Sticky Capital Controls

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ABSTRACT

Much debate remains on capital controls as useful policy instruments. This is partly due to the lack of empirical studies that look at the *intensive* margin of controls. This, in turn, has prevented a quantitative assessment of models of optimal capital controls in terms of their empirical performance when accounting for the observed behavior of controls. We contribute to this debate by addressing both positive and normative features of capital controls. On the positive side, using a new dataset built using textual analysis, we document the key stylized facts of capital controls along the intensive and extensive margins for 21 emerging markets. We find that capital controls are "sticky": conditional on being used, their changes occur rather infrequently, with large heterogeneity in their intensity, and display very little mean reversion. Moreover, controls have not been used systematically across time or countries. On the normative side, we show that capital control models relying on pecuniary externalities are unable to account for this stickiness. We propose an extension to this set up that postulates an Ss-type cost of implementing capital controls bringing the model closer to the data. These costs reduce the welfare-enhancing effects of capital controls by as much as half, compared to the Ramsey benchmark with no Ss costs. While we do not microfound such costs, we conclude with a discussion of their potential causes which calls for a richer set of policy constraints when considering an optimal use of capital controls.

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JEL codes: Capital controls, Macroprudential policies, Stickiness, Costs of policy making.

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1 Introduction

Following the Global Financial Crises, a body of research has taken a closer look at the use of unconventional policy tools, namely macro prudential instruments, aimed at curbing potential imbalances that can trigger financial crises and sudden stops. Capital controls (or capital flow management policies) are among the instruments that have arguably drawn the most attention.

The case for capital controls primarily rests on the volatility of foreign capital inflows. As macroprudential measures, they are designed to mitigate systemic crises.[2] Recent normative analysis of these policies has argued that their cyclical use can have nontrivial welfare implications by reducing the probability of financial crises. However, much debate remains on what these new policy instruments should be, as well as how and when to use them. As an illustration, when reflecting on the current state of "*progress and confusion*" of macroeconomic policy, Blanchard and Portillo (2016) summarize the current state of affairs regarding the use of capital controls, among other unconventional tools, as follows: "(...) *do these tools work? When should they be used, and how should they be articulated with the rest of the toolbox?*"

An important limitation to the evaluation of policy has been the lack of cross-country measures on the *intensive* margin of capital controls (i.e. rates) over time. Although there has been important progress in documenting the extensive margin of capital controls, i.e. whether controls are in place or not, no analysis has yet documented the behavior of the intensive margin of this policy instrument, its cyclical properties across countries and its interaction with other instruments in the macro prudential toolbox.

Related to this shortcoming, there is a disconnect between the normative implications of models in terms of the optimal use of capital controls and the data. The normative prescriptions of most models rely heavily on the use of controls along the intensive margin. That is, the optimal policy tends to involve not just the use of controls in certain states of nature (extensive margin) but, more importantly, by certain level/amount (intensive margin). Hence, the lack of data on the intensive margin has made it difficult to bring models of

[2] In addition, controls can have a protectionist or mercantilist motive related to affecting the value of the currency (Magud et al. 2018, Alfaro et al. 2017).

optimal capital controls to the data.

Our work makes several contributions to this debate, which relate to the aforementioned shortcomings. First, using textual analysis on official regulation from multilateral and national sources, we build a novel quarterly data set on the use of de jure capital controls along their extensive and, importantly, *intensive* margins. To our knowledge, this is the first cross-country panel dataset on the extensive and intensive margins of capital controls. The dataset covers a panel of 21 well established emerging market economies (EMEs) for the period of 1995 to 2014.[3] We focus on two types of quantitative capital controls: unremunerated reserve requirement (URRs) rates applicable to cross-border flows; and tax rates to cross-border inflows and outflows. When distinguishing the extensive from the intensive margins, we differentiate controls that have been of a quantitative nature (as the two that we focus on) and those of a qualitative nature (e.g. authorizations and other kinds of regulations that do not directly target market prices or volumes).[4] We further complement the dataset with information on other macroprudential instruments from Federico et al. (2014) and Cerutti et al. (2017).

With the data in hand, we uncover a set of stylized facts that, taken together, document a large degree of "stickiness" in the time series processes of the intensive margin of capital controls. In our period of analysis, the intensive margin of quantitative controls (taxes and URRs) has not been systematically used across countries or over time, and changes in this policy instrument along its intensive margin occur rather infrequently. When they have been used, quantitative controls display considerable heterogeneity across countries in terms of the intensity in with which they have been used and little mean reversion, i.e. controls remain in place for longer than a typical business cycle. More generally, when analyzing the joint dynamics of capital controls and other macro prudential policies, there is little evidence of complementarity. If anything, they appear to have been substitutes.

We then contrast the canonical model of optimal capital controls based on pecuniary externalities to the new data. More precisely, we assess whether the calibrated model can

[3]During our period of analysis, most developed nations had limited use of capital controls (see Fernández et al. 2016).

