On Overborrowing:
Trend Shocks and Capital Controls

Hernán D. Seoane∗ 
Universidad Carlos III de Madrid

Emircan Yurdagul† 
Universidad Carlos III de Madrid

March 2017
Preliminary, please do not distribute.

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 international, demand and supply factors in generating the proper dynamics in a small open economy with endogenous borrowing limits. We find that permanent income changes are key in generating a sudden stop followed by a slow recovery. In this type of economy, optimal capital controls can be larger than 3% during times of crisis and exhibit strong pro-cyclicality.

Keywords: Borrowing constraint; trend shocks; sudden stops; optimal capital controls.

JEL Classification: E62, E63, E32, E44.
1 Introduction

Sudden stops are episodes of macroeconomic and financial crisis that tend to hit emerging economies and became relatively common in the last 30 years. These episodes are characterized by large output drops, sudden and sizable current account reversals and real exchange rate depreciation that has usually been followed by a slow recovery. That is, the main dynamics of sudden stops are asymmetric, the crisis unravels quickly affecting financial and real variables, but the recovery is sluggish both in terms of relative prices, such as the evolution of the real exchange rate, and real variables such that the current account, trade-balance and output dynamics.

Even though understanding the dynamics behind these episodes has been of first order importance in open macroeconomics literature, 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) where they model small open economies with endogenous borrowing limits to foreign debt issuance and pecuniary externalities, in the case of Mendoza (2010) from the price of capital and for Bianchi (2011) due to the changes in the real exchange rate. However, these models have not been able to generate the observed persistence and sluggishness in the recovery after the crisis.

This paper studies the role of international shocks, domestic demand shocks and domestic supply shocks in generating the comovement and persistence observed in the data around sudden stop episodes in a model in which the collateral constraint depends on the tradable value of domestic income. We follow the methodology in Chari, Kehoe, and McGrattan (2007) to provide the guidelines for the development of quantitative macroeconomic models of sudden stops by introducing time-varying wedges to summarize the importance of international, demand and supply features. We find that transitory supply shocks and international financial shocks can generate a sizable depreciation of the real exchange rate but imply counter-factual persistence in macroeconomic data around sudden stops. Demand shocks, on the other hand, can generate a slow recovery following a sudden stop but only a mild impact on the real exchange rate and can lead to counterfactual co-movement between net exports and income. On the other hand, negative permanent income shocks produce dy-
namics of macroeconomic variables that resemble the evolution around sudden stop episodes, suggesting that permanent income shocks can be a relevant source of disturbance around sudden stop episodes.

Based on this evidence, we calibrate a model with trend shocks as in Aguiar and Gopinath (2006) to match output dynamics and simulate sudden stops as defined in the data and we find that the model with trend shocks produces realistic sudden stop episodes. The result that trend shocks are likely to generate the type of crisis emerging economies experience as sudden stops is central in the light of Aguiar and Gopinath (2006) and Aguiar and Gopinath (2007) where the authors highlight the importance of trend shocks in generating the observed unconditional dynamics in emerging economies. Trend and transitory supply shocks generate very different dynamics in small open economy models given that the first ones are permanent shocks and as such, they are likely to induce a larger change in consumption compared to output and a larger deterioration of the trade balance to output ratio; whereas the later ones generate an improvement in the trade balance, results that are in line with those of the permanent income hypothesis. Existing literature has focused on these dynamics in standard models of small open economies. Instead, combined with endogenous borrowing limits, trend shocks are likely to induce more persistent debt crisis as when the trend shocks occur, they have permanent effects on income and by a downward revision of the permanent income have a strong impact of the real exchange rate and the chance to issue foreign debt.

Moreover, we find that the trend shocks model can generate overborrowing of 1.3% compared to the constrained efficient economy for the baseline calibration. The overborrowing result tends to increase with trend shocks volatility, i.e. an economy with highly volatile trend shocks are likely to suffer from a 50% larger overborrowing syndrome compared to low volatility trend economies. The overborrowing phenomena occurs when the competitive economy issues larger levels of debt than the constrained planner economy and this tends to happen when the pecuniary externality relaxes the borrowing constraint too much compared to the economy with internalization, that is, it occurs nearby the region in which the constraint is likely to be binding. With higher volatility there are two forces playing in opposite directions. On the one hand the precautionary savings motive induce a 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 planners problem. Whether higher volatility induces more overborrowing is a quantitative statement that seems to hold for many measures of overborrowing.

