The empirical dimension of overborrowing*

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Abstract

Persistent current account deficits are common among low and middle income countries. When is this situation dangerous? Is there a critical value for the yearly current account deficit just before the crisis sets off? We provide a positive answer to the last question; a finding that gives rise to an empirical measure of overborrowing. We observe that countries that have increased their external indebtedness by at least 26%-31% of the GDP in a time span of 3 to 5 years are more prone to be hit by a sudden stop. The typical crisis produces a consumption drop of 4% of GDP and current account reversal of 2.5-4.5% of GDP. We also contribute to the structural characterization of sudden stops. Using a canonical model we are able to replicate these stylized facts. Moreover, we compute the ratio of net debt to GDP. This parameter is two or three times bigger than the benchmark value in the literature, a fact that improves the empirical performance of the model. From a policy perspective, our findings help to elaborate leading indicators to anticipate a sudden stop.

Keywords: sudden stops, current account deficits, debt

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1 Introduction

Persistent current account (henceforth CA) deficits are a recurrent phenomenon in a large fraction of low and middle income economies. In a panel of 34 countries between 1970 and 2016, we verified that almost half of the sample contains observations with a deficit of at least 2% of GDP during five consecutive years. Since in general these dynamics are followed by balance of payments crises, they beg important questions: When does a country have effectively overborrowed? Heuristically, we can say it happens when these deficits are followed by a balance of payments crises. But, is there a critical value for the yearly CA deficit observed before the crises? This question is policy relevant as it may help to design macro-prudential policies based on a rule that is simple to communicate and easy to detect.

The purpose of this paper is to provide a positive answer to the last question. We find that there is a monotonic relationship between the yearly CA deficit that precedes a sudden stop (henceforth SS) and its duration. This fact gives rise to a threshold as "crossing" it may give rise to a balance of payment crises. We also identify that the threshold is decreasing in its persistence and it ranges between 6.2% and 8.8% of the GDP. Moreover, we investigate the effects of accumulated borrowing on several economies: we find that there is a set of countries that have increased their external indebtness by at least 26% to 31% of the GDP in 3 to 5 years; when these countries are hit by a systemic shock, they suffer a SS. In this sense, the results in this paper provides a measure of *external fragility*, a fact that we call *the empirical dimension of overborrowing*. Figure 1 summarizes the main characterization. The figure depicts the monotonic relationship between the yearly CA deficit observed before a balance of payments crisis (i.e. threshold) and its persistence (P, i.e. the number of years with that CA deficit). In the right axis of the picture we plot the product of the two as a measure of accumulated external borrowing (B). As the threshold is decreasing in P, it would have been possible to observe a "bell shaped" figure. However, there is a stable relationship between the rates at which the threshold decreases and persistence increases; giving rise to our empirical dimension of overborrowing: a stable accumulated increase in external indebtness between 26% and 31% of the GDP.

[INSERT FIGURE 1 HERE]

In order to structurally test the presence of overborrowing we use a standard model in the small open economy literature. We found that, provided that GDP is sufficiently persistent, it can replicate the dynamics of an economy that has suffered a SS after 2 to 5 years of persistent CA deficits. We use these results to compute the maximal value of net external indebtness before a balance of payments crisis. We found that this parameter is 2 or 3 times bigger than the benchmark value in the literature and it is increasing in the persistence of the yearly deficit. This fact allows the model to replicate the observed net external debt-to-GDP ratio, a frequenltly used measure of fragility, more accuratelly when compared with the state of the art parameterization.

This paper contribution to the literature is three-fold.

First, we identify and define empirically SS episodes using a measure of overborrowing defined as a given persistence of big CA deficits (a generalization of one condition in the definition of SS provided by Edwards, 2004, the one associated with a large inflow of foreign capital previous to the SS crisis). When the SS hits on the economies that satisfy these conditions (the treatment group), it produces the a large drop in consumption, as compared with countries not having that overborrowing condition (the control group). Countries selected in the treatment group were all affected by major crises, including the global oil shocks in the 70s, the Latin American debt crises of the 80s, the Russian default in the 90s and the subprime crisis in the 00s.

This procedure allow us to establish a threshold of overborrowing, measured as the simple accumulation of yearly current account deficits in the pre-phase of the SS: 26%-31% of the GDP. When reaching that threshold, consumption drops and a current account reversal is activated, two features that we think must have a role in the definition of a SS event (as in Mendoza, 2010; Bianchi, 2011). The typical SS produces a consumption drop of 4% of GDP and CA reversal of 2.5-4.5% of GDP. This finding is robust to different estimators of the threshold.

Second, we contribute to the structural characterization of SSs. We propose a calibration method based on the concept of hitting times due to Durret (1996, p. 176). We study the behavior of accumulated CA deficits between crises. Using the canonical set-up due to Bianchi (2011), we identify overborrowing using different hitting times or, equivalently, by allowing a flexible number of periods without a crisis. As the model has a block recursive structure in the system of equations characterizing the sequential equilibria between crises, we can identify the distinctive characteristic of those countries that can be matched using the model: a measure of persistence in the GDP. In particular, the norm of the matrix of coefficients in a standard vector autoregressive can be used to identify a positive match. Moreover, equipped with these results we can use the matched hitting time to calibrate the frequency of crises and consecuently the tightness of borrowing limits. We found that the critical ratio of net debt to GDP is significantly bigger, when compared to the benchmark case, for those countries in the tretment group. We interpret this result as suggesting that a SS preceded by overborrowing is an infrequent event, at least when compared to the benchmark case. For instance, at most we observe 2 positive matches out of 2000 cases (0.1%) when the "typical" event was assumed to have a frequency of 5% (see Bianchi, 2011, p.3411). In this sense, this paper contributes decisively by improving the match of standard models to data; a quest that has been elusive in the literature (see Seaone and Yurdagul, 2018).

Moreover, our empirical definition of overborrowing contrasts with the one frequently used in the literature. In particular, since Bianchi (2011) overborrowing is defined as an excesive level of indebtness with respect to a *normative benchmark* (i.e. the solution to a constrained Pareto efficient version of the model). Our definition of overborrowing can be identified in data in a simple and clear manner, without the necessity of structurally estimating a model. However, if we would like to perform a policy experiment, a standard model can be easily adapted to it as we are able to reproduce the dynamics of overborrowing using a parsimonious set of parameters, provided that GDP is sufficiently persistent.

Finally, our results provide a useful guidance to policy makers. SSs episodes have shaken many countries, particularly emerging ones, for the last 40 years. From a macro-prudential policy perspective, our findings can help elaborate leading indicators to anticipate a SS, rules of thumb to estimate the occurrence of a crisis (see Bianchi and Mendoza, 2018). After significant external debt issuance, local authorities may consider taking measures to tackle persistent current account deficits that are near to the estimated threshold. Our policy implications, then, are crystal clear: fast accumulation of current account deficits or debt issuance increase the likelihood of a sudden stop, and so authorities must be aware before reaching the 26%-31% of GDP threshold in the time span of 3 to 5 years. To this end, we compute the thresholds in the systemic SS literature (see Calvo et al., 2008) that match our criteria. We found that these values are on average at a 0.7 standard deviation from our estimated values.

This paper is organized as follows. Section 2 presents the definitions of sudden stops used in the literature and how it relates to our definition. Section 3 describes the empirical strategy for identification and the results. Section 4 describes the canonical cases. Section 5 presents the structural estimation. Section 6 concludes.

2 A broad definition of sudden stops

Our broad definition of a sudden stop (SS) includes episodes that involve at the same time the following characteristics:

Definition: Sudden Stop

- (i) *Recession*: a sharp drop in (total) real consumption.
- (ii) *Overborrowing*: several and persistent years of accumulated current account deficits.
- (iii) *Reversion*: an acute correction of the current account following the sudden stop.

The concept of SS is originally due to Calvo (1998), but definitions in the literature are quite distant to each other. These descriptions can be classified in two types as being found in a) empirical papers; and b) theoretical (or structural) papers. While the former type involves a *relatively abnormal behavior* of a particular episode when compared with similar countries and a *pre-determined cut-off threshold* (a drop of x% in capital inflows), the latter is *qualitative in nature* and it omits any reference to the *pre-phase* of a SS. The empirical definition refers to the dynamic behavior of the capital account of the balance of payments, while the theoretical type is based on certain path in the current account (CA). This difference is due to the fact that most known models are based on real variables and, thus, they do not take into account the role of international reserves.

We now list the most relevant definitions in the literature. Among the structural or theoretical class we find:

(1) Mendoza (2010) Three main empirical regularities define SS: (a) reversals of international capital flows, reflected in sudden increases in net exports and the CA; (b) declines in absorption and production, and (iii) corrections in asset prices.

(2) Mendoza and Smith (2006) SS is defined by three stylized facts: sudden, sharp reversals in capital inflows and the CA, large declines in absorption and production, and collapses in real asset prices and in the price of non-tradable goods relative to tradables.

Regarding the empirical type we highlight:

(3) Calvo et al. (2008) SS is characterized by episodes in which the economy exhibits a large and largely unexpected cut in capital inflows. In addition, they consider "systemic" SS (3S), i.e., SS that take place in conjunction with a sharp rise in aggregate interest-rate spreads.

(4) Calvo et al. (2004) They define SS as a phase that meets the following conditions: (a) it contains at least one observation where the year-on-year fall in capital flows lies at least two standard deviations below its sample mean (this addresses the 'unexpected' requirement of SS); (b) the SS phases end once the annual change in capital flows exceeds one standard deviation below its sample mean. This will generally introduce persistence, a common fact of SS; (c) moreover, for the sake of symmetry, the start of SS phases are determined by the first time the annual change in capital flows falls one standard deviation below the mean.

(5) Edwards (2004) SS episodes are an abrupt and major reduction in capital inflows to a country that up to that time had been receiving large volumes of foreign capital. More specifically, the following requirements are used for an episode to qualify as SS: (a) the country in question must have received an inflow of capital larger to its region's third quartile during the previous two years prior to the SS; (b) net capital inflows must have declined by at least 5% of GDP in one year.

Notice that, except for definition (5), the remaining concepts focus on the SS *consequences*. We take the route chosen by Edwards (2004) because this definition when combined with a parsimonious list of variables (i.e. it will be only required to test the behavior of the current account and aggregate consumption) will allow us to try to match the presence of overborrowing using a simple model; within a reasonable range for the structural parameters. As a consequence, our definition of SS will be more demanding, and thus, the number of events will be smaller.

Our definition stands in the middle of both types. This is because we want to perform a structural test of our definition of SS, which allows the order of magnitude involved in the event to be determined endogenously in the model. We wish to connect the pre-phase of an event with an empirical notion of overborrowing. In particular, clause (ii) of the definition above will give rise to a threshold, which determine if a certain country has overborrowed and thus is prone to SS. In order to recover the episodes from data, we follow a difference-in-differences strategy, which borrows from the relative nature of the empirical definition, but we extract from it a stylized fact that can be tested using a model in the small open economy family. Thus, our definition involves the behavior of the CA and it is more restrictive than any definition in the empirical or the theoretical class as it is concerned with elements of both types of existing definitions. On one hand, our definition will 'pick' a small subset of events when compared with the empirical literature. On the other hand, we will test for more than one country, as it is frequent in the theoretical literature, but with a parsimonious set of parameters; a fact that allows us to structurally test the presence of overborrowing.