[4]We document that more than half of the measures coded as capital controls in the extensive margin do not aim directly at modifying the intensive margin. We labeled these measures as non-price based type of capital controls.

replicate the observed behavior of controls along the extensive and intensive margins. We are particularly interested on the extent to which the model can reproduce the intensity, cyclicality and frequency of changes of capital controls in the data. When taken to the data, the calibrated canonical model is unable to account for some of the aforementioned stylized facts, namely the stickiness in the observed behavior of this policy instrument. Indeed, the model counterfactually predicts the intensive margin to be used actively over the business cycle, hence displaying a considerable degree of mean reversion.

Lastly, we explore how certain modifications to this canonical framework can help the model better account for the data along these dimensions, and document the implications of such modifications in terms of the welfare impact of capital controls.

Of course, there are many reasons why positive and normative implications may differ.[5] Our exercise attempts to understand if additional considerations or frictions could be incorporated into the benchmark model, albeit in reduced form, to better account for the stylized facts that we uncover. In particular, we consider the stickiness of controls. We naturally turn to S-s types of costs, which have been a quintessential devise for economists when generating inaction in variables of interest such as prices, investment, etc. Our work extends this concept to a policy variable, namely capital controls.

More precisely, we modify the model by introducing a fixed cost (of policymaking) in the tradition of S-s models whereby the policy maker equates the current level of this policy instrument to its optimal one only once the value of doing so surpasses the cost. If that condition is not met, then the (policy) cost is large enough to deter the policymaker from moving the policy instrument, thereby staying in an inaction region, thereby allowing the model to reproduce the stickiness observed.[6] We then calibrate the canonical model and evaluate the welfare effects generated by the presence of these fixed costs in the economy. We find that they reduce the welfare-enhancing effects of capital controls by as much as half, compared to the Ramsey benchmark with no Ss costs.

As mentioned, we are conscient that there may be several reasons why models of optimal

[5]In the last section of the paper we discuss possible explanations.

[6]While the use of Ss type of costs is intuitive, we do consider other types of (convex and concave) costs. In the Appendix we document how, when compared to Ss costs, such alternative cost specifications do not help the canonical model in a meaningful way to better replicate the data.

capital controls may be at odds with the data. Moreover, the reduced form specification with which we try to capture such reasons through an S-s cost surely is, at best, a crude approximation to reality. However, we view the enhanced performance of the modified model as a call for including a richer set of policy constraints when considering the optimal use of capital controls in the presence of pecuniary externalities. In the last section of the paper we discuss some of the these potential policy constraints based on previous studies, such as the perceived lack of effectiveness of capital controls by policy makers, or their potential reputation concerns when using them, among others.

This paper relates to several strands of the literature. On the empirical front, a set of seminal empirical that have measured capital controls and their use include Quinn (1997), Chinn and Ito (2006),Schindler (2009), Pasricha (2012), Klein (2012), Aizenman and Pasricha (2013), Ahmed and Zlate (2014), Eichengreen and Rose (2014), Fernández et al. (2015); Fernández et al. (2016), Jahan and Wang (2017); Pasricha et al. (2018) among others. Klein (2012) casts doubts about assumptions behind recent calls for a greater use of episodic controls on capital inflows and finds, with a few exceptions, there is little evidence of the efficacy of capital controls. Glick et al. (2006) find that countries with liberalized capital accounts experience a lower likelihood of currency crises. Contrary to prescriptions put forth in the recent theoretical macro literature, Fernández et al. (2013) do not find evidence of capital controls implemented as macro-prudential tools in the period 1995-2011. We build on these papers and complement the work by adding an intensive dimension to the analysis.

A growing theoretical macro literature posits the benefits of capital controls albeit focusing exclusively on debt rather than equity to motivate the model frameworks (Lorenzoni 2008; Korinek 2018; Jeanne and Korinek 2010; Bianchi 2011; Bianchi and Mendoza 2010; Farhi and Werning 2014, among others). The lack of data on the intensive margin has precluded contrasting these models to the data, to which we contribute in this paper.

The paper proceeds as follows. Section 2 presents the data and documents thevstylized facts. Section 3 takes the canonical model to the data, and postulates the extension with Ss costs. The last subsection discusses possible avenues to microfound these costs. Section 4 concludes.

2 Capital Control Dynamics: Stylized Facts

2.1 New Dataset

We build a novel cross-country panel data set on capital controls and other macro prudential instruments. We focus on the intensive margin (which are the rates at which capital controls are set) of each instrument and document their quarterly behavior for a set of 21 EMEs. In this section we described the instruments documented in our dataset, the methodology used to record them and the coverage we have. For further details, we refer the reader to the Dataset's Technical Appendix.

2.1.1 Definitions and Instruments

In a country's balance of payments, international purchases and sales of financial assets are recorded in the financial account. A capital control is any policy designed to limit or redirect transactions on a country's financial account.

The International Monetary Fund (IMF) distinguishes between administrative and market-based capital controls. Administrative (i.e., direct) controls either prohibit or require prior approval for certain capital account transactions. Market-based (i.e., indirect) controls consist of taxes on cross-border capital movements and dual exchange-rate systems.[7]

We focus on two *de jure* price-based measures of capital controls which capture the intensive margin of these instruments, which we further complement with other macro prudential tools.