Under this setup we study the features of optimal taxation that corrects for the overborrowing syndrome. In particular we show that capital controls are procyclical, meaning a high (low) tax on foreign debt issuance when output growth is low (high). The reason for this result is that the overborrowing enters into this model through the cases in which the borrowing constraint binds, which are the times when the pecuniary externality has a stronger impact relaxing the borrowing limit. In the economy with trend shocks, the borrowing constraint is more likely to be binding during bad times, hence the optimal capital control should tax debt issuance during crisis times. Meanwhile, in the good times there is no inefficiency in the level of borrowing of the decentralized equilibrium, as the borrowing limit typically does not bind in these cases. The debt in good times arise due to future output increases – a permanently richer economy, and increasing the debt in those circumstances is optimal. This result contrasts with the theoretical literature advocating for countercyclical capital controls, surveyed in Fernández, Rebucci, and Uribe (2015). Nevertheless, the later paper highlights that the observed capital controls in the data are acyclical, and point at the implied gap between these empirical patterns and those suggested as optimal by the theoretical papers in the literature. Accordingly, we argue that the permanent supply shocks can provide a useful and realistic tool in reconciling these differences between the theory and the practice.

Our paper also contributes to the literature that studies the importance of real exchange rate in emerging economies, for instance Seoane (2016), by explicitly considering the impact on real exchange rate adjustments on the allocation of resources. This literature also abstracts from the channel that connects real exchange rate variability, sectoral relocation and business cycle dynamics.

This paper also contributes to the study of capital flows and capital controls. Recently there has been a renewed interest in the determinants of capital controls and the welfare implications of this policy instrument. Benigno, Otrok, Rebucci, Young, and Chen (2012), Fernández, Rebucci, and Uribe (2015), Fernández, Klein, Rebucci, Schindler, and Uribe (2015) study, using endowment version of a model with systemic externalities, whether optimal capital controls should be procyclical or countercyclical.

All 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 macro-prudential policies and to quantify how important is the misallocation issue in the design of these policies.

This paper relates to recent literature that studies sudden stops in endogenous growth models. Even though this is not the only interpretation, articles in this literature such as Ates and Saffie (2016), Guerron-Quintana, Saffie, Gornemann, et al. (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 more broad suggesting that other disturbances such as permanently perceived fiscal policy changes, change in trade policies or political cycles that are prone to have permanent impact on income can affects the dynamics around sudden stops in a plausible way.

The remainder of the paper goes as follows. In Section 2, we document the empirical relationship between misallocation, overborrowing and real currency appreciation for a set of emerging economies. 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. 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: first, sudden reversals 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; second, a drop in output and third, a fall asset prices and a depreciation of the real exchange rate. 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.

Figure 1 shows these data patterns by the average behavior of debt to output ratio, output growth, trade-balance to output ratio and the real exchange rate around sudden stop episodes for 35 economies for the period 1960-2015 where 43 sudden stops were identified.

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, annualized at the average of 4% 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 episode in our database replicates the features highlighted by the existing literature. The trade balance to output ratio switches from a 2% of GDP deficit to a 5% surplus and only starts deteriorating slowly after two years. In fact, the strength of this correction impacts on the unconditional trade-balance to output ratio strong negative correlation with output in emerging economies that is widely recognized by the literature.
Note: Macroeconomic crisis around sudden stops. Average of sudden stop episodes dynamics for 21 emerging economies during the period 1967-2012 summing up to 28 episodes. The period 0 dates the sudden stop episode and the figures plot the ten years interval around this episode.

Additionally, output growth rate is dramatically negative at the moment of the financial crisis and recovers after two periods. This strong output fall affects the debt to output ratio that increases more than 50% compared to 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 is still 15% larger than the pre-crisis period. The real exchange rate, additionally, depreciates substantially and does not recover in the short run.

These dynamics do not change when sudden stops are defined in terms of changes in current-account to output ratio. Moreover, even-though a large part of the literature is
concerned about the differences in sudden stop episodes and current account reversals, see Edwards (2007), in standard models of sudden stops this distinction does not apply unless foreign reserves are considered, for this reason we focus in crisis episodes defined in terms of changes in net export output ratio dynamics.