Instead of imposing an ex ante criterion for the pre-phase or the SS, we allow for multiple thresholds as measured by the combination of a minimum level of CA deficit and the number of consecutive years which the actual figure were at or above that mark, something that we call *persistence*. The domain of potential overborrowing measures are then the results of the level of CA deficit per year for a given persistence level. For each threshold, the countries matching this criteria are placed in the "treatment group". We then draw a curve by mapping the difference between the change in consumption in the treatment group relative to the change in the control group (i.e. a d-in-d approach) against the CA deficit in the threshold. The intuition is that if this level of overborrowing is associated with the SS event, then this should be empirically observed in terms of the consumption dynamics: a drastic reduction in consumption, after averaging out countries idiosyncratic differences. We have a different curve for each persistence level. The SS is then identified as the "biggest" reversion in capital flows, measured in relative terms, measured by the steepest tangent of this curve. This allows us to determine the most likely overborrowing measure in terms the maximum discrimination between the implied treatment and control groups. Note that this procedure corresponds to an empirical selection of the 'large volume of foreign capital' that is key to the definition (5) of Edwards (2004).

Our structural estimation method consists in applying a standard minimal state space recursive representation as in Bianchi (2011) in order to replicate condition (ii) of our definition of SS. Thus, this paper test a *sufficient condition* for the presence of overborrowing in a small open economy. Typically, overborrowing is defined using a constrained Pareto efficient equilibria as a benchmark. As the purpose of this paper is to describe an empirical measure of this phenomenon, we have to avoid using the normative definition of it. Because the model refers to a small open economy, it is not possible to test for condition (i) as it requires to model a control group. Thus, we cannot test the presence of a sufficient condition for the occurence of a sudden stop. However, once we have identified the treatment group, we can compute the ”size” of overborrowing using the threshold for the current account deficit and its persistence.

3 Empirical identification strategy

As explained above, our goal is to identify the SS event by evaluating a measure of overborrowing (condition (ii) in the SS definition above) that is associated with the expected consequences of SS (conditions (i) and (iii) of the SS definition above). The empirical strategy is to link the measure of overborrowing that is associated to a discrete and significant fall in consumption measured in (constant) dollar terms. More specifically, we are interested in finding a *clear discontinuity* in the relative behavior of consumption growth depending on the CA deficit level for different persistence levels.

The identification strategy has two steps. In the first step, we consider different amount of CA deficits given by magnitude and persistence, which corresponds to a measure of overborrowing. A threshold is defined as the level of CA deficit of maximal discrimination between countries with that level of CA deficit vs. those with less CA deficit, in terms of consumption fall. The intuition is that this level of magnitude and persistence of CA deficit is associated with a crisis. This is in fact a difference-in-differences (d-in-d) estimator, where the treatment corresponds to CA deficit accumulation. In a second step, for the group of countries that are at or above the first step threshold amount, we evaluate their average performance for those countries that also satisfy ex-post with conditions (i)-(ii) of SS given above.

In sum, the empirical identification strategy below follows these steps:

- *First step: Overborrowing.* First, we find the value of the threshold, γ below, that maximizes the differences in consumption fall between the two groups, where the groups are constructed according to the level of accumulated CA deficits for different persistence levels, h.
- *Second step: SS crisis.* Second, among the treated, we study those countries that satisfy (i) and (iii) of the SS definition above for the threshold γ defined in the first step.

3 .1 Data description

We construct a panel of 34 countries for which reliable data are available for the period 1970-2016, with annual frequency. The variables collected include current account in (current) dollars and percentage of GDP; consumption and GDP in (2010 constant) dollars; real multilateral exchange rates; and (net) external debt as percentage of GDP. We also performed an estimation of the tradable and non-tradable categorization by grouping the value added of agricultural and manufacturing sectors (tradables), and construction and service sectors (non tradables).

The sources are the World Bank Database; the Economic Commission for Latin America and the Caribbean Statistics; the National Accounts Section of the United Nations Statistics Division; and the REER database due to Darvas (2012). In order to complete the database we also asked for specific data to several national statistical institutes.

We cover fewer countries but for a longer lapse of time when compared with Edwards (2004) (i.e. 157 countries between 1970-2001) but more countries during a longer period when compared with Calvo et al. (2004) (i.e. 32 countries between 1990-2001).

3 .2 First step: An empirical measure of overborrowing

The hypothesis is that countries face a SS when persistent current account (hereafter denoted as CA) deficits cannot be sustained anymore. The identification of an event would thus correspond to different combinations of persistence in CA deficits. We are aware that the persistent behavior of the CA could be associated with a rigid fiscal deficit, an investment boom, or even a combination of the two; just to mention a few examples. In any case, the duration and the order of magnitude of the external imbalance would be the same, which suggest that the accumulation rate of external debt may be at the center of the scene. We will try to disentangle ex post for every SS, the possible origin of the disequilibrium, as this information could be useful for future research.

Specifically, a *threshold* is determined by the level of CA deficit per year during all the time periods involved in the pre-phase of the SS event, a time window that we call *persistence*. The hypothesis is that this threshold will be observed before a given drop in consumption and a certain current account reversal. The countries in the *treatment group* have at least the threshold CA deficit during the pre-phase of a SS. The *control group* will be defined by the complement, that is, they have less CA deficit.

Let CA_{it} be the current account of countri i at time t, as a percentage of GDP. We argue that the SS is associated with the magnitude of CA_{it} and its persistence. We consider the treatment vs. control mean effect for a given combination of (γ, h), where γ represents the current account threshold, i.e. $CA_{it} \leqslant -\gamma$ and h is the number of periods for which the current account deficit was at or above that given value (i.e. the persistence of the deficit). Define $H_{it}(\gamma, h)$ as an indicator function that takes the value 1 if the following condition is satisfied: country i had experienced $-\gamma$ CA deficit for h years prior and including year t (i.e., $t-h, t-h+1m, \ldots, t$).

Define thus

$$\mu_1(\gamma, h) = \mathbb{E}\left[\Delta ln(c_{i,t+1}) \mid H_{it}(\gamma, h) = 1\right] - \mathbb{E}\left[\Delta ln(c_{i,t+1}) \mid H_{it}(\gamma, h) = 0\right], \qquad (1)$$

as the difference between the treatment and control groups in consumption growth $\Delta ln(c_{i,t+1})$, where c corresponds to total consumption in real terms. Here we use the notation $\mathbb{E}$ for the empirical expectation or average. Note that the expectation is taken with respect to all the countries without further conditioning. We are thus concerned with a significant drop in consumption that will be associated with this accumulated CA deficit. The above parameter can be considered a d-in-d estimator.

Note that this strategy is designed to capture the typical event for an "average" country. Thus, the threshold may not be accurate to describe the behavior of specific cases. In other words, a SS is also related to a myriad of country specific components. Our identification procedure consists in averaging out this specificity in each country, keeping instead the mean effect over those events that satisfy the required conditions in the treatment group.

The parameter $\mu_1(\gamma, h)$ is a time independent variable. We consider a grid of values with $h = 2, \ldots, 5$ and $\gamma \in \Gamma = \{1, 1.1, ..., 10\}$. That is, we will consider the CA deficits accumulated for up to 5 years, and we will consider CA levels each year with values in Γ. Our interest lies in finding the threshold γ for which this difference in relative consumption has a clear discontinuity for every h. The assumption is that this discontinuity is only due to the SS. Although strong, this hypothesis allow us to keep the set of variables involved in the empirical identification strategy simple, a fact that will be crucial for the structural procedure below.

Figure 2 plots the estimated effects for the d-in-d estimator for every pair of (γ, h). By looking at the figure, we can spot the corresponding CA deficits associated with the SS. For instance, if we take 5 years of persistence ($h = 5$, see the solid line), there is a jump in the figure at about 6% CA deficit. While we are specifically interested in consumption behavior during the crises, the SS affects the whole economy since the same pattern is observed for GDP and investment.

[INSERT FIGURE 2 HERE]

The first step in our identification strategy relies on finding a discontinuity in the average change in relative consumption at a value of γ for different fixed values of h. To avoid being deceived by mere visual inspection, we identified it by looking at the maximum numerical derivatives. More formally define,

$$\gamma^*(h, \epsilon) = \underset{\gamma \in \Gamma}{\operatorname{argmax}}\, \mu_1'(\gamma, h, \varepsilon), \tag{2}$$

where

$$\mu_1'(\gamma, h, \varepsilon) \equiv \frac{\mu_1(\gamma, h) - \mu_1(\gamma - \varepsilon, h)}{\varepsilon}. \tag{3}$$

We consider $\varepsilon \in \{0.1, 0.2, 0.3, 0.4, 0.5\}$. Tables 1-4 reports the three estimated maximum derivatives. The SS level of overborrowing should be search for within those values.

[INSERT TABLES 1-4 HERE]

Table 5 contains the weigthed average threshold given by

$$\sum_{\varepsilon,pos} \gamma^*(h,\varepsilon,pos)w(\varepsilon,pos), \tag{4}$$

where $\gamma^*(h,\varepsilon,pos)$ is the maximum empirical derivative, ordered by position or rank $pos = 1,2,3$,[1] for a given h and ε, and $w(\varepsilon,pos)$ weights according to the number of episodes. In particular, the weight $w(\varepsilon,pos)$ is constructed as the number of cases in the treatment group for a particular pair (ε,pos), that also satisfy the second step criteria below (fall in consumption, CA reversal) over the total number of events for a given persistence level.

[INSERT TABLE 5 HERE]

From the first step we can obtain the following stylized fact.

Stylized Fact 1: Decreasing threshold, stable overborrowing. The minimal CA deficit among the treated ($\gamma(h)$) is decreasing in the persistence level for h. The level of overborrowing is stable around 26-31% of the GDP.

We interpret this fact as evidence against the "deep pockets" assumption. Following Calvo (1999) or Cerruti et al. (2015), we argue that the assets under management of the lenders are critical to undertand an emerging market crises. In particular, note that a borrower can accumulate a well defined amount of debt at markets rates (i.e. between 26 and 31% of GDP, depending on the level of persistence). Our findings suggest that the *level of wealth* of the brokers trading this type of securities could be a determinant of the SS as the fraction of the total portfolio allocated to emerging economies could be constant all along the duration spell of the threshold. As Table 5 shows, these borrowing levels cannot be sustained for more than h years, thus we say that the listed countries has actually *overborrowed*.