The two price based capital controls that we focus on are: 1. Unremunerated reserve requirement (URRs) rates applicable on cross-border flows (for the URR we also calculate the tax equivalent cost of the URR), and 2. Tax rates on cross-border inflows and outflows. We do this across as many types of assets as we found.[8]

[7]Another way to classify capital controls is according to their function. Chile, for example, regulated capital inflows during the 1990s, as did Malaysia in 1994. Controls on capital outflows, in contrast, are advocated to manage crises as they occur. Thailand imposed controls on capital outflows in 1997 as a response to the Asian financial crisis, as did Malaysia in 1998. Of course, it is often difficult for policy makers to separate neatly the effects of controls on inflows and outflows. Restrictions on outflows may deter inflows as well, since investors are generally less willing to put their money in countries that restrict their exit.

[8]This comes, however, at a cost, since we do not have the balance of payments data of each asset class,

With respect to other macro prudential tools, defined as measures directed to the domestic financial system, we document reserve requirements to deposits in domestic currency (RRs), reserve requirements on foreign exchange (RRs on FX) and, when necessary, we use other tools from alternative data sets (Cerutti et al. 2017; Federico et al. 2014).

Section II of the Dataset's Technical Appendix describes in detail the list of variables studied with their respective definition and acronym.

2.1.2 Methodology

To build our dataset from scratch we perform a textual analysis on official documents summarizing the regulations on cross border flows from multilateral and national sources, and other data sets. We follow four specific steps:

1. Textual analysis. We implemented textual analysis on the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). Specifically, for URRs (which have two specific sections on the AREAER) we systematically focused on the words "*unremunerated*", "*nonremunerated*", "*URR*" or "*reserve*". For taxes the words we systematically identified were "*tax*" or "*taxable*".

2. Manual sorting. From the policy measures identified in 1., we cleared regulation that were not capital controls or do not provide any clear allusion to the intensive margin.[9]

3. Complement with national sources. We analyze, for each country, legal instruments (e.g. decrees or country-specific economic literature) to confirm, complement or correct information found in non-national sources. Whenever we found discrepancies across sources, we made a case-by-case analysis. We recorded each of those cases in the Technical Appendix.

4. Cross validation. We cross-validated the data using other data sets on capital controls and direct consultation with the central banks of each of the EMEs considered in our sample. From the literature we complemented our measures with the datasets

hence our analysis is silent about volumes of flows.

[9]Trade measures (e.g. tariffs) were a recurrent example of a regulation that was included in 1 but excluded in 2.

developed by Federico et al. (2014); Reinhart and Reinhart (2008); Cerutti et al. (2017), Chantapacdepong and Shim (2015), Magud et al. (2018) & Ghosh et al. (2018).[10]

Section III in the dataset's Technical Appendix explains in detail the general rules and criteria to document each instrument, section IV shows how we calculate the tax equivalent of URR, section V shows the consistency check with other datasets, and section VI documents the cases where we found discrepancies between multilateral and national sources.

2.1.3 Coverage

We cover 21 conventional emerging market countries. Importantly, these were not chosen by any criteria of ex ante use of capital controls (or other macro prudential instruments). These are economies that have been included in the most recent peer-reviewed studies of EMEs' business cycles (Journal of Monetary Economics, Journal of International Economics, American Economic Journal: Macroeconomics), or that have been classified as emerging economies by multilateral organizations or rating agencies (IMF, MSCI, JP Morgan).

Those countries, grouped by region, are:

- Latin America (7): Argentina, Brazil, Chile, Colombia, Ecuador, Mexico and Peru.
- East Asia & Pacific (7): China, India, Indonesia, Korea, Malaysia, Philippines, and Thailand.
- Eastern Europe and Central Asia (5): Czech Republic, Hungary, Poland, Russia, and Turkey.
- Other Regions (2): South Africa, and Israel.

Applying to these countries the methodology described above, we document a panel dataset with a quarterly frequency from 1995 to 2014 (daily frequency is also partially available and pre/post 1995/2014 to avoid truncation). Section VI in the dataset's Technical Appendix clarifies all details regarding each individual country.

[10] More than half of the central banks we contacted responded our inquires. None objected the dataset we had found. In a couple of cases they complemented it with additional regulations. For Magud et al. (2018) and Ghosh et al. (2018) we made a systematic comparison and found a nearly perfect overlap of 95% in our dataset conditional on te same countries, years and types of controls.

The Data Appendix presents descriptive statistics on the coverage of the dataset. There are a total of 1712 quarterly observations recorded for URRs and 1680 for taxes on capital flows cross the 21 EMEs during the years covered. From these, 286 observations (17%) had an active capital control in the form of a URR; 378 (22.5%) had it in the form a tax on inflows and 445 (26.4%) had them in the form of a tax on outflows.