These dynamics, however, have proved to be very hard to capture with DSGE models in the business cycle literature because of the difficulties to capture the 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 changes 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) has 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 A model of sudden stops 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 the fixed risk free 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,

$$\max_{\{b_{t+1}, c_{t}^{T}, c_{t}^{N}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_{t}^{T}, c_{t}^{N})$$
subject to

\[
\begin{align*}
    b_{t+1} + c_t^T + p_t^N c_t^N &= b_t(1 + r) + p_t^N y_t^N + y_t^T \\
    b_{t+1} &\geq -\kappa (y_t^T + p_t^N y_t^N)
\end{align*}
\]

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 households 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 \(\kappa\). As is standard in the literature, we assume that the preferences are represented by

\[
u(c_t, c_n) = \left[ \omega (c_T^t)^{-\eta} + (1 - \omega) (c_N^t)^{-\eta} \right] \frac{1 - \sigma}{\eta} - 1.
\]

The first order conditions for the households’ problem are:

\[
\begin{align*}
    u_1(c_t^T, c_n^N) &= \lambda_t & (1) \\
    p_t^N &= \frac{1 - \omega}{\omega} \left( \frac{c_T^t}{c_N^t} \right)^{\eta+1} & (2) \\
    \lambda_t &= \beta (1 + r) E_t [\lambda_{t+1}] + \mu_t & (3) \\
    b_{t+1} + c_t^T + p_t^N c_t^N &= b_t(1 + r) + p_t^N y_t^N + y_t^T & (4) \\
    \mu_t [b_{t+1} - \kappa (y_t^T + p_t^N y_t^N)] &= 0; \quad \mu_t \geq 0 & (5)
\end{align*}
\]

Periods in which the borrowing constraint becomes binding make \(\mu_t > 0\) and affects intertemporal consumption decisions. The endogeneity of the constraint comes from \(b_{t+1}\) and from the fact that \(p_t^N\) is part of the total output measured in terms of tradable goods and in periods of real depreciation, when the price of domestic non-tradable goods become cheaper
in terms of tradable goods, the constraint is more likely to bind as the value of the collateral is smaller. The real depreciation will endogenously drive the sudden stop episodes and its persistence depends on the persistence of the real exchange rate, hence on 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, as common, we use asterisks to denote future variables and \( V \) denotes the value function of the households. The recursive representation of the representative households problem is then,

\[
V(b, B, y^N, y^T) = \max_{b', c^T, c^N} u(c^T, c^N) + \beta E[V(b', B', (y^N)', (y^T)')] \\
\text{s.t.} \\
b' + c^T + \tilde{p}^N c^N = b(1 + r) + \tilde{p}^N y^N + y^T \\
b' \geq -(\kappa^T y^T + \kappa^N \tilde{p}^N y^N) \\
\tilde{p}^N = p^N(B, z^N, z^T) \\
B' = \Gamma_B(B, z^N, z^T)
\]

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

Recursive Competitive Equilibrium. A RCE of 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:

\[ \hat{c}^N(b, B, y^N, y^T) = y^N \]

\[ \hat{c}^T(b, B, y^N, y^T) = y^T - \Gamma_B(B, y^N, y^T) + B(1 + r) \]

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

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

where \( \Gamma_B \) denote the next period aggregate assets and capital, given the current states of the economy.

4 Dissecting the baseline model

In this section our objective is to highlight the quantitative and qualitative features of the baseline model, which is an off-the-shelf model with borrowing constraint and pecuniary externality, around sudden stops. Accordingly we use a standard calibration, hence we fix preference, financial and endowment parameters to the values in Bianchi (2011). In particular, we set the discount factor, \( \beta \) equal to 0.91; risk aversion, \( \sigma \), to 2; the relative weight of the tradable goods in preferences, \( \omega \), to 0.31; and the elasticity of substitution between the tradable and non-tradable goods, \( \eta \), to \( 1/0.83 - 1 \). The risk free interest rate is assumed at 4 percent, and the parameters for the tightness of the borrowing constraints, \( \kappa^T \) and \( \kappa^N \) are 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).\(^1\) We use a debt grid of equally spaced 500 points.

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

\[ \rho = \begin{bmatrix} 0.901, & 0.495 \\ -0.453, & 0.225 \end{bmatrix}, \quad V = \begin{bmatrix} 0.00219, & 0.00162 \\ 0.00162, & 0.00167 \end{bmatrix}. \]
Table 1 summarizes the calibration of this model.