3 .3 Second step: Characterizing the SS crises

For the overborrowing measure found in the first step, we evaluate countries according to conditions (i) and (iii) of the SS definition above. If a SS occurs, we expect that for those countries involved consumption drops and current account deficit reverses. Therefore, we further characterize SS by its empirical effects:

$$\mu_2(\gamma,h) = \mathbb{E}\left[\Delta ln(c_{i,t+1}) \mid H_{it}(\gamma,h)=1, \Delta ln(c_{i,t+1})<0, \Delta(CA_{i,t+1})>0\right], \tag{5}$$

and

$$\mu_3(\gamma,h) = \mathbb{E}\left[\Delta(CA_{i,t+1}) \mid H_{it}(\gamma,h)=1, \Delta ln(c_{i,t+1})<0, \Delta(CA_{i,t+1})>0\right]. \tag{6}$$

Figure 3 shows these results for every pair (γ,h). Our interest lies in characterizing countries that experience SS by finding $\mu_2(\gamma^*,h)$ and $\mu_3(\gamma^*,h)$ from the γ^* definition

[1] The order implies that $\mu_1'(\gamma^*(h,\varepsilon,1),h,\varepsilon) < \mu_1'(\gamma^*(h,\varepsilon,2),h,\varepsilon) < \mu_1'(\gamma^*(h,\varepsilon,3),h,\varepsilon)$.

above. The figure also reports the number of episodes (country, year) that satisfy the corresponding criterion. As expected, as the magnitude and persistence of CA deficit increases the number of episodes decreases.

[INSERT FIGURE 3 HERE]

Tables 1-4 report the average values of $\mu_2(\gamma, h)$ and $\mu_3(\gamma, h)$ for all the potential episodes in terms of the maximum empirical derivative. In general, most values coincide in terms of the magnitude of the fall in consumption and CA reversal. For consumption fall, most estimates coincide in a 4-5% drop. For CA reversal, the values are framed within 2.5-4.5%.

In order to further characterize the SS crises we consider the following. As noted before, events can be overlapped with each other for the same country. That is, it is possible to observe an event in the treatment group for $h = 2, 3, 4, 5$, provided that consumption falls and the CA deficit reduces. Thus, we keep the longest duration spell and compute the performance of those episodes.

Table 6 reports the characterization of typical SS events, together with the average values. Note that there are no events for $h = 3$ that are not also encountered with $h = 4$, thus we do not report the value for this persistence value. Section 4 qualitatively describes these episodes.

[INSERT TABLE 6 HERE]

The following stylized fact emerges.

Stylized Fact 2: Decreasing crises, persistent deficit. The reversal in the current account (i.e. $\Delta ln(CA_{i,t+1})(h) > 0$) is decreasing in the persistence of overborrowing h. However, none of the treated registered a surplus after the crises.

This behavior could have been caused by the presence of a *lender of last resource* as there seems to be a minimum level of credit (around 2% of the GDP) that is granted despite the SS. In addition, there could have been heterogeneity among lenders.

3 .4 Different empirical strategies

The empirical identification above relied on finding a clear discontinuity in terms of consumption drop, based on the level of accumulated CA deficits. The first step strategy for identification described above used a criterion of maximum empirical derivatives. As an alternative measure, we consider formal econometric tests based on the theory of structural breaks. Consider two regression models of $\mu_1(\gamma, h)$ on a constant, and a constant and γ. Thus the idea is to search for an structural break in either intercept or intercept and slope that occurs at a given value of γ, by considering the *sup* $Wald$ test of Hansen

(1997).[2] In turn this corresponds to the maximum discrimination between the treatment and control group that defines $\mu_1(\gamma, h)$.

Table 8 presents the results of this robustness exercise. We present the threshold corresponding the maximum Wald statistic value, and the two consecutive ordered values. Overall the results show a similar picture to that described in the empirical section. The findings suggest an overborrowing measure of about 26-31% (i.e. $\gamma \times h$) that corresponds to a consumption drop of about 5% and a CA adjustment of 3-4%.

[INSERT TABLE 8 HERE]

Finally, we also compute the empirical exercise above but using the difference in medians instead of means. The idea is that the results above could be driven by extreme values, thus when searching for a discontinuity this could be affected by outliers. The results in tables 9-12 are qualitatively very similar to those found for the difference in means.

[INSERT TABLES 9-12 HERE]

4 Characterizing selected SS episodes

In this section, we briefly describe the 8 episodes presented in Table 6. We can identify 2 major debt crises that affected all the countries involved: the first one occured in the late 70s-early 80s and the second one is due to the sub-prime crises. Thus, in this sense, *overborrowing* and *systemic sudden stops*, as in Calvo et al. (2008) are connected.

Israel 1975, $h = 2$

In close relationship to a huge and systematic US capital inflow, Israel started in the late 60s to experience many years of CA deficits. This deficit was particularly high in 1975, when it reached almost 12% of GDP. This path suffered a drastic change in 1976, when the current account had to adjust by almost 10 percentage points and consumption fell by 3 percent in the following two years.

Even though the Yom Kippur War were in part responsible for this crash, the main shock was due to the hike in oil prices back in 1973. After those years, inflation accelerated in the 1970s, rising steadily from 13% in 1971 to 111% in 1979. The economy experienced "stagflation" and the government was forced to postpone its full-employment policy until the 1980s. But inflation kept gathering pace and explode into an hyperinflation at mid-80s. From the sudden stop of 1975 up to 1985, nominal and real instability ruled the economy.

Panama 1981, $h = 4$

[2] Hansen (1997) tests is designed for a time-series model where the structural break occurs at a certain time. We are replacing time with γ.

Panama experienced since 1970 permanent CA deficits averaging 7.7 percent of GDP. In 1981 the external deficit soared to 10.2% and accumulated 25 oercentage points in just 3 years. One year later, consumption adjusted downwards by almost 4%. There were at least three reasons for this hard landing. First, the extreme vulnerability in external and fiscal accounts observed in Central America in general, and Mexico in particular (a key trade partner). Second, the oil crisis that triggered a brutal upwards adjustment in international interest rates. Third, the unexpected death of president Torrijos that unraveled a severe political crisis.

In 1981 the external sector suffered a drastic reversal, accumulating a contraction in the current account deficit of 13% of GDP in the two following years. Consumption growth returned in 1983 and 1984, but Panama could not fully recover from the crisis until the 90s.

Peru 1977, $h = 4$

The government of President Velasco inherited recessionary conditions in 1968, and soon started to boost aggregate demand. Thus, there was an increasing CA deficit reaching a peak of 12% of GDP by 1975. The following two years continued with this trend: 10% more in 1976 and another 8.5% in 1977. Due to a fixed exchange rate regime, in an increasingly inflationary context, the real exchange rate fell steadily up to 1975. By 1975, external creditors had lost confidence in Peru's ability to repay its debts and capital inflows slowed down.

Whether because of such external pressure or because of growing internal opposition to the increasingly arbitrary decisions of the government, the Peruvian military government decided to replace Velasco in 1975. The Government kept the deficit running, but in 1978 capital inflows stopped suddenly and the external sector had to adjust by 6% in that year, and by an additional 7.5% the following year. The corresponding adjustment in consumption was by -9% and -2% each year.

Costa Rica 1981, $h = 5$

The economic crisis in Costa Rica between 1980 and 1982 was triggered by a serious financial collapse that hit the Central American country during the administration of Rodrigo Carazo Odio. This event is considered one of the worst economic crises in the country's history. The Costa Rica economy, which at that time depended almost exclusively on coffee and banana exports, faced a sudden drop in international export prices. The conflict with Nicaragua, at that time involved in a civil war and during which the Costa Rican government supported the Sandinista rebels, caused further tensions between countries, in particular with the Somoza regime and United States.

The oil crises added problems to energy imports. Therefore, the Costa Rican fiscal deficit rose to 11% and forced the country to default loans granted by international organizations, an event that quickly cut off access to financing. During this period unemployment doubled from 4.4% in 1979 to 9.4% in 1982, and the crisis brought also shortages of basic products, hyperinflation and high popular discontent.

The Costa Rican external sector showed permanent CA deficits since the 60s (or more accurately, since data can be gathered). But the deficit increased quickly since 1978, accumulating more that 50% of GDP in just four years. In 1981, the crisis exploded and consumption started to fall. In that year, private expenditure fell by almost 13%, and another 6% in 1982.

Spain 2008, $h = 4$

During the subprime crisis in 2007 and the bankruptcy of Lehman Brothers a year later, the "Great Recession" began. Inside the Eurozone, the crisis hit harder on economies with real state bubbles and a large financial sector, as was the case of Spain. Although 2008 began with a low public sector debt (about 36% of GDP), this figure was the result of an artificially high tax revenues resulting from the housing bubble. Spain was a "peculiar" case in Europe because of the significant social costs associated with the collapse: total unemployment peaked almost 27% in the first quarter of 2013, and youth unemployment was reported to be 50%.

As the time of the crash, the economy as a whole was experiencing a huge CA deficit, around 10% of GDP. Moreover, in the previous 4 years Spain had been accumulating 35 percentage points of external deficits in terms of GDP. Without the possibility of adjusting the real exchange to restore competitiveness, Spain suffered not just a SS, but also a painful adjustment in the four years that followed. That is, Spain suffered in 2009 a contraction of real consumption of 1.7%, contrasting with an average growth of 4% since the creation of the Euro until 2007. The CA deficit experienced a sharp reduction of 5 percentage points of GDP in 2008, but the process continued until 2012, when the CA finally balanced and Spain restored growth at a slow rate.

Portugal 2008, $h = 5$

The case of Portugal is somewhat different from Spain. Although the crisis hit both economies hard, Portugal could not take advantage from the Euro arrangement in the years following 2000, as Spain clearly did. From 2001 to 2007 Portugal grew at a rate of barely 1.1% a year on average. Even that, the economy was not immune to the 2008 events that worsened the situation for the Portuguese economy. The failure to exploit the advantages of the Euro was due primarily to a competitiveness problem: when entering the Eurozone Portugal had already a 10% CA deficit, a fact that could not be corrected along the Euro-partnership decade. The adjustment finally started in 2008 and intensified severely since 2011.

In 2008 Portugal suffered its first shock, and the following year consumption growth in real terms was -1.2 percent of GDP. This was the first negative figure 1993, the year when the Exchange Rate Mechanism collapsed. After a slight rebound in 2009, consumption fell again for three consecutive years at a -3.3% pace. The CA began its adjustment in 2009 by almost 2 percentage points of GDP, but the process was much more severe since 2011, with the external gap closing in just two years, starting from a 10% deficit.

Greece 2008, $h = 5$

The case of Greece was dramatic, mainly because of what happened since 2009 on. During the golden years of the Euro, the country grew at an impressive rate of 4% on average, which allowed an average of 3.8 annual percent of consumption progress. However, between 2000 and 2009 Greece showed a CA deficit of 8.8% of GDP on average, with a 2008 peak of 14.5%. Although it was clear that there was a problem with the official fiscal figures, which were found to be false, the external gap was clear to everyone.