2.2 Stylized Facts

With the new data set at hand we document six stylized facts that have not previously been identified in the literature. For the purpose of documenting such facts, we use the data to explore the following five dimensions of capital controls across countries: 1. *Use* of these instruments across countries and time. 2. *Intensity* with which they are used. 3. *Frequency* of adjustment. 4. *Cyclicality* with real income. 5. *Complementarity* with other macro prudential tools. 6. *Consistency* with the extensive margin. Taken together, the facts signal a large degree of "stickiness" in the time series processes of the intensive margin of capital controls. The results are summarized as follows:

Fact 1. ***Use: There is a lack of widespread use of capital controls across countries and time***

In this dimension we explore first how many countries in our sample have used each instrument at least once during the whole time period. The top panel of Figure 1 shows, for each instrument (horizontal axis), the share of countries that have used them (vertical axis) in our sample. We find that while taxes on inflows/outflows have been used by less than half of the EMEs in the sample, URRs have been used by less than a third of the countries.

Second we explore across countries what share of time, on average, have capital controls been put into place. The bottom panel of Figure 1 shows the cross-country average share of time during which each instrument has been used. We find that their use has been limited only to a small fraction of the period covered by the dataset: taxes on inflows/outflows have been actively used (i.e. above 0) in less than 20% of the quarterly time series of the dataset, while URRs were used in less than 10%. On the other hand, RRs and RR on FX accounts

In contrast with these results, more than 90% of the countries have made used of RRs and 80% of RR on FX accounts and have been respectively used 75% and 95% of the time. Marginal RRs are much less pervasive, being used by 13% of the countries and less than 5% of the time.

Fact 2. ***Intensity: Conditional on their use, there has been considerable heterogeneity across countries in terms of the intensity with which capital controls have been used.***

As mentioned, intensity of capital controls and other policy instruments refers to the exact value each of them takes during each period of time. As opposed to the extensive margin which refers to whether or not they are used, the intensive margin explores the values at which those policy instruments are set, which can later be contrasted with the normative implications of the models. Here we explore such dimension for each country along the sample's period and then take cross-country averages to summarize this fact.

Figure 2 shows 4 panels. The two top panels show the mean intensities of URR and its tax equivalent for each country in the sample (including those with 0 intensity). The bottom two shows the same but now for mean taxes on inflows and mean taxes on outflows, respectively. Since the intensity of capital controls and other instruments is 0% in countries where they have never been put into place along the period of our sample, we focus on those who have used them.

We find that URR have ranged between 10% and 43%, with an equivalent tax rate between 0.2% to 8%. Taxes on inflows have ranged between 0.3% and 20%, while those on outflows have been used across more countries and more intensively, with the average tax varying ranging from 0.3% to 55%.

In contrast, RR and RR-FX have been used more homogeneously across countries, varying between 5%-10% and 4%-10% respectively.

Fact 3. ***Frequency: Changes to capital controls occur infrequently, and when they do they remain in place for long.***

Figure 3 has on the horizontal axis the number of changes in the instruments and on the vertical axis the number of countries in our sample. The figure has one panel for each of the thee instruments we just mentioned, where in each of them there are three type of bars: the blue bar shows the number of countries with that did not used the instrument (so their number of changes is zero), the cream bars show the number of countries that had the number of changes displayed on the horizontal axis, and the red bar shows the countries that did not change the instrument but the intensive margin of it was above 0%.

Out main takeaway from Figure 3 is that, conditioning on their use, the average changes to capital controls (above a threshold of 10% of its previous value) is between 4, for URRs, and 6 (4) for taxes on inflows (outflows) during the 20 years covered by our data set. Thus, changes to capital controls occur rather infrequently.

We also document the behavior of capital controls around episodes where they are activated, meaning when they experience an increase of more than 10% of its previous value. Figure 4 shows quarterly episodes for two and ten periods respectively before and after the activation, where the activation period in the horizontal axis is represented by period t. The first panel of Figure 4 shows both the behavior of RRs and their tax equivalent around the activation period. The second panel shows both the same behavior but for taxes on inflows and on outflows. The last panel shows it for RRs and RRs on FX. Figure 5 shows the same as the first two panels of Figure 4 but with an annual frequency.

Based on Figure 4 we find that episodes when taxes on inflows (outflows) displayed large increases, on average from 1% to 3% (0% to 25%), from one quarter to the next, three years later continue to exhibit values above 2.5% (20%). As a result, capital controls display very high serial autocorrelation (Figure 6 shows the serial autocorrelation between periods $t-2$ and $t+2$ for both taxes on inflows and on outflows). This means that when capital controls are activated, they do remain in place for long. This stands in contrast to the frequency of changes in RR (which triple the average number of changes in capital controls).[11] Along with Facts 1 and 2, our findings in this Fact allow us to classify capital

[11] Our results are also robust to different exchange rate regimes, as shown by Figure 13. More on this on

controls as "Sticky".

Fact 4. ***Cyclicality*****:** ***The cyclicality of capital controls differs sharply across instruments.***

Figure 7 shows for URR, URR tax equivalent and tax on inflows and tax on outflows, their cross-country mean behavior of the intensive margin around the same episodes documented in Figure 4 where controls were activated (left axis) compared to the cross-country average deviation of GDP growth with respect to its mean (right axis).

We find that while URRs have been used countercyclically during episodes of large economic booms, taxes on both inflows and on outflows have been used in the contractionary phase of the GDP cycle.