Table 1: Calibration

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Definition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>Risk aversion coefficient</td>
<td>2</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>0.91</td>
</tr>
<tr>
<td>$r$</td>
<td>Risk free interest rate</td>
<td>0.04</td>
</tr>
<tr>
<td>$\kappa^N$</td>
<td>Borrowing constraint</td>
<td>0.32</td>
</tr>
<tr>
<td>$\kappa^T$</td>
<td>Borrowing constraint</td>
<td>0.32</td>
</tr>
<tr>
<td>$\omega$</td>
<td>Share of tradable/non-tradable consumption</td>
<td>0.31</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Elasticity of substitution between $N$ and $T$</td>
<td>$1/0.83-1$</td>
</tr>
</tbody>
</table>

Figure 2 presents the dynamics around sudden stop episodes implied by the baseline model under the current calibration. To facilitate comparison, we re-write the real exchange rate as increasing if appreciation, and plot data objects in blue measured in the right axis and model objects in green in the left axis.

The figure shows that the sudden stops implied by the model is far from the type of crisis documented in the empirical literature and described in Section 2. There are two main issues with the dynamics implied by the model. First, before the sudden stop, the model implies that the dynamics that lead to a crisis develop in only one period while in the data the unraveling of the crisis is fast but the dynamics that lead to the crisis develop in several years. Second, the correction after the crisis in the model takes a short time while the effects of the crisis in the data are much more persistent.

The model generates only one period deterioration in the trade-balance to output ratio before the sudden stop, a one period reversal of the trade-balance to output ratio at the moment of the sudden stop and the model economy is running a trade balance deficit one period after that. On the other hand, 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. The patterns around a sudden stop are remarkably different. This is not only the case for this variable, debt to output ratio exhibits substantial differences too, mimicking the trade balance dynamics.

The model can replicate the immediate real exchange rate depreciation that is one of
the common denominators of these types of crisis. However, 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 tightening of the borrowing constraint in these types of model last for only one period.

In this way, this model cannot be considered a suitable model to understand key features of these crisis, in particular the development of the crisis that in the data requires an accumulation of current account deficits for several years before the crisis, the slow recovery of the real exchange rate, consumption of tradable goods and persistence correction of foreign
debt stocks.

5 Time-varying wedges

Our take from the exercise above is that the standard model with occasionally binding borrowing constraints and mean reverting technology shocks do not capture the essential dynamics around a sudden stop episode, 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, or transmission channels, are missing in the model. Our strategy is to follow the one described in Chari, Kehoe, and McGrattan (2007) by introducing 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 preference shocks that push them to prefer tradable consumption goods over non-tradable good by assuming \( \omega_t \) is time-varying and follows 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 to introducing demand shocks in the baseline economy: (1) preference discount shocks to \( \beta \), but under this formulation, a demand shock that triggers a sudden-stop-like crisis would imply that households becomes 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; and (2) a shock to the complementarity between tradable and non-tradable consumption given by \( \eta \), which even though plausible has a less direct and clean effect in the demand for tradable goods than those arising from \( \omega \).
Consequently, focusing on $\omega_t$ shocks, the pricing of non-tradable goods can be written as

$$p^N_t = \frac{1 - \tilde{\omega}}{\omega_t} \left( \frac{c^T_t}{c^N_t} \right)^{\eta+1}.$$  

(6)

Notice that we assume that the share of tradable goods is time-varying but we keep the share of non-tradable goods fixed to $\tilde{\omega}$ that is not time-dependent, this is done such that we can isolate the impact of a shock to the tradable consumption demand.

---

Figure 3: Dynamics after a $\omega_t$ increase

Note: this picture plots a one period shock to $\omega_t$. Solid line denotes parametrization (1) and dashed line parametrization (2).

---

2 A more detailed explanation follows. In particular, shocks to $\beta$ will make the households more patient (if $\beta$ increases) or more impatient (if $\beta$ decreases). In the case in which $\beta$ 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 $\beta$ 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 $\eta$ are more subtle and less transparent as changes in $\eta$ 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.
With this formulation, there is a direct effect of changes in $\omega_t$ 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 6 presents the dynamics after an increase in the demand wedge for two calibrations for the $\omega_t$ 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 $\omega_t$ triggers remarkably different dynamics depending on the size of the demand change. For a mild increase in $\omega_t$, there is a mild and very transitory fall in $p^N$ due to the substitution between tradable and nontradable goods. This has a negative wealth effect that induces a drop in tradable consumption, which has a larger effect than the substitution effect, implying an improvement in the trade balance. Due to the output fall, debt to output ratio increases. When the change in demand is large enough, such that overcompensates for the wealth effect, the consumption fall has a persistent effect in the price of non-tradable goods together with a more persistent impact on output and deterioration in the debt dynamics.