In 2009 the SS hit the country and Greece started a painful adjustment that keeps going on today. The Greek crisis was triggered by the sovereign debt crisis. Without the possibility of an exchange rate adjustment, European authorities and the IMF came to the rescue and urged strong austerity measures. Far from recovering confidence, this agenda produced a huge downturn. In 2009 the CA deficit had to adjust by almost 5 percentage points of GDP and the following year consumption experienced a contraction of almost 6% in real terms. The process did not stop there, and the country continued a recessive path until very recently. Just to illustrate the point, in 2016 GDP was 25% below the last peak, that was attained in 2007. Social and political disturbances followed. The seasonally adjusted unemployment rate grew from 7.5% in September 2008 to a then record high of 23.1% in May 2012, while the youth unemployment rate time rose from 22.0% to 54.9%.

Honduras 1981, $h = 5$

In late 1979, as insurgency spread in neighboring countries, and Honduran military leaders support the United States policies in the region, a fact that implied a decisive financial support. Honduran defense spending rose throughout the 1980s until it consumed 20 to 30% of the national budget and the country soon became the tenth largest recipient of United States assistance aid.

The increasing dependence of the Honduran economy on foreign aid was aggravated by a severe, region wide economic decline during the 1980s. As a consequence, private investment plummeted and capital flight soared. To make matters worse, coffee prices plunged on the international market and remained low throughout the decade. The CA went from an average deficit of 9.4% between 1974 and 1981 to -3.3% between 1986 and 1990. Contrarily to the remaining countries in the treatment group, consumption in Honduras did not experienced a drastic reduction. However, there was a severe drop in investment (12% in 1982) that affected GDP (-1.5%).

4 .1 Relationship with other events

We verify the presence of overborrowing in an extensive list of sudden stops as computed in Calvo et al. (2008). Taking into account that all events in the treatment group can be associated with two major international crises, we use the results in the systemic sudden stops literature to check the accuracy of our estimates.

Table 7 contains all the events classified as a SS by Calvo et al. (2008) which at the same time satisfy the definition of SS used in this paper. In order to make those results comparable with ours, we: (a) restrict attention to the countries listed in our database, (b) filtered the events with conditions (i), (ii) and (iii) of our empirical definition. Namely, we require a consumption drop and a current account reversal in the year of the SS (conditions (i) and (iii), respectively) and the presence of overborrowing with a different threshold (condition (ii)).

Calvo et al. (2008) reported 23 episodes with different thresholds. However, after imposing our conditions we can only keep 3 of them. The standard deviation of $\Delta(CA_{i,t+1})$ is 4.8. Thus, we confirm that our estimates are accurate as we can find an average threshold less than 0.7 standard deviation away from our results. In order to estimate the threshold in Calvo et al. (2008), we took the identified SS in that paper and computed the minimal yearly CA deficit for all possible persistence levels (i.e. $h = 2, 3, 4, 5$). We compare these thresholds $\gamma_i(h)$ with our values $\gamma(h)$ and kept the closest value in terms of the standard deviation of CA in the whole sample. For instance, in the case of Argentina 1998, we identify a threshold of 3% of the GDP and a persistence level of 5 years. The critical value is at 0.62 STDs away from our estimated threshold for that duration (i.e. 6.2%).

5 Structural estimation

This section describes a canonical and parsimonious model to test the presence of overborrowing. We use the workhorse in the literature, a recursive version of the model in Bianchi (2011). The theoretical structure in the paper concentrates only on the behavior of consumption and current account, a simplicity that makes it ideal to test the presence of overborrowing. Financial frictions in the model are introduced by assuming incomplete capital markets and the presence of a collateral constraint. A crisis occurs when the level of debt hits the collateral constraint.

We are aware of the existence of more complex and realistic models to represent the findings in this paper. For instance, using a recursive equilibria, Mendoza (2010) highlights the importance of investment. Along the same lines, Mendoza and Smith (2006) takes into account the interaction between two assets in order to match the order of magnitude of the recession generated by a SS. On a more theoretical branch, Schmitt-Grohé and Uribe (2017) and Pierri and Reffett (2018) exploit the multiplicity of the sequential equilibria to generate more "variability" in the time series behavior of the simulated paths. However, taking into account the numerical burden implied by the test, we must use the most parsimonious model. The endogenous variables depicted in Bianchi (2011) are sufficient to verify the presence of overborrowing as we only need to model the behavior of the current account and the possibility of a crises.

In order to test the results in the empirical section, we build a random variable: the number of periods without crises, that is, the time between hits to the collateral constraint. This variable will contain or will be equal to our structural measure of persistence (h). As we can't replicate the behavior of the control group in this class of models, we try to match the current account path for an arbitrary country in the treatment group. According to Table 6, we must replicate the behavior of economies with $h = 2, 4, 5$ as these are the persistence levels found after applying conditions (i) to (iii) of our definition of SS.

5 .1 The Model

We assume a small open endowment economy populated by an infinitely lived representative agent who consumes tradable and non-tradable goods, respectively c^T and c^N. The relative price of non-tradables is denoted by p. The agent can also borrow / save using an internationally traded asset b (if $b > 0$ we say that the agent holds net foreign assets), paying a constant interest rate, $r > 0$. This type of trade is restricted by a borrowing constraint. In particular, it is required that the ratio of debt to current income, measured in tradable units, must lie above $-\kappa < 0$ with $\kappa > 0$. The borrowing constraint is interpreted to be a collateral constraint and the pledgeable object is a fraction κ of income. Let $y^T + py^N$ be the total income in any given period, then the principal paid by the agent is given by $max\left\{b, -\kappa(y^T + py^N)\right\}$. We assume that y=(y^N, y^T) follows a finite state Markov process with transition matrix q constructed using an auxiliary regression for each country in Table 6. Finally, preferences are the standard in the literature: the intertemporal problem is characterized by a CRRA instantaneous return function with parameter $\sigma > 0$, while the intratemporal problem assumes CES preferences with parameters $\eta > -1, \omega \in (0, 1)$.

The agent solves the following maximization problem:

Problem 1

$$Max_{\left\{c_t^T, c_t^N, b_{t+1}\right\}} E_0 \sum \frac{C_t^{1-\sigma} - 1}{1-\sigma}$$

Subject to

$$C_t = \left[\omega \left(c_t^T\right)^{-\eta} + (1-\omega)\left(c_t^N\right)^{-\eta}\right]^{-1/\eta}$$

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

$$b_{t+1} \geqslant -\kappa(y_t^T + p_t y_t^N)$$

$$b_0 \in \mathbb{R}, y_0 \in \mathbb{R}^2_{++}$$

where the second equation is the flow budget constraint and the third is the collateral requirement. Now we are in a position to define a (sequential) competitive equilibrium. Recall that randomness in this economy comes from the markovian process that drives the endowments. This guarantees the existence of an infinite horizon process for $\{y^t\}$, $(\Omega, \mathcal{F}, \mu_{y_0})$, where Ω is the sample space which lies in the space of infinite bounded sequences, $\mathcal{F}$ is the associated sigma algebra with filtration $\mathcal{F}_t$ and μ_{y_0} is the associated probability measure for a given initial condition, y_0 (see Stokey, Lucas and Prescott, 1989, ch. 7).

Definition 1: Sequential Competitive Equilibrium (SCE)

A SCE for this economy is composed by 4 progressively $\mathcal{F}_t$-measurable functions $p, (c^T, c^N, b)$ such that:

- i) Given p,(c^T, c^N, b) solves Problem 1
- ii) For each $t, \omega_t \in \mathcal{F}_t$; $c^N(\omega_t) = y^N(\omega_t)$

Pierri and Reffett (2018) provide sufficient conditions to guarantee the compactness of the SCE, a necessary condition to approximate the model numerically. The authors show that it suffices to impose bounded marginal utilities and $\beta(1+r) < 1$. As the preference structure in problem 1 do not match these assumptions, we must impose the existence of an upper bound on debt, $-D > 0$, which is never binding. Under this assumption, we can assure that for each $t, \omega_t \in \mathcal{F}_t$, $\left[p, c^T, c^N, b\right](\omega_t) \in K$ with $K \subset \mathbb{R}^4$ compact.

Now we are allowed to characterize a (compact) SCE by means of a sequence of FOCs. We choose a primal version of the Karush-Kuhn-Tucker conditions because of their simplicity. We look for a system of equations that characterize definition 1. Thus, for each $t, \omega_t \in \mathcal{F}_t$, $[p(\omega_t), y(\omega_t), b(\omega_t)]$ must satisfy:

$$\left[[X_t(p_t, b_{t+1}) - \beta(1+r)E_t(X_{t+1}(b_{t+1}))]\left[b_{t+1} + \kappa(p_t y_t^N + y_t^T)\right]\right](\omega_t) = 0 \tag{7}$$

$$p_t = \left(\frac{1-\omega}{\omega}\right)\left[\frac{(1+r)b_t + y_t^T - max\left\{b_{t+1}, -\kappa(y_t^T + p_t y_t^N)\right\}}{y_t^N}\right]^{(1+\eta)} \tag{8}$$

Eq. (7) characterizes the inter-temporal behavior and it is composed by 2 brackets, the Euler equation and the collateral constraint, both greater or equal than zero. Eq. (8) controls the inter-temporal behavior. The preference structure implies that $X_t(\omega_t)$ for each $t, \omega_t \in \mathcal{F}_t$ must satisfy:

$$X_t(\omega_t) = \left[\left[\omega\left(c_t^T\right)^{-\eta} + (1-\omega)\left(y_t^N\right)^{-\eta}\right]^{\frac{-1+\sigma-\eta}{\eta}}\left(c_t^T\right)^{-\eta-1}\right](\omega_t) \tag{9}$$

$$c_t^T(\omega_t) = \left[(1+r)b_t + y_t^T - max\left\{b_{t+1}, -\kappa(y_t^T + p_t y_t^N)\right\}\right](\omega_t) \tag{10}$$

Eq. (7) gives rise to 2 different regimes: one characterized by constrained level of debt, which is related to the occurrence of a balance of payment crises, and one that is unconstrained. As we are interested in the pre-phase of the crises, we must focus on the former. Thus, in order to match the facts found in the empirical section, we must concentrate on the non-binding version of the system of equations above. In this sense, it is convenient to characterize the SCE using the primal version of optimality because of at least two reasons: i) the Lagrange multiplier associated with the collateral constraint will not be needed, 2) the system formed by equations (7) to (10) can be de-composed in two parts, where the first (eqs. (7),(9),(10)) determines the level of assets. Thus, the equations above can be written in a "block recursive" style where the first part determines b_{t+1} and the second p_t. As our definition of overborrowing only concerns the behavior of consumption and CA, we focus on the first part.