Fact 5. ***Complementarity: There is no systematic evidence of complementarity between capital controls and other macro prudential tools. If anything, there has been substitutability between the two.***

In this dimension we analyze whether capital controls have been used systematically to complement a broad set of different macro prudential instruments shown by Cerutti et al. 2017.

Figure 8 shows for URR, URR tax equivalent, taxes on inflows and taxes on outflows, the behavior of each of these instruments around their activation period (red lines) compared to the behavior of the other instruments, both including RRs (dark-purple line) and without RRs included (light-purple line).

The fact that the red lines do not move in tandem with the others, evidences no complementarity with neither RRs or a broader set of macroprudential instruments.

Figure 9 breaks down the serial correlation of these policy tools with the business cycle into those countries that have and have not used: Capital controls in general, URRs and taxes (on inflows or outflows). The main result here is that countries where capital controls have not been used, show more action in using RRs and other instruments. Hence, rather

the Appendix.

than evidence of complementarity, there seems to be substitutability between capital controls and other macro prudential instruments.

Fact 6. Robustness: Measures of capital controls along their extensive margin account for a much broader set of regulations than those of the intensive margin. Still extensive margin measures display also a considerable degree of stickiness.

Are these findings robust if extensive measures of capital controls are used? In order to answer this we took the dataset in Fernández et al. (2016), which measures the evolution of the extensive margin for several countries, along a much wider array of assets, and reclassified the policy measures accounted in their dataset in terms of price-based -i.e. the ones included in our dataset (URRs, tax rates on capital flows)-, and non-price, such as authorization requirements and other bureaucratic measures that do not directly affect the relative cost of cross border flows.

Figure 10 and Table 3 summarize the findings of this excercise. The bars in Figure 10 show, for each country, what share of instruments corresponds to priced-based (dark shade) and non-priced based (light shade) policy measures, respectively. Table 3 breaks down these two types of controls into further subcategories among which URRs and taxes are included. Results indicate that priced-based measures represent on average less than half (40%) of all instruments, from which URR and taxes (including prohibitions, i.e. a tax of 100%) represent a little over 10% of the measures. Regarding the remaining 60% of measures that are non price-based, a little less than half of those are authorization requirements.

A natural question is, thus, whether the previous stylized facts documented on the intensive margin are robust to these broader set of regulations, most of which account for non-price based measures. Figure 11 shows a similar exercise to the one shown in Figures 4 and 5 using the extensive margin of capital controls in Fernández et al. (2016). Since now we are analyzing the extensive margin, the vertical axis is not a rate but rather a scale where the scale used in this work that goes from 0 -no controls exist in neither of the asset categories- and 1 -there are controls in all categories. Results are quite robust in terms of the stickiness observed.

3 Accounting for Capital Control Dynamics

3.1 Baseline Model of Pecuniary Externalities

The baseline model is the same as the canonical model of open economies with flow collateral constrains developed by Bianchi (2011), but we rely heavily on the notation and illustration of the model developed by Schmitt-Grohé and Uribe (2017).

3.1.1 Setup - Decentralized Economy

The economy has a continuum of identical, infinitely-lived households of mass one, with time-separable preferences of the form:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t) \tag{1}$$

The utility function has a standard CRRA form: $U(c_t) = \frac{c_t^{1-\sigma}-1}{1-\sigma}$. Where $\sigma > 0$ is the constant risk aversion parameter, $\beta \in (0,1)$ denotes the subjective discount factor and $\mathbb{E}_0$ is the expectations operator at period $t = 0$.

Each period's aggregate consumption, c_t, is a composite of tradable (c_t^T) and non-tradable goods (c_t^N): $c_t = A(c_t^T, c_t^N)$, $\forall t \in [0, \infty)$. The aggregator follows an Armington-type CES form: $A(c_t^T, c_t^N) = [a(c_t^T)^{1-1/\zeta} + (1-a)(c_t^N)^{1-1/\zeta}]^{1/(1-1/\zeta)}$, where parameters a and ζ are respectively the weight of tradables in the CES aggregator and the intratemporal elasticity of substitution between tradable and non-tradable goods.

Households have access to a one-period internationally traded bond denominated in terms of tradable goods. The return of these bonds between periods t and $t+1$ is the exogenous risk-free rate r_t. The households' sequential budget constraint is:

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + \frac{d_{t+1}}{1+r_t} \tag{2}$$

Where d_{t+1} represent the amount of debt obtained in period t and due in period $t+1$ and p_t is the relative price of non-tradables in terms of tradables. Variables y_t^T and y_t^N represent the exogenous endowments processes for, respectively, tradable and non tradable goods, and are the only source of uncertainty in the present version of the model. Notice that debt is equivalent to negative holdings of the aforementioned internationally traded bond.

The (flow) collateral constraint is:

$$d_{t+1} \leq \kappa(y_t^T + p_t y_t^N) \tag{3}$$

With $\kappa > 0$ being the fraction of income that can be pledged as collateral, which determines the upper bound of debt that households can take during the current period and (completely) pay in the next one. This constraint is the key to the pecuniary externality: Due to the atomistic nature of households they take p_t as given, although it is endogenously determined in equilibrium. In other words, households do not internalize that their collective absorption of tradables may increase the value of collateral through increases in the relative price of non-tradables.