Even though different size of demand changes induce different responses in the trade-balance to output ratio, the comovement between variables is not in line with the one implied by the data. If the crisis were triggered by a 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 mild such that it generates 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 to capture this possibility is to allow for a wedge in the borrowing limit, assuming that $\kappa$ is time-varying.
Under this assumption, a drop in $\kappa_t$ 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 would be able to explain the persistence of the net exports to output ratio after a sudden stop and the fact that the borrowing limit is persistent would contribute to a persistent drop in tradable consumption and medium term undervalued real exchange rate. Figure 7 presents the dynamics after a drop in the borrowing limit for two calibrations of the $\kappa_t$ 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: Dynamics after a $\kappa_t$ drop

Note: this picture plots a one period shock to $\kappa_t$. Solid line denotes parametrization (1) and dashed line parametrization (2).

Figure 7 presents the dynamics after a negative shock to the borrowing limit. As seen in
the figure, even a persistent shock to $\kappa_t$ does not generate the empirically-observed dynamics around 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 $\kappa_{t+1}$ as the debt level has been re-paided, 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 real exchange rate and output which relaxes the borrowing limit even further.

5.3 Supply-driven crisis

As implied by the Permanent Income Hypothesis and pointed out in Aguiar and Gopinath (2007), the dynamics following a 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 $z^j_t$ for $j = \{T, N\}$ and a common trend shock, $\Gamma_t$,

$$y^j_t = z^j_t \Gamma_t.$$  

The trend is stochastic and its growth rate follows an AR(1) process as in Aguiar and Gopinath (2007), $rac{\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 present the dynamics after a negative permanent change in the conditions of the supply side of the economy. We assume the following parametrizations (1) that as-
Figure 5: Dynamics after a $g_t$ drop

Note: this picture plots a one period shock to $g_t$. Solid line denotes parametrization (1) and dashed line parametrization (2).

sumes Aguiar and Gopinath (2007) parametrization and (2) double of the permanent shock variance of Aguiar and Gopinath (2007). The dynamics after a permanent income shock are remarkably different from those of transitory supply shocks, demand or international investors’ disturbances. In particular, 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 perceived it is becoming permanently richer which lead 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 episode occurs, 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

This section quantifies how well the trend shocks can help us account for the sudden stop features observed in the data. Accordingly, we introduce a model exhibiting permanent supply side changes, as described in Section 5.3, and in order to keep the calibration of the model as clean as possible we omit all the other sources of uncertainty described above, including the transitory income changes. Meanwhile, transitory shocks to income, to preferences or to the borrowing constraint, as described earlier in the paper, can easily be introduced to this new model together with more moment conditions.

We keep the preferences and financial parameters fixed to the values Table 1 and calibrate the parameters governing the income process to match the directly related moments in the data for Argentina shown in Table 2. The reason for targeting Argentina’s output process is because a key moment we need to match is the average growth of the economy, a moment that in order to identify properly we need long sample, and for Argentina our annual data set goes back to 1879. For completeness, the table shows that long term moments, in the case of Argentina, are not very different from the latest 25 years of more recent data.

In particular, we set the parameters of the trend process directly following the growth patterns in the data. The average annual growth both of the tradable and the non-tradable output in the data is around 3 percent, hence we set \( \mu_g \) equal to 1.03. The standard deviation of the growth rates in these two sectors are both around 7 percent and we set \( \sigma_\nu \) equal to 0.07 accordingly. Finally, the autocorrelation of these growth rates are -0.1 for the tradable sector and 0.04 for the non-tradable sector. Following the latter, we set \( \rho_g \) equal to 0.04. The calibration for these parameters are summarized in Table 2. Additionally, we set \( r = 0.08 \) in line with the real net rates in emerging economies and \( \kappa = 0.32 \) as in Bianchi (2011). We approximate the process for the trend shocks following the Tauchen algorithm with a grid
### Table 2: Targets