Let Θ be the set of structural parameters in the system of equations above. Our empirical identification strategy involves three conditions. The first one, i), takes into account the relative behavior of the treated. As the model described above is related with an emerging economy for each set of structural parameters $\theta \in \Theta$, we can only test the presence of those conditions that affect a treated country. Thus, it is not only possible to test a *necessary condition* for the occurrence of a SS but a *sufficient condition* for overborrowing. In particular, we choose to test condition (ii). Formally, we look for $\theta_i \in \Theta$ which satisfies:

$$CA_{i,s}(\theta_i) \equiv \frac{b_{s+1} - b_s}{p_s y_t^N + y_t^T} \geqslant -\gamma, \quad s = 1, ..., h, \tag{11}$$

where we have omitted the subscripts in the RHS of equation (11) for exposition purposes. Note that the above equation concerns with the realization of several random variables in the model. However, as suggested by the definition of SCE, these functions are generated by the underlying stochastic process $(\Omega, \mathcal{F}, \mu_{y_0})$ which in turn imply that we must look for a sequence of shocks $\{y_s\}_1^h$ capable of matching equation (11). As we have to focus on the un-constrained regime, using the system of equations formed by (7),(9),(10), we can figure out the type shocks y that may generate (11). More to the point, the "block recursive" nature of the unconstrained sequential equilibria allows us to match separately the numerator and the denominator of equation (11). Formally, if the collateral constraint does not bind, we have:

$$X_t(y_t^T, b_{t+1}) = \beta(1+r)E_t(X_{t+1}(b_{t+1})) \tag{12}$$

$$p_t = \left(\frac{1-\omega}{\omega}\right)\left[\frac{(1+r)b_t + y_t^T - b_{t+1}}{y_t^N}\right]^{(1+\eta)} \tag{13}$$

Note that eqs. (7),(9),(10) imply that the Euler equation, (12), is independent of y_t^N and p_t. Thus, we have highlighted the dependence on y_t^T and b_{t+1} in equation (12). This equation will allow us to match the numerator of (11). In particular, the convexity of preferences implies that any *decreasing* sequence $\left\{y_s^T\right\}_1^h$ will generate a *decreasing* sequence $\{b_{s+1} - b_s\}_1^h$. That is, a recession caused by tradable output implies a decline in net external assets, which in the model is associated unequivocally with a downturn in the CA as we are not considering valuation effects. Taking into account the extensive numerical burden of the structural test, we must discretize the state space of Y. Thus, the number of possible elements in $\{\Delta y_s\}_1^{h-1}$ is limited by the cardinality of Y. Fortunately, the bounded nature of the SCE can be used to solve this problem. Suppose that the optimal choice in time $s-1$ is $\hat{b}_s$ and that $y_s^T = y_{LB}^T$, where y_{LB}^T is the lower bound in Y^T with $Y = Y^T \times Y^N$. Thus, we have:

$$X_s(y_{LB}^T, \hat{b}_s) > \beta(1+r)E_t(X_{s+1}(\hat{b}_s))$$

The above equation implies $\hat{b}_{s+1} < \hat{b}_s$. Thus, we look for a *weakly decreasing sequence* $\left\{y_s^T\right\}_1^h$ to replicate an adequate behavior in the numerator of (11). Of course, we will have $\hat{b}_{s+1} < \hat{b}_s$ until we hit the collateral constraint in period, say, τ.

As regards the denominator, note that: i) typically, (y^T, y^N) will be positively correlated (this will be shown in the next subsection), ii) p is *increasing* in c^T. Thus, *even for the same value of* $b_{s+1} - b_s < 0$, the ratio will be *decreasing* as GDP measured in tradables will go down if $y_{s+1}^T \leqslant y_s^T$.

Finally, we now turn to the relevance of *hitting times* in the identification process. It is usual in the literature (see Bianchi, 2011, p.3411) to say that a "crises has occurred" if the collateral constraint binds (i.e. $b_{t+1} \leqslant -\kappa(y_t^T + p_t y_t^N)$). However, the literature is silent with respect to the pre-phase of a SS. By looking at the definition of the SCE, it is easy to see that we can define an event as the number of time periods τ between crises (i.e. the $t, \omega_t \in \mathcal{F}_t$ which generate $b_{t+1}(\omega_t) \geqslant -\kappa(y_t^T + p_t y_t^N)(\omega_t)$ with $t = 1, ..., \tau$). This sequence of shocks may generate different accumulated deficits depending on τ. We are interested in finding a CA deficit above the threshold γ for each possible persistence level h with $h \leqslant \tau$. Note that it is possible that we observe a level of borrowing above the threshold but a SS (i.e. the collateral constraint is not binding in the period which follows the last overborrowing period). We will say that there is a *crisis* for a time spell of τ and persistence level h if we observe a CA deficit which is above $\gamma(h)$ in the last h periods of a τ spell.

5 .2 Structural Estimation Procedure

In this subsection we describe the procedure that will be used to verify the presence of overborrowing for some empirically meaningful set of parameters $\theta \in \Theta$. Taking into account the infinite dimensional nature of the problem, we must first take care of a numerical procedure. The first choice, following the structural literature (see Bianchi, 2011; Mendoza and Smith, 2006), is to compute the model using recursive minimal state space representation. As we are dealing with a decentralized equilibria with incomplete markets, we do not have the welfare theorems. Thus, we must take care of the evolution of prices, in particular the real exchange rate, p.

As we have insured the compactness of the SCE, we can choose a set K which contains all possible values for the endogenous variables in the model. In particular, for each $t, \omega_t \in \mathcal{F}_t$, $\left[p, c^T, c^N, b\right](\omega_t) \in K \equiv P \times K_1 \times K_2 \times B$. Let p_t^0 be an initial guess for the price function with $p : B \times Y \to P$. Note that given p_t^0, the system of equations (7)-(10) can be solved for any possible values of $(b_t, y_t) \in B \times Y$, giving rise to a function $b_{t+1}^0(b_t, y_t; p_t^0)$, taking values in B. We call this object *Policy Function*. Moreover, after obtaining b_{t+1}^0, we can update p using equation (8). Thus, we can define the following procedure:

Computable Recursive Equilibrium

- i) Set B, Y, $\delta > 0$ and p_t^0.
- ii) Compute b_{t+1}^0 using equations (7)-(10).
- iii) Update p_t^0 using equation (8)
- iv) continue until $SUP \left\| b_{t+1}^{n+1} - b_{t+1}^n \right\| < \delta$

Where step iv) implies the existence of number $N(\delta)$ such that $n \geqslant N(\delta)$ implies:

$$SUP_{(b_t, y_t) \in B \times Y} \left\| b_{t+1}^{n+1}(b_t, y_t; p_t^{n+1}) - b_{t+1}^n(b_t, y_t; p_t^n) \right\| < \delta \tag{14}$$

After achieving convergence in the above procedure, equipped with a policy and a price function, we can try to verify condition (11). In order to test it, we need to refine the definition of SS so it is possible to identify the requirements concerning each specific country. Those are the structurally testable conditions as we can only model the behavior within the treatment group.

Let CA_t be the current account at time t, as a percentage of GDP, Y_t. We guess that the SS is associated with the magnitude of CA_t and its persistence. In order to verify this hypothesis, we split condition (i) in our definition in two: the first one will test the relative behavior of the treated and the second one will keep track of the time series performance of the affected countries. Thus, we have evaluated $E(\Delta ln(C_{t+1}))$, which is the average variation in logs of the relative consumption C, in the empirical section. This variable determines the threshold together with the treatment group. We take the expectations for a given combination of (γ, h), where γ represents the current account threshold, i.e. $CA_t < -\gamma$ and h is the number of periods for which the current account deficit was at or above that given value (i.e. the persistence of the deficit). Note, further, that the expectation is taken with respect to all the countries in the treatment group (i) and in the control (j) group. Finally, C_t is the ratio between the consumption in the treatment and in the control group.

That is, we look for events at time t which satisfies:

Empirical Identification Strategy: Conditions

- (i.1) $E(\Delta ln(C_{t+1})) < 0$
- (i.2) $\Delta ln(c_{i,t+1}) < 0$ for all i in the treatment group
- (ii) $CA_{i,t} < -\gamma, CA_{i,t-1} < -\gamma, ..., CA_{i,t-h+1} < -\gamma$ for all i in the treatment group
- (iii) $\Delta(CA_{i,t+1}) > 0$ for all i in the treatment group

Table 6 contains the empirical results. For each of the countries i in this table we will look for the set of parameters $\theta_i \in \Theta$ such that condition (ii) in the empirical identification strategy (i.e. $CA_{i,t-s} < -\gamma(h)$ for $s = 1, ..., h$) is satisfied. We proceed in several steps for each persistence level h:

Structural Estimation Procedure

- i) Find the values $\theta_i \in \Theta$ that has the maximum level of accumulated borrowing in any pre-phase of length h for several simulations of length T.
- ii) For these values of θ_i, or any vector of parameters nearby, find if there is a longer pre-phase spell τ which contains the desired level of accumulated borrowing in the last h years
- iii) For these values of θ_i, or any vector of parameters nearby, find if there is a sequence of shocks which contains the desired level of accumulated borrowing in h years.

As described in the previous subsection, in step iii), we are looking for a decreasing sequence of shocks and possibly an stagnation phase. However, Claessens and Ghosh (2016) found that in emerging economies recessions last 4 or eventually 8 quarters. These facts imply that we have to restrict the sequence of decreasing shocks to a maximum of 3 as we are calibrating the model with yearly data. More to the point, the some authors do not find a persistent stagnation process. Thus, we have to restrict simulations to $\{\Delta y_s < 0\}_{t+1}^{t+2}$ and $y_{LB} = y_{t+3}$, where s is any time period within a pre-phase of a SS of length $\tau \geqslant h$.

5 .3 Results

In this section we present the results of the estimation procedure. We take 3 cases based on our empirical procedure, from Table 6, and 1 from the systemic SS literature adjusted to our framework, presented in Table 7.

Note that the results in table 7 can be used to verify the accuracy of the numerical procedure. As we are modeling the SS in Argentina 1998, based on the results in Calvo et al. (2008), we can use this event to test the performance of the model in Bianchi (2011), who calibrates the model to Argentinean data. In particular, after checking if our simulations can replicate the results in Bianchi (2011) using the parameter structure in this paper, we can try to match the SS that hit Argentina in 1998 using the parameter set in that paper.

In order to select the countries in Table 6, we choose to keep 1 country for each persistence level h. Moreover, among those countries, we select the events that has a stationary bivariate $AR(1)$ process for (y^T, y^N) according to the results in the Appendix. Some countries, even after detrending the series, has an auto-regressive coefficient above 1, a fact that does not allow us to discretize the process using the Tauchen (1986) procedure. Even if we can discretize a non-stationary process, using the results in Fella et al. (2019) for instance, the required compactness of the SCE will make simulations unsuitable.

Argentina 98, $h = 5$

The table below shows the parameters used in Bianchi (2011), the standard deviation (STD) of the ratio current account to GDP obtained using the simulations in the original article and using our results. Moreover, we present the STD computed from data in Bianchi (2011) and using our database.