Households choose a set of processes $\{c_t^T, c_t^N, c_t, d_{t+1}\}_{t=0}^{\infty}$ to maximize (1) subject to (2) and (3) given the initial debt position d_0[12]. To illustrate how the pecuniary externality generates a sub-optimal (constrained) allocation, we need to show how an economy where the relative price of non-tradables is not taken as exogenous but rather internalized differs with respect to the decentralized economy above. For this endeavor, the literature call such type of economy, the Ramsey Planner's economy.

3.1.2 The Ramsey Planner

The Ramsey planner chooses a set of processes $\{c_t^T, c_t^N, d_{t+1}\}_{t=0}^{\infty}$ to maximize:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} U(c_t) \tag{4}$$

Subject to:

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t} \tag{5}$$

[12]See the Appendix for a full derivation of the equilibrium in this economy.

$$d_{t+1} \leq \kappa[y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta} y_t^N] \tag{6}$$

Notice that now, as opposed to the decentralized economy, the Ramsey planner internalizes the equilibrium value of p_t (see the Appendix for the full derivation of the model and the equilibrium price) in the latter, which is shown directly in the collateral constrained represented by equation (6).

3.1.3 Optimal Capital Control Policy

Let τ_t be the tax on the value of debt to be paid next period, d_{t+1}, charged in the current period t. The government's budget constraint is:

$$\tau_1 \frac{d_{t+1}}{1+r_t} = l_t$$

Where l_t is a lump-sum transfer to households. Therefore, the households' budget constraint becomes[13]:

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + (1-\tau_t)\frac{d_{t+1}}{1+r_t} + l_t$$

Thus, there is a tax that reduces utility to the point where households borrow less, down to the same amount as the Ramsey Planner. Schmitt-Grohé and Uribe (2017) show that the optimal tax to implement such allocation when the constraint is slack is[14]:

$$\tau_t = 1 - \frac{E_t \lambda_{t+1}^R (1 - \mu_{t+1}^R \Psi_{t+1})}{E_t \lambda_{t+1}^R} \tag{7}$$

Where:

$$\Psi_{t+1} = \kappa \frac{1-a}{a} \frac{1}{\zeta} (\frac{c_T^T}{y_T^N})^{1/\zeta - 1}$$

And for the periods when the constraint binds, the optimal tax is indeterminate, mean-

[13] See the Appendix for a full derivation of the equilibrium in the regulated economy.

[14] They prove that to obtain the optimal capital control tax as a result of an optimal taxation exercise, it suffices to cast the Ramsey Planner's problem as it is in section 3.1.2, and then combine its first order conditions with equation (37) from the decentralized equilibrium with capital control taxes

ing that there are n combinations of τ_t and μ_t that implement the Planner's allocation in the decentralized economy with capital control taxes[15].

3.1.4 Bringing the Baseline Model to the Data

The model is calibrated as in Bianchi (2011), where the process of tradable and non-tradable endowments (y_t^T and y_t^N) are calibrated for the Argentinean economy. Table 1 shows the values of the calibrated parameters. We solve the decentralized model by using a modified Euler equation iteration algorithm, and the Ramsey Planner's problem by value function iteration. We follow Schmitt-Grohé and Uribe (2017) and simulate one million years for the endowment process and, using the solution to the Ramsey planner's problem, we find a one-million-period series for τ_t.

To compare the properties of the simulated capital control tax with the data, we use the observed *average* of the documented taxes on inflows and outflows (however, our conclusions remain the same if we use separately ether one or the other). Thus, from now on we refer indistinctly to this average as the observed capital control tax in the data.

With the simulated series of the capital control tax we compare the model along the dimensions in the data from the stylized facts documented above[16].

1. Use: what is the share of time that controls are used? While in the baseline model the capital controls tax is above zero 100% of the time, in the data the average time with the capital control tax above zero is 20% of the observed periods. Figure 16 shows this result. The vertical axis measures the share of time with $\tau_t > 0$ and the horizontal axis has both the baseline model and the data. The blue bar represents the former and the yellow bar represents the latter.

2. Intensity: Mean value of τ_t. Figure 17 compares the mean value of the capital control tax both in the model and in the data. It clearly shows that the baseline model can account for the mean intensive margin in the data, where in both cases this value is close to 5%.

[15] This optimal capital control tax is the same as the one obtained by Bianchi (2011).

[16] As we explain below, we do not contrast the fifth dimension analyzed (*Complementarity*) with the baseline model of capital controls because the analytical framework we use only incorporates the capital control tax as a policy instrument.

3. Frequency I: Number of changes of τ_t in 20 periods. Here we explore for the average 20-year period (same as in the data), the number of changes that the tax exhibits. As shown by Figure 18, the baseline model overpredicts the number of changes in τ_t. While in it the tax changes all periods, in the data it changes 1.5 times (taxes on inflows change one time and taxes on outflows change twice).