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data 1994-2016</th>
<th>Data 1879-2004</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu(\gamma^T)$</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>$\mu(\gamma^{NT})$</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>$\sigma(\gamma^T)$</td>
<td>0.05</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>$\sigma(\gamma^{NT})$</td>
<td>0.06</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>$\rho(\gamma^T)$</td>
<td>-0.14</td>
<td>-0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>$\rho(\gamma^{NT})$</td>
<td>0.16</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>$\rho(\gamma^T,\gamma^{NT})$</td>
<td>0.66</td>
<td>0.48</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Annual data for Argentina. $\gamma^T$ and $\gamma^{NT}$ denote the growth rates of output in tradable and non-tradable sectors, respectively. $\mu(x)$ and $\sigma(x)$ denote the mean and the standard deviation of $x$, $\rho(x)$ denotes the first order autocorrelation of $x$ and , $\rho(x,y)$ denotes correlation of $x$ and $y$.

of 11 points. As in the previous sections, we use a debt grid of equally spaced 500 points. This calibration generates 7% frequency of sudden stop episodes as defined in the empirical section, which provides a similar order of magnitude to the frequency observed in the data.

![Graphs of economic indicators](image_url)

**Figure 6: Sudden stops in the model and the data**

Note: Macroeconomic crisis around sudden stops. Average of sudden stop episodes dynamics for 21 emerging economies during the period 1967-2012 summing up to 28 episodes. 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.
Figure 6 compares the dynamics around sudden stops for our preferred model and the data. As seen in the figure, the model with permanent income shocks exhibit dynamics around sudden stops that are in line with those observed in the data. In particular, 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 four years, as well as the current account to output ratio.

Additionally, the price of non-tradable goods, that proxy the evolution of the real exchange rate implies a similar dynamics, only lasting for one period for the baseline economy but a persistent depreciated exchange rate for the model with permanent supply wedges.

![Figure 7: Tradable output and consumption dynamics around a sudden stop episode](image)

Note: Detrended variables around a Sudden Stop dynamics.

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 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 ob-
served in the data. According to Figure 6, 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 induce a persistent deterioration in the net exports balance, which starts three periods before the sudden stop but becomes negative only the last period before the reversal due to larger increases in tradable consumption than tradable output as seen in Figure 7. Current account, on the other hand is negative for the whole five years before the reversal and significantly worsens on period before the sudden stop occurs. The positive pressure in consumption, distributed between tradable and non-tradable consumption implies an appreciation in the real exchange rate.

When the negative income shock hits the economy, the debt to output ratio jumps high, implying large interest repayments which forces the correction in the net exports and the current account, consumption and the real exchange rate, i.e. sudden stop episode, which contributes to a further tightening in the size of the collateral together with a drop in the desire to issue foreign debt from the fact that households revise their income down due to the permanent drop in the trend. In this way, dynamics, in line with those implied by the Permanent Income Theory, produce dynamics greatly in line with those in the data, suggesting that permanent revisions of permanent income are key to the dynamics around a sudden stop episode.

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.\footnote{Moreover, this is also true given that non-tradable consumption falls by the same magnitude and persistence of non-tradable output.}

The model is able to match qualitatively various non-targeted unconditional first and second order moments for the case of Argentina. In particular, as seen in Table 3 under the column labeled “Competitive Equilibrium”, the model 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 of the same order
Table 3: Model comparisons of second moments

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comp. Eq</td>
<td>SP</td>
</tr>
<tr>
<td>Average (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output growth</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Current account / GDP</td>
<td>-1.6</td>
<td>-0.6</td>
</tr>
<tr>
<td>Trade balance / GDP</td>
<td>1.95</td>
<td>1.7</td>
</tr>
<tr>
<td>Standard dev. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption growth</td>
<td>7.5</td>
<td>10.6</td>
</tr>
<tr>
<td>Real exchange rate (log)</td>
<td>40.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Current account / GDP</td>
<td>4.5</td>
<td>3.4</td>
</tr>
<tr>
<td>Trade balance / GDP</td>
<td>3.96</td>
<td>3.7</td>
</tr>
<tr>
<td>Corr. with GDP growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption growth</td>
<td>0.41</td>
<td>0.83</td>
</tr>
<tr>
<td>Real exchange rate (log)</td>
<td>0.16</td>
<td>0.65</td>
</tr>
<tr>
<td>Current account / GDP</td>
<td>-0.10</td>
<td>-0.61</td>
</tr>
<tr>
<td>Trade balance / GDP</td>
<td>-0.17</td>
<td>-0.62</td>
</tr>
</tbody>
</table>

Note: Annual data for Argentina period 1875-2004. (log) denotes natural logs and the real exchange rate is computed using Argentina’s GDP deflator and US CPI.

of magnitude, except for the case of the volatility of the real exchange rate, for which the model can generate 7.3% of volatility, similar to other models in this literature, while the real exchange rate in the data is more volatile. Importantly, the model is able to get the right comovement of endogenous variables with output growth in all dimensions.