Model STD	Model STD Bianchi (2011)	Data STD	Data STD Bianchi (2011)
2.5	2.8	2.7	3.6
β	κ	η	ω
0.91	0.32	0.21	0.31

Argentina 98: Accuracy of simulations

Our results not only replicates Bianchi's procedure, but also our data generates a closer match.

We now proceed to test the presence of overborrowing in the SS that affected Argentina in 1998 as reported in the empirical section. We present the level of accumulated borrowing achieved by the simulations (B_i), the empirical threshold for this event (γ_i), the persistence level associated with this threshold (h), the empirical minimal borrowing to be matched ($\gamma_i \times h$) and the distance with respect to our findings using the d-in-d approach ($(\gamma - \gamma_i)/\sigma$). Finally, we declare if the simulations generated the reported level of borrowing B_i followed by a crises, where as it is usual we are looking for a binding collateral constraint in the period which follows the last overborrowing year.

The first step of our structural procedure is not necessary as we are borrowing the parameters from the original article. The threshold γ and the persistence h were presented in Table 7, except for the last row, which contains the largest accumulated borrowing (12.2) and the associated threshold (0.8) that could be obtained using a "tailor made" simulated path according to step iii) in our structural procedure. In particular, we simulated a severe recession that lasted 2 years, a stagnation period and later on we took a path from the $AR(1)$ process calibrated to Argentinean data using the autoregressive coefficients and errors reported in the appendix. We found an overborrowing spell of 4 years which was followed by a crises (i.e. the collateral constraint was binding in the fifth period). Moreover, we are reporting the empirical threshold (-2.0) according to our data base and the associated borrowing (8.0) to be matched. Finally, we present the scaled deviation from the d-in-d approach for this particular event.

B_i	γ_i	h	$\gamma_i \times h$	$(\gamma - \gamma_i)/\sigma$	Step	Crises?
6.7	3.0	5	15.0	0.7	1	YES
14.4	3.0	5	15.0	0.7	2	NO
12.3	3.0	5	15.0	0.7	3	NO
12.2	0.8 / 2.0	4	8.0	1.2	3	YES

Argentina 98: Estimation results

The results of the table indicate that: i) the model cannot generate an empirically meaningful current account deficit, ii) transitions to a crisis are in some cases "too fast" and in others "too slow". In particular, the first fact can be verified by looking at the maximal level of borrowing for a pre-phase of 5 years followed by a crisis (6.7% of the GDP, in the second row of the table). The empirical evidence suggests that this value must have been more than twice the reported figure (15%), even if we allow for some statistical error (i.e. 0.7%). The second fact can verified by looking at the remaining rows: when we are close to replicate the level of borrowing and the persistence level (third and forth rows), we cannot generate any crisis. That is, convergence to the collateral constraint is "too slow". In the last row, we observe the opposite situation: the simulated threshold (0.8) is below the empirical one (2.0) which is not only quite distant to our findings (1.2 STD away from it) but also has lower persistence ($h = 4$ vs. $h = 5$).

In order to solve these problem we: i) increase the value of the subjective discount factor β, ii) the fraction of pledgeable GDP κ will be calibrated. A higher β implies a steeper policy function for debt and thus bigger current account deficits in a recessionary path. Moreover, a "flexible" κ will allow us balance the trade-off between the frequency of the crises and the level of borrowing in the pre-phase of the SS. Thus, in the following 3 cases, those obtained using the d-in-d approach, we set $\beta = 0.965$ and let κ to be free.

Israel 75, $h = 2$

The table below presents the results for Israel 75. We show the selected parameters as well as the simulation results. In step i) we are reporting the average parameters for 5 ordered maximal values in terms of borrowing (i.e. B_i). We simulated a time series of 21.000 periods and kept only a spell of 2 periods without crises.

We used the parameters in step i) as a starting point for the next strategy. In step ii) we are allowing the pre-phase τ to be equal to 50 (years) in a time series of length 100.000. As we are discarding the first 1000 simulations (the length of the simulated path is actually 101000), we are assuming as it is usual that the path has reached a stable equilibrium (i.e. ergodic). Pierri and Reffet (2018) provides conditions for these paths to be actually ergodic.

Assuming ergodicity, we can interpret the simulated path as containing 2000 replicas of a spell of 50 periods without crises. *We found 2 sudden stops preceded by a similar level of overborrowing (16.1%). Both spells have a yearly deficit over the required level implied by the presence of a persistent threshold, 7.7% per year.* Thus, the probability of observing this event is 0.1% (i.e. 2 over 2000 cases). In this sense, the value of κ, among others, balanced the trade-off between overborrowing and the occurence of crises efficiently. Bianchi (2011) found a lower value for this parameter simply because the author wanted to match a more recurrent type of crises. In fact, the targeted frequency of a crises in that paper was 5.5%.

These findings are not surprising as the type of event we are trying to match is constructed using the intersection of several definitions of sudden stops. As we are looking to match a considerable number of events using a parsimonious and tractable model, the scope of the definition must be reduced. However, *the estimated model allows us to replicate more closely the observed ratio of external debt to GDP in Israel during that time.* According to our estimates, this ratio, after netting out only international reserves, reached almost 200% of the GDP. Our estimate for κ, suggest that the level of net external debt actually oscillated around 70%; which seems more reasonable than the original 30% proposed by Bianchi (2011).

Step	κ	η	ω	σ	B_i	γ	h	$\gamma \times h$
1	1.00	0.97	0.31	1.89	9.3	7.7	2	15.4
2	0.71	1.34	0.37	1.89	**16.1**	7.7	2	**15.4**

Isreael 1975: Estimation results

Note how the parameters change from step i) to step ii): basically, we only need a reduction in the elasticity of substitution (i.e. a hike in η), with respect to step i), generating a current account that is more responsive to price and income fluctuations. This parameter value coupled with a higher β, with respect to Bianchi (2011), allows us to capture the required level of borrowing. Moreover, κ is well above the estimated value in Bianchi (2011) (i.e. 0.32) as step ii) required 50 years without a crises in order to accumulate a sufficiently high current account deficit (i.e. above 7.7% of the GDP).

Peru 77, $h = 4$

The table below describes the results for Peru 1977. We found not only that the model can replicate the dynamics of the pre-phase of the SS but also that the probability of observing this type of crises is lower when compared to the case of Israel 75: we simulate 5000 spells of 20 periods each and we only found 1 match. That is, for a persistence of 4 years, the probability is reduced to 0.02% (from 0.1% for a persistence of 2 years). This result is of course due to the restrictiveness of the conditions imposed to replicate the presence of overborrowing in Peru and is captured by a bigger value of κ (i.e. 0.96 for Peru and 0.71 for Israel).

Step	κ	η	ω	σ	B_i	γ	h	$\gamma \times h$
1	0.96	0.32	0.21	2.00	9.7	6.7	4	26.8
2	0.96	0.32	0.21	2.00	**36.7**	6.7	4	**26.8**

Peru 1977: Estimation results

Honduras 81, $h = 5$

The results for Honduras highlight the limitations of the canonical model to capture the presence of overborrowing. In particular, even if we allow for a bigger pledgeable fraction of GDP, in order to generate a larger current account spell in the pre-phase, we could not match the stylized facts. By looking at the table below it is easy to see that: i) borrowing is insufficient, ii) the threshold found in the simulated current account spell is well below its empirical counterpart for countries with a similar persistence level (for $h = 5$, γ_i is on average of 0.68 STDs away from our estimated results as can be seen in Table 7).

Step	κ	η	ω	σ	B_i	γ	h	$\gamma \times h$	$(\gamma - \gamma_i)/\sigma$	Crises?
1	0.92	0.69	0.26	2.00	7.1	6.2	5	31.0	NA	YES
2	1.00	0.69	0.26	2.00	26.4	6.2	5	31.0	**1.26**	YES
3	1.00	0.69	0.26	2.00	11.4	6.2	5	31.0	**1.05**	NO

Honduras 81: Estimation results

In step 2 we have used a 30 years spell and the selected path in step 3 is a 2 years recession followed by stagnation.

5 .4 Take away points

In section 5.1 it was claimed that the pre-phase of a SS has to be generated by a canonical savings model. In this model, the system of equations has a "block recursive structure" due to the effect of the market clearing condition for non-tradables (see the definition of the SCE). In particular, the CA deficit, measured in tradables, has to be generated by *tradable* income shocks (see equation (12)) while the effect of consumption on prices (see equation (13)) feedback *only* on the CA to GDP ratio. Thus, *the persistence of tradable income is critical in order to generate the overborrowing spell*. More to the point, as during the pre-phase the collateral constraint is not binding, consumption is smoother than income which implies that the only way to generate 5 years of excessive borrowing is due to a strong and persistent recession.

In this model the only source of uncertainty are income shocks, which are assumed to follow a bi-variate autoregressive process. The appendix contains the estimated VAR(1). As it is usual, persistence of income is reflected in the matrix of coefficients. As we are modeling jointly the tradable and non-tradable sectors, it is a 2×2 matrix. Note that we have a positive match for Isreal, with a persistence of 2 years and Peru, with 4. However, we fail to replicate a similar type of event in Honduras. The difference between these countries is in the matrix of auto-regressive coefficients. While the norm for this matrix in Israel is 0.77, for Peru is 1.03 but for Honduras is 0.59. Thus, the persistence level of income is Israel is sufficient to match a spell of 2 years. The positive result in Peru is explained by the hike in persistence of income. However, the lack of inertia, especially in tradable income, in Honduras could not be compensated by any change in the parameter structure. This fact seems reasonable as only κ is related to the duration of the spell as it affects the frequency of crises. However, if κ is "too" high, we may have substantial accumulated borrowing not followed by a crises as can be seen in Honduras.

We believe that it is matter of future research to provide a solution to the excessive dependence of the model on income shocks.

6 Conclusions

Persistent current account deficits are a recurrent phenomenon in a large fraction of low and middle income economies. Since these dynamics are usually followed by balance of payments crises, we answer the questions of when does a country have effectively overborrowed and if there is a cut-off value for an accumulated deficit just before the crisis sets off. These issues are key, as they may help to design macro-prudential policies by applying a rule that are easy to follow and to communicate.

Our paper is a contribution to the characterization of sudden stops. First, our empirical analysis shows that there is a robust overborrowing measure indicating that sudden stops can be associated with persistent current account deficits that accumulate about

26%-31% of GDP in a time span of 3 to 5 years. Second, the typical sudden stop event produces a drop in real consumption of about 4% of GDP and a current account reversal of 2.5%-4.5% of GDP. This finding is robust to different estimates of the threshold. Our results provide a potential measure of external fragility that we dubbed as the empirical dimension of *overborrowing*.

In order to check the conceptual features of overborrowing, we test these empirical findings in a standard structural model due to Bianchi (2011). The model results allow us to compute the maximal value of net external indebtness that a country can reach before being hit by a balance of payments crisis. According to our calculations, this parameter is two or three times bigger than the benchmark value normally employed in the literature. Taking into account the restrictive nature of our definition, a sudden stop preceded by overborrowing is a rare event, which implies a somewhat "loose" borrowing limit. This last fact implies a better match of the model taking into account the observed level of net external indebtedness.