4. Frequency II: Serial correlation of τ_t. Figure 19 shows the autocorrelation (vertical axis) of order t+j of τ (horizontal axis), for $j = \{-2, -1, ..., +2\}$. The blue line represents the baseline model and the red line the data. Except for the contemporary correlation (which by construction is one), the blue line is always below the red one. In other words, the baseline model underpredicts the degree of persistence of τ_t.

5. Frequency III: Episodes of τ_t. The model cannot account for the stickiness in capital controls that the data exhibit. Figure 20 shows 3 periods before and 10 periods after the activation of the tax (horizontal axis), where in the vertical axis we observe the value of the tax and the blue and red lines correspond to the baseline model and the data respectively. Specifically, we want to point out that once the tax is activated to its highest level in the data (almost 15%), it takes considerably longer time to return to a considerable lower level (of about 5%). This feature is absent from the model-based simulation.

6. Cyclicality: Episodes of τ_t and y_t^T. For the same average 14 periods described in the previous point, we plot together in Figure 21 the process of tradable endowments (right axis) and the capital control tax (left axis). The green line represents the latter and the blue line represents the former. As already documented by Schmitt-Grohé and Uribe (2017), the baseline model generates procyclical capital control taxes, which is also observed in the data (although only in taxes on inflows, not URRs or taxes in outflows).

The six dimensions explored above show that the model misses some of the key properties of the process of capital controls observed in the data. Specifically, it is unable to reproduce the stickiness documented in the empirical section.

Even though the baseline model was designed for normative purposes, and not positive ones, we consider that a theory developed with the purpose of guiding policy should provide an accurate description of the data. In this case, what element departs the theory from the empirical observations? In the next section propose a simple modification to the baseline model that brings the theory and the data closer to each other.

3.2 Extending the Baseline Model: An Ss Cost Approach

Motivated by the disconnect between the baseline model and the empirical observations shown in the previous section, we conjecture that there must be a cost of policy making that gives rise to the observed stickiness.

We postulate an S-s cost structure to bridge the gap between the theory and the empirical observations. This structure is the canonical model of inaction in economics, arising from costs of adjustment. There is a long tradition in using this set up to explain inertia of durable goods, investment, money demand, and perhaps most notably, providing microfoundations for price stickiness (hence the name of our work).

In this framework, agents allow their state to drift in response to shocks until it reaches and adjustment trigger, before setting it to a target value. Here we postulate a similar environment, but adapted to the Ramsey Planner that is confronted with internalizing a (reduced form) cost in terms of utility that agents face but do not internalize when the capital control tax is adjusted. While providing microfoundations of such cost is beyond the scope of this work, in the end we discuss the possible deep causes that could give rise to such types of costs.

3.2.1 Setup

We now assume that there is an initially given capital control tax, such that for period $t = 0$, the tax is τ_{-1} (i.e., the tax becomes a state variable).

We define V^A as the value of adjusting the capital control tax from its initial value to the one that is optimal in absence of policy-making costs, τ_t^*. This adjustment carries out an (adhoc) fixed utility cots K. We also define V^{NA} as the value of not adjusting the capital control tax. Therefore, we have:

By mapping the sequential formulation of the Ramsey Planner's problem into a recursive, we have that for every period t: $\tau = \tau_{-1}$ and $\tau' = \tau_t$.

$$V^A(y^T,r,d,\tau) = [U(c^T(\tau^*)) - K] + \beta E[Max(V^A(y^{'T},r',d',\tau'),V^{NA}(y^{'T},r',d',\tau'))] \quad (8)$$

$$V^{NA}(y^T,r,d,\tau) = U(c^T(\tau)) + \beta E[Max(V^A(y^{'T},r',d',\tau'),V^{NA}(y^{'T},r',d',\tau'))] \quad (9)$$

Thus, the Ramsey Planner can set $\tau' = \tau_{-1}$, in case of non adjusting the tax, or τ'^* in case of adjusting it.

The recursive formulation of the planner in this environment becomes:

$$V(y^T,r,d,\tau) = Max(V^A(y^T,r,d,\tau),V^{NA}(y^T,r,d,\tau)) \quad (10)$$

Subject to:

$$c^T + d = y^T + \frac{d'}{1+r} \quad (11)$$

$$d'^T + \frac{1-a}{a}(\frac{c^T}{c^N})^{1/\zeta}y^N] \quad (12)$$

Now the planner chooses a tax that, under this set up, will exhibit inaction for different periods of time, due to the fact that for some values of K, there will not be incentive to adjust the tax.

Notice two extreme cases: 1. Having $K = 0$ is equivalent to the Ramsey Planner's world in the baseline model, which is that of maximum welfare for households. 2. Equation 8 implies that there exists a sufficiently large K such that the planner never adjusts τ. This case is equivalent to the decentralized economy in the baseline model, which is the lowest possible welfare.

This implies that welfare is bounded between the decentralized case in the baseline model and the Ramsey Planner without adjustment costs. Below we will see that indeed, welfare is bounded between these cases and decreasing in K.