7 Overborrowing and optimal capital controls

Given the considerable performance of our preferred model in capturing the macroeconomic dynamics around the sudden stops, it is important to study the quantitative relevance of trend wedges in the overborrowing result and the properties of optimal capital controls.

In this section, 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,

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

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

$$b_{t+1} + c_t^T = b_t (1 + r) + y_t^T$$

$$b_{t+1} \geq -\kappa \left( y_t^T + \left( \frac{1 - \omega}{\omega} \left( \frac{c_t^T}{y_t^N} \right)^{\eta+1} \right) y_t^N \right).$$

Figure 8: Debt distribution for the competitive equilibrium and the constrained optimal allocation

Figure 8 plots the distribution of debt for the competitive equilibrium (in red bars) and the constrained optimal allocation (in blue bars). As seen in the figure, even though debt distributions coincide in a large share of the debt space, the competitive equilibrium
generates overborrowing as it attains higher levels of debt that the planner’s solution but also because the frequency of relatively large debt is higher than in the constrained optimal allocation. Moreover, even though this overborrowing result persist, it seems to be milder than the one obtained in Bianchi (2011). In particular, Table 4 shows that for the baseline calibration the degree of overborrowing ranges from 1.03% to 1.31% and importantly, the overborrowing result tend to occur during bad times, that is when the economy’s growth is lower than the average growth.

Regarding the optimal policy, Table 4 shows the implied optimal tax that would make the competitive equilibrium mimic the constrained planner equilibrium. This optimal tax is defined over new debt issuance, affecting the budget constraint such that

\[(1 - \tau_t)b_{t+1} + c_t^T = b_t(1 + r) + y_t^T\]

and we compute it using the solution of the social planner’s problem as follows:

\[\tau_t = \frac{\beta(1 + r)g^{-\sigma}\mathbb{E}_t(\mu_{t+1}\psi_{t+1}) - \mu_{t+1}\psi_t}{u_{t, t}^*}.\]

As seen in the table, under the column labeled “Baseline” the optimal tax is procyclical, i.e. tax is larger during bad times and lower during good times. This procyclicality of the optimal tax is robust to alternative definitions of good and bad times as in the table good times refer to the case in which the economy grows at a rate higher than the average growth rate of the economy but we obtain similar results for other definitions of good times.

The optimal tax that corrects for the overborrowing syndrome, i.e. capital controls, are procyclical implying high tax on foreign debt issuance when output growth is low and low taxes when high. The reason for this result is that in the economy with trend shocks, the borrowing constraint is more likely to be binding during bad times and the impact of the pecuniary externality relaxes the constraint, and hence promotes overborrowing, in those periods. Consequently the optimal capital control should tax debt issuance during crisis times. Another intuition comes from the fact that with trend shocks, debt in good times reflects future output increases and then issuing debt in those circumstances is optimal, given that in these scenarios the borrowing constraint is not binding, a constrained efficient
Table 4: Trend volatility and overborrowing

<table>
<thead>
<tr>
<th>Overborrowing measures (%)</th>
<th>Low volatility</th>
<th>Baseline</th>
<th>High volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BE_{min} - BS_{min}$</td>
<td>1.17</td>
<td>1.29</td>
<td>1.76</td>
</tr>
<tr>
<td>$F_{10pc} - F_{10pc}$</td>
<td>1.10</td>
<td>1.03</td>
<td>1.29</td>
</tr>
<tr>
<td>$F_{25pc} - F_{25pc}$</td>
<td>1.21</td>
<td>1.31</td>
<td>1.11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implied optimal tax (%)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, mean</td>
<td>2.88</td>
<td>2.20</td>
<td>1.32</td>
</tr>
<tr>
<td>Good times, mean</td>
<td>2.42</td>
<td>0.98</td>
<td>0.09</td>
</tr>
<tr>
<td>Bad times, mean</td>
<td>3.33</td>
<td>3.42</td>
<td>2.56</td>
</tr>
<tr>
<td>Corr. with GDP growth</td>
<td>-0.19</td>
<td>-0.67</td>
<td>-0.70</td>
</tr>
<tr>
<td>Corr. with Debt / Output</td>
<td>0.17</td>
<td>0.58</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Note: Good times refer to the case in which the economy grows at a rate higher than the average growth rate of the economy.

