-2016	Philippines	1960-2016
Egypt	1987-2016	South Africa	1960-2016
Guatemala	1965-2016	Turkey	1968-2016
Honduras	1960-2016	Uruguay	1983-2016
India	1960-2016	Venezuela	1960-2016