Our results may give useful advice to policy makers. Many "stress" indicators displaying debt and financial conditions has been developed in order to anticipate a potential hit of a threshold that would trigger a sudden stop. However, all these indicators are usually empirically weak and/or rarely based on formal theoretical ground. We made an effort to obtain a much better justified measure, which also happens to be simple and easy to understand. Our findings can help elaborate better leading indicators to anticipate a sudden stop and eventually avoiding the awful consequences of a crisis. In practice, after significant external debt issuance, local authorities may consider taking measures to tackle persistent current account deficits that are near to the estimated threshold. Specifically, early policies intended to adjust the current account before the threshold has been reached can help prevent a much more drastic and painful adjustment later. Sudden stops, it must be recalled, do not just bring a deep drop of real consumption, but also make future borrowing less likely. Fast accumulation of current account deficits or debt issuance severely increase the likelihood of a sudden stop, and so authorities must be aware of reaching the 26%-31% of GDP threshold in the time span of 3 to 5 years.

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Tables

Table 1: Maximum numerical derivatives 2 years accumulated of CA deficit (means)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	0.039	8.2	2	-0.0549	4.2	12
	2	-0.038	6.6	2	-0.0505	4.2	20
	3	-0.024	7.1	2	-0.0508	3.7	15
0.2	1	-0.03	9.8	2	-0.0505	3.3	7
	2	-0.025	10	2	-0.0525	2.8	5
	3	-0.017	6.6	2	-0.0505	4.2	20
0.3	1	-0.04	9.8	2	-0.0505	3.3	7
	2	-0.033	10	2	-0.0525	2.8	5
	3	-0.018	6	2	-0.0522	4.3	24
0.4	1	-0.052	10	2	-0.0525	2.8	5
	2	-0.044	9.8	2	-0.0505	3.3	7
	3	-0.029	8.4	2	-0.055	4.2	12
0.5	1	-0.087	10	2	-0.0525	2.8	5
	2	-0.05	9.8	2	-0.0505	3.3	7
	3	-0.043	6.8	2	-0.0505	4.2	20

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

Table 2: Maximum numerical derivatives 3 years accumulated of CA deficit (means)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	-0.080	9.2	3	-0.0505	3.3	7
	2	-0.063	9.4	3	-0.0505	3.3	7
	3	-0.042	6.6	3	-0.0476	3.8	12
0.2	1	-0.032	9.4	3	-0.0505	3.3	7
	2	-0.025	9.2	3	-0.0505	3.3	7
	3	-0.018	8.2	3	-0.0515	3.8	9
0.3	1	-0.048	9.4	3	-0.0505	3.3	7
	2	-0.025	8.4	3	-0.0515	3.8	9
	3	-0.021	9.6	3	-0.0505	3.3	7
0.4	1	-0.068	9.4	3	-0.0505	3.3	7
	2	-0.048	9.6	3	-0.0505	3.3	7
	3	-0.038	8.4	3	-0.0515	3.8	9
0.5	1	-0.092	9.6	3	-0.0505	3.3	7
	2	-0.084	9.4	3	-0.0505	3.3	7
	3	-0.053	8.4	3	-0.0515	3.8	9

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

Table 3: Maximum numerical derivatives 4 years accumulated of CA deficit (means)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	-0.0532	9.1	4	-0.0575	3.3	6
	2	-0.0372	8.2	4	-0.0575	3.3	6
	3	-0.0357	5.7	4	-0.0447	3.8	13
0.2	1	-0.0322	5.7	4	-0.0447	3.8	13
	2	-0.0310	7.1	4	-0.0428	3.2	9
	3	-0.0277	7.5	4	-0.0472	3.2	8
0.3	1	-0.0334	5.7	4	-0.0447	3.8	13
	2	-0.0331	7.5	4	-0.0472	3.2	8
	3	-0.0310	7.1	4	-0.0428	3.2	9
0.4	1	-0.0424	5.9	4	-0.0475	3.8	12
	2	-0.0367	7.7	4	-0.0515	2.9	7
	3	-0.0360	5.7	4	-0.0447	3.8	13
0.5	1	-0.0740	5.9	4	-0.0475	3.8	12
	2	-0.0650	7.7	4	-0.0515	2.9	7
	3	-0.0567	7.9	4	-0.0515	2.9	7

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

Table 4: Maximum numerical derivatives 5 years accumulated of CA deficit (means)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	-0.0497	7.1	5	-0.0515	2.9	7
	2	-0.0477	5.9	5	-0.0514	3.1	8
	3	-0.0395	5.7	5	-0.0469	3.2	9
0.2	1	-0.0248	7.1	5	-0.0515	2.9	7
	2	-0.0248	5.7	5	-0.0469	3.2	9
	3	-0.0238	5.9	5	-0.0514	3.1	8
0.3	1	-0.0291	5.9	5	-0.0514	3.1	8
	2	-0.0236	7.5	5	-0.0476	2.9	5
	3	-0.0221	5.7	5	-0.0469	3.2	9
0.4	1	-0.0441	5.9	5	-0.0514	3.1	8
	2	-0.0390	6.1	5	-0.0515	2.9	7
	3	-0.0221	5.7	5	-0.0469	3.2	9
0.5	1	-0.0677	6.1	5	-0.0515	2.9	7
	2	-0.0664	5.9	5	-0.0514	3.1	8
	3	-0.0327	7.3	5	-0.0515	2.9	7

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

Table 5: First step estimation results: overborrowing

Threshold (γ)	Persistence (h)	Borrowing ($\gamma \times h$)	Average Episodes
7.7	2	15.5	15
8.8	3	26.4	8
6.7	4	26.6	10
6.2	5	30.8	8

Table 6: Second Step: SS characterization

γ	h	$\mu_2, \Delta ln(c_{t+1})$	$\mu_3, \Delta CA_{t+1}$	$\Delta ln(GDP_{t+1})$	$\Delta ln(I_{t+1})$	(i,t)
9.6	2	-1.0	7.4	0.3	-10.5	Israel 75'
6.7	4	-3.9	6.9	5.3/-4.5*	-27.8	Panama 81'
6.7	4	-8.9	6.0	-2.6	-8.9	Peru 77'
6.7	4	-1.7	5.1	-3.6	-16.9	Spain 08'
6.2	5	-5.9	5.4	-7.3	-27.8	Costa Rica 81'
6.2	5	-0.8	3.6	-4.3	-13.9	Greece 08'
6.2	5	1.1/-1.5*	2.9	-1.4	-12.1	Honduras 81'
6.2	5	-1.2	1.7	-3.0	-7.6	Portugal 08'
9.6	2	-1.0	7.4	0.3	-10.5	Average
6.7	4	-4.8	6.0	-3.6	-17.9	Average
6.2	5	-2.4	3.4	-4.0	-15.4	Average

Notes: Growth rate for period t instead of $t+1$.

Table 7: Accuracy of the estimated thresholds

$(\gamma - \gamma_i)/\sigma$	h	$\mu_2, \Delta ln(c_{i,t+1})$	$\mu_3, \Delta(CA_{i,t+1})$	(i,t)
0.62	5	-1.3	0.6	Argentina 98'
1.2	5	-11.4	14.5	Ecuador 98'
0.2	5	-0.7	3.2	Peru 98'
0.68	5	-4.5	6.1	Average

Table 8: Sup Wald Tests

Rank	Wald	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
			Intercept			
1	386.5824	7.1	2	-5.08	3.70	15
2	376.7787	7.2	2	-5.08	3.70	15
3	363.9187	7.3	2	-5.08	3.70	15
			Intercept & Slope			
1	202.8212	6.6	2	-5.05	4.25	20
2	199.306	6.5	2	-5.24	4.20	21
3	196.5287	6.4	2	-5.24	4.20	21
			Intercept			
1	352.1523	7.9	3	-4.79	3.51	10
2	347.0499	8	3	-5.15	3.81	9
3	338.461	8.1	3	-5.15	3.81	9
			Intercept & Slope			
1	908.2407	7	3	-4.72	3.81	11
2	905.6498	7.1	3	-4.79	3.51	10
3	901.1994	6.9	3	-4.72	3.81	11
			Intercept			
1	320.2766	6.1	4	-4.72	3.81	11
2	317.0707	6	4	-4.75	3.84	12
3	315.9967	6.2	4	-4.729	3.81	11
			Intercept & Slope			
1	295.8734	5.7	4	-4.47	3.85	13
2	291.4265	5.9	4	-4.75	3.85	12
3	290.9093	5	4	-4.49	3.00	18
			Intercept			
1	415.979	5.7	5	-4.69	3.18	9
2	394.3888	5.8	5	-4.69	3.18	9
3	381.1993	5.9	5	-5.14	3.09	8
			Intercept & Slope			
1	129.5686	5.7	5	-4.69	3.18	9
2	125.0401	4	5	-3.26	3.77	19
3	124.734	4.5	5	-3.26	3.67	18

Notes: Growth rate for period t instead of $t+1$.

Table 9: Maximum numerical derivatives 2 years accumulated of CA deficit (medians)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	-0,0486	6.6	2	-0,0505	4,2	20
	2	-0,0231	8.1	2	-0,0549	4,2	12
	3	-0,0220	6.2	2	-0,0524	4,2	21
0.2	1	-0,0250	10	2	-0,0525	2,8	5
	2	-0,0228	6.6	2	-0,0505	4,2	20
	3	-0,0173	5.6	2	-0,0539	4,2	27
0.3	1	-0,0334	10	2	-0,0525	2,8	5
	2	-0,0206	6.6	2	-0,0505	4,2	20
	3	-0,0164	5.6	2	-0,0539	4,2	27
0.4	1	-0,0421	10	2	-0,0525	2,8	5
	2	-0,0357	6.8	2	-0,0505	4,2	20
	3	-0,0243	6.6	2	-0,0505	4,2	20
0.5	1	-0,0598	6.8	2	-0,0505	4,2	20
	2	-0,0546	10	2	-0,0525	2,8	5
	3	-0,0348	6.6	2	-0,0505	4,2	20

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

Table 10: Maximum numerical derivatives 3 years accumulated of CA deficit (medians)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	-0,118	9.2	3	-0,0505	3,3	7
	2	-0,097	8.9	3	-0,0463	3,5	8
	3	-0,049	8.4	3	-0,0515	3,8	9
0.2	1	-0,059	9.2	3	-0,0505	3,3	7
	2	-0,049	8.9	3	-0,0462	3,5	8
	3	0,025	7.7	3	0,0479	3,5	10
0.3	1	-0,046	9.4	3	-0,0505	3,3	7
	2	-0,039	9.2	3	-0,0505	3.3	7
	3	-0,033	8.7	3	-0,0463	3,5	8
0.4	1	-0,094	9.4	3	-0,0505	3,3	7
	2	-0,072	9.1	3	-0,0505	3,3	7
	3	-0,037	8.9	3	-0,0463	3,5	8
0.5	1	-0,145	9.4	3	-0,0505	3,3	7
	2	-0,116	9.1	3	-0,0505	3,3	7
	3	-0,060	8.9	3	-0,0462	3,5	8