solution will imply the same debt level and hence no overborrowing arises here as for the planner would also be optimal to issue debt during good times given that good trend shocks imply permanently richer economy; on the other hand, during bad times, capital controls will constrained those episodes in which the borrowing limit is relaxed inefficiently by the pecuniary externality. The existing literature, in turn, advocates for countercyclical capital controls, which are optimal under transitory output shocks, however, Fernández, Rebucci, and Uribe (2015) find that in the data capital controls are a-cyclical and as they point out: “Our results allow for at least two interpretations. One is that, in light of the recent growing theoretical literature arguing that countercyclical capital control policy can be welfare improving, our findings point at a case of theory running ahead of policy practice. Under this view, one would expect that as time goes by and the message of the new theories percolate into policymaking circles, capital controls will become more cyclical. A second possible interpretation is that these theories may not be capturing all of the relevant economic or political factors that determine the cyclical properties of optimal capital controls. To the extent that policymakers have a better grasp of the complexity of factors determining optimal capital controls, our results could be interpreted as policy practice running ahead of theory.”, and in
this sense, permanent income changes can be part of the missing story behind the capital controls cyclicality in the existing literature.

7.2 Trend volatility and overborrowing

Next, we study the sensitivity of our overborrowing results to trend shocks volatility. In particular we repeat the exercises of Section 7.1 by halving and doubling the calibrated trend shock volatility of our preferred economy.

Figure 9 plots the debt distribution for the competitive equilibrium and constrained optimal problem for the case of low trend volatility and high trend volatility. As can be seen in the figure, the precautionary savings motive strongly operates in the economy as the economy with low volatility issues substantially larger levels of debt compared to the economy with high volatility. However, the overborrowing result seems more extreme in the economy with high volatility rather the economy with low volatility.

![Graphs showing debt distribution for low and high volatility](image)

(a) Low volatility
(b) High volatility

Figure 9: Debt distribution for the competitive equilibrium and the constrained optimal allocation

Additionally, Table 4 shows the results for high and low volatility scenarios, particularly that higher volatility induces lower levels of debt on average but higher overborrowing, i.e. there is a positive reinforcing effects between permanent income shocks and the pecuniary externality. This result is, however, not robust to all the overborrowing measures and depends on the percentile of debt accumulation we focus.
Figure 10 helps characterizing the optimal policy for good and bad times and in contexts of high and low volatility of the trend shocks. As seen in the figures, the optimal tax is increasing in the level of debt and kicks in for economies growing at low rates (red lines) and even earlier for highly volatile trend economies. In other words, economies tend to overborrow (and need to be corrected in order to attain the constrained optimal dynamics) more in low growth scenarios of highly volatile economies.

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 induce 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, it can be seen that the implied tax is much smaller than for the low volatility model.

8 Final remarks

Recent models on overborrowing and systemic externalities had significant success in explaining various important features of financial crisis of emerging markets. In this paper, we evaluate the performance of such a standard model in replicating the behavior of macroeconomic variables around the sudden stops and argue that it fails generating 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 an overborrowing model match the aforementioned features, namely preference shocks, international lending 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 models are calibrated to match output moments of Argentina, the dynamics around the sudden stop replicates the qualitative behavior of the data.

In this environment, the model can generate about 1% overborrowing. Moreover, we show that the optimal capital control tax, when the sudden stops are triggered by permanent income shocks, is pro-cyclical in the sense that should be high in bad times and low in good times. The intuition for this result comes from the fact that during good times (high output growth) the borrowing constraint is less likely to be binding and high trend shocks implies high future output which makes it optimal both for the constrained planner and the household in the decentralized equilibrium to issue large levels of debt. On the contrary, when the model is hit by a negative trend shock, the borrowing constraint is more likely to bind and here is where the existence of a pecuniary externality plays a role in relaxing the constraint due to non-internalization effects in the competitive equilibrium, a situation that optimal policy aims to solve by taxing capital inflows.
References


——— (2010b): “Regulating capital flows to emerging markets: An externality view,” Available at SSRN 1330897.