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

Table 11: Maximum numerical derivatives 4 years accumulated of CA deficit (medians)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	-0,1355	9.1	4	-0,0575	3,3	6
	2	-0,0492	8.4	4	-0,0575	3,3	6
	3	-0,0486	8.2	4	-0,0575	3,3	6
0.2	1	-0,0678	9.1	4	-0,0575	3,3	6
	2	-0,0368	5.5	4	-0,0461	3,8	17
	3	-0,0258	5.7	4	-0,0447	3,8	13
0.3	1	-0,0452	9.1	4	-0,0575	3,3	6
	2	-0,0375	5.7	4	-0,0447	3,8	13
	3	-0,0367	5.5	4	-0,0461	3,8	17
0.4	1	-0,0617	5.7	4	-0,0447	3,8	13
	2	-0,0488	8.4	4	-0,0575	3,3	6
	3	-0,0370	8.6	4	-0,0575	3,3	6
0.5	1	-0,0983	5.7	4	-0,0447	3,8	13
	2	-0,0689	8.6	4	-0,0575	3,3	6
	3	-0,0681	8.4	4	-0,0575	3,3	6

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

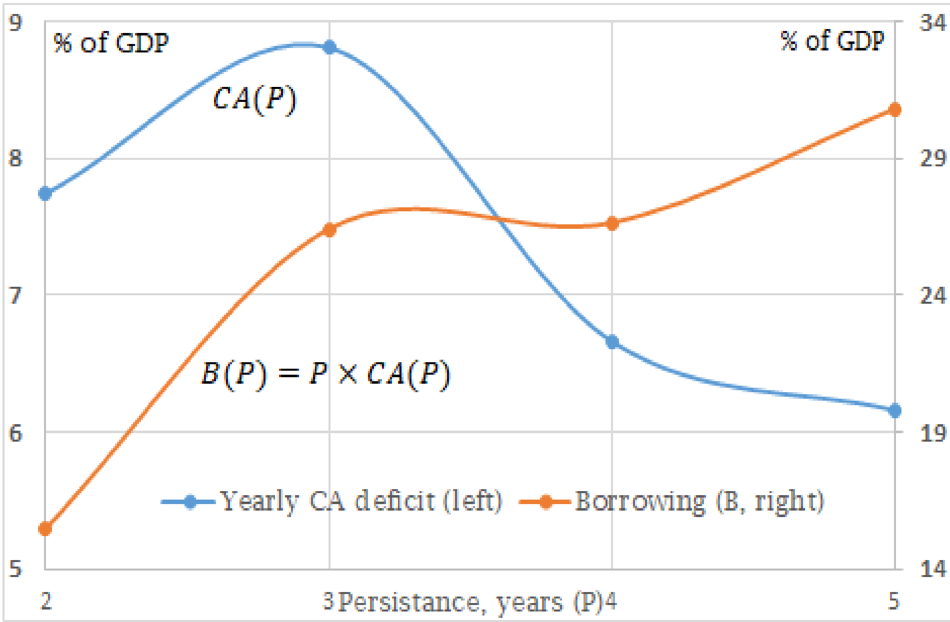
Table 12: Maximum numerical derivatives 5 years accumulated of CA deficit (medians)

ε	Rank	Slope	γ	h	Δlnc_{t+1}	ΔCA_{t+1}	# Episodes
0.1	1	-0,0352	5.7	5	-0,0469	3,2	9
	2	-0,0327	7.2	5	-0,0515	2,9	7
	3	-0,0279	5.5	5	-0,0367	3,6	15
0.2	1	-0,0166	4.1	5	-0,0326	3.8	19
	2	-0,0157	7.2	5	-0,0515	2.9	7
	3	-0,0157	5.7	5	-0,0469	3,2	9
0.3	1	-0,0178	5.7	5	-0,0469	3,2	9
	2	-0,0166	4.1	5	-0,0326	3,8	19
	3	-0,0124	5.9	5	-0,0515	3,1	8
0.4	1	-0,0257	5.9	5	-0,0514	3,1	8
	2	-0,0254	5.7	5	-0,0469	3,2	9
	3	-0,0200	7.4	5	-0,0499	2,5	6
0.5	1	-0,0443	5.9	5	-0,0514	3,1	8
	2	-0,0347	7.4	5	-0,0498	2.5	6
	3	-0,0346	5.7	5	-0,0469	3.2	9

Notes: Identification of SS using maximum derivatives of $\mu_1(\gamma, h)$ in the direction of γ.

Figures

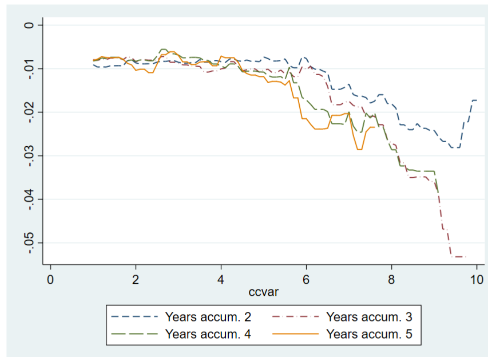
Figure 1: The empirical dimension of overborrowing



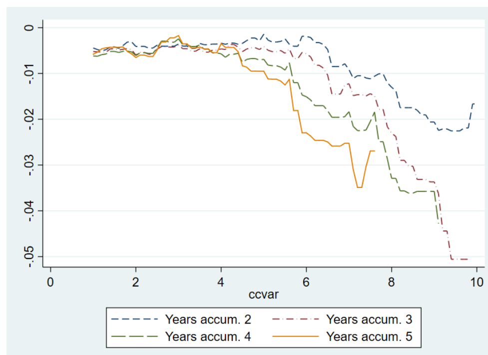
Notes: Left vertical axis correspond to yearly current account deficit (threshold). Right axis to accumulated current account deficit (borrowing).

Figure 2: First step difference-in-differences estimator

Consumption



GDP



Investment

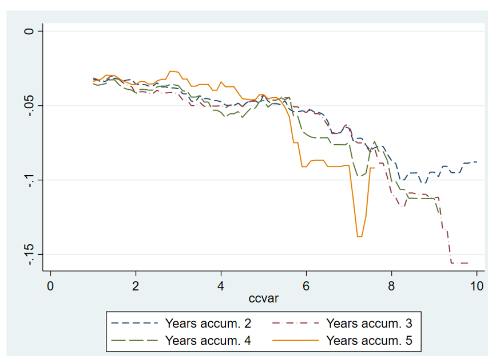
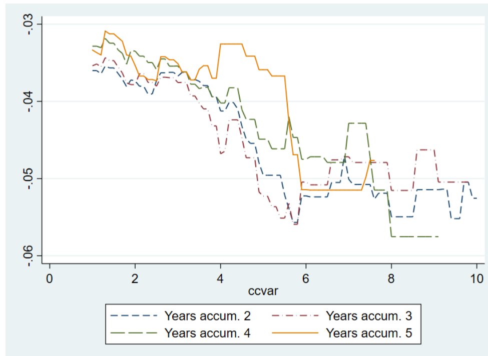
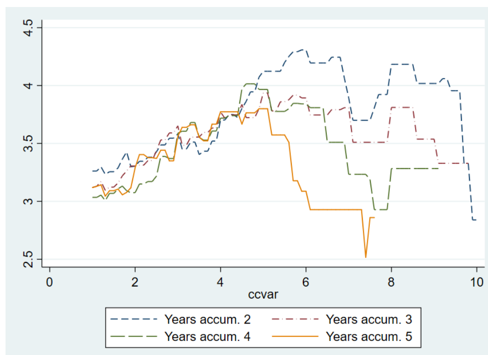


Figure 3: Second step: SS crises

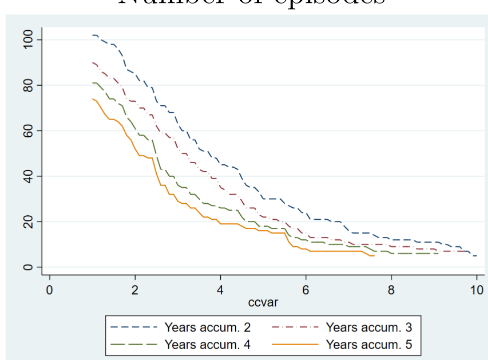
Fall in consumption



Current account reversal



Number of episodes



Appendix: Matrices

$$\rho_{Israel\,75'} = \begin{bmatrix} 0.393 & 0.114 \\ -0.077 & 0.758 \end{bmatrix} \quad V_{Israel\,75'} = \begin{bmatrix} 0.191 & 0.020 \\ 0.020 & 0.094 \end{bmatrix}$$

$$\rho_{Panama\,81'} = \begin{bmatrix} 0.536 & -0.002 \\ -0.106 & 0.819 \end{bmatrix} \quad V_{Panama\,81'} = \begin{bmatrix} 0.115 & 0.064 \\ 0.064 & 0.190 \end{bmatrix}$$

$$\rho_{Peru\,77'} = \begin{bmatrix} 1.001 & -0.234 \\ 0.143 & 0.687 \end{bmatrix} \quad V_{Peru\,77'} = \begin{bmatrix} 0.213 & 0.173 \\ 0.173 & 0.178 \end{bmatrix}$$

$$\rho_{Spain\,08'} = \begin{bmatrix} 1.038 & -0.176 \\ 0.271 & 0.668 \end{bmatrix} \quad V_{Spain\,08'} = \begin{bmatrix} 0.059 & 0.059 \\ 0.059 & 0.046 \end{bmatrix}$$

$$\rho_{CostaRica\,81'} = \begin{bmatrix} 1.055 & -0.358 \\ 0.253 & 0.569 \end{bmatrix} \quad V_{CostaRica\,81'} = \begin{bmatrix} 0.148 & 0.075 \\ 0.075 & 0.066 \end{bmatrix}$$

$$\rho_{Greece\,08'} = \begin{bmatrix} 0.806 & -0.004 \\ 0.250 & 0.740 \end{bmatrix} \quad V_{Greece\,08'} = \begin{bmatrix} 0.11 & 0.0517 \\ 0.051 & 0.086 \end{bmatrix}$$

$$\rho_{Honduras\,81'} = \begin{bmatrix} 0.574 & 0.120 \\ 0.050 & 0.155 \end{bmatrix} \quad V_{Honduras\,81'} = \begin{bmatrix} 0.133 & 0.035 \\ 0.035 & 0.067 \end{bmatrix}$$

$$\rho_{Portugal\,08'} = \begin{bmatrix} 0.808 & -0.208 \\ 0.191 & 0.623 \end{bmatrix} \quad V_{Portugal\,08'} = \begin{bmatrix} 0.115 & 0.033 \\ 0.033 & 0.090 \end{bmatrix}$$