3.2.2 Solution and Calibration

We use the same calibration than in the baseline model, shown in Table 1. In this stage, we set the value of K to 0.006 which yields a frequency of changes every 20-years of 2, close to the 1.5 observed in the data. However, we solve the model for different values of this parameter. Thus, K takes values of 0 (i.e., the baseline model), 0.002, 0.006, 0.01, 0.014, 0.018 and 0.021.

The solution method of this problem first requires to solve for Ramsey economy to obtain the policy functions of the control variables, including τ_t^*. Then, given the stochastic process of endowments, we simulate one million periods and obtain τ_t^* for each period (recall that each period corresponds to a state of the pair $\{y_t^T, y_t^N\}$ and d_t). Using the same simulated endowments, we simulate the decentralized (but regulated) economy for all the (one million) values of τ_t^* obtained in the previous step. By doing this we obtain all the possible combinations, given a simulated process for the endowments, of policy functions for each state of the economy for each different τ_t^*, and thus its correspondent indirect utility at each period. This process facilitates the solution of the Ramsey Planner problem with Menu Costs. Once it is done, in the Menu Cost model we need to keep track of the state of τ_t, and assume that $\tau_0 = 0$ (it could be any value). Then for each period in the simulation, given an exogenous value of K, we obtain V_t^A and V_t^{NA}, and then the maximum among both. In case the former is greater than the latter $\tau_t = \tau_t^*$, otherwise $\tau_t = \tau_{t-1}$. In the appendix we provide a step by step of the algorithm used to solve the model.

3.2.3 Bringing the Extended Model to the Data

Exploring again the six dimensions of the capital control tax discussed in section 3.1.4, we show how the S-s structure allows the model to come closer to the data:

1. Use: what is the share of time that controls are used?. Figure 19 shows how the presence of fixed costs of policy-making bring the model closer to the data. The height of the blue bars, corresponding to different values of K, are decreasing in this parameter, meaning that the higher the costs of policy-making the lower the amount of periods capital control taxes will be activated above zero.

2. Intensity: Mean value of τ_t. Even though the baseline model accounts well for the intensity of the capital control tax displayed in the data, the S-s model can also account partly for the variability in the intensive margin (documented earlier on Figure 2). Figure 23 shows how for different values of K the mean value of the tax varies, although all values are close to the one in the data.

3. Frequency I: Number of changes of τ_t in 20 periods. Again we explore for the average 20-year period, the number of changes that the tax exhibits. Figure 24 shows that the S-s costs bring this statistic considerably closer to the data. Though by construction the values of K are in the neighborhood of generating the number of changes observed empirically, the point of this exercises is tho show that our framework provides a rationale for the low observed number of changes in capital control taxes.

4. Frequency II: Serial correlation of τ_t. Figure 25 shows the autocorrelation (vertical axis) of order t+j of τ (horizontal axis), for $j = \{-2, -1, ..., +2\}$. The blue line represents the baseline model and the red line the data. The other lines correspond to some values of K (we do not show all for the sake of visual clarity). The S-s model allows a better match of the persistency in capital controls exhibited in the data.

5. Frequency III: Episodes of τ_t. The S-s model helps to account for the stickiness in capital controls in the data. Figure 26 shows for different values of K different patterns of inaction in the tax. Focus, for instance, on $K = 0.02$ the black line. For this value the tax is activated and then remains high for 5 periods, and then decreases to a lower value (that is still above the initial value), and remains there. This is a similar behavior than that shown by the red line (which represents the data), although they differ in the variability of the tax and the intensity. In spite of this differences, the S-s model is considerably closer to the data in this dimension than the dark-blue line, which corresponds to the baseline model.

6. Cyclicality: Episodes of τ_t and y_t^T. Including the process of tradable endowment in the dimension above shows that, as well as in the data and the baseline model, τ_t is procyclical in the S-s model. Figure 27 shows this result.

In sum, the S-s cost extension to the baseline model helps it to account better for some key properties of the processes of capital controls observed in the data. More importantly, it now reproduces the stickiness documented in the empirical section.

Because the welfare gains of implementing capital control taxes in the baseline model are sizable, it is of relevance to measure the implications of S-s costs in terms of welfare. This can also deliver a welfare based measure of the S-s costs that we have postulated.

3.2.4 Welfare Analysis

We estimate the welfare effect, λ, of having S-s type costs for different values of K. We do this in different two ways of computing consumption equivalences. First, we postulate:

$$\sum_{t=0}^{\infty} \beta^t u \left[c_t^{UR} \left(1 + \lambda^{UR}(K) \right) \right] = \sum_{t=0}^{\infty} \beta^t u \left[c_t^{Ss}(K) \right] \tag{13}$$

Where UR and Ss stand, respectively, for unregulated (i.e., decentralized with $\tau = 0$) and Ss economies. And $\lambda^{UR}(K)$ is the percentage increase in the consumption stream of a representative individual living in the UR economy that would make her as happy as living in the S-s economy with the adjustment cost of policy making equal to K.

Second, we postulate:

$$\sum_{t=0}^{\infty} \beta^t u \left[c_t^{Ss} \left(1 + \lambda^{Ss} \right) \right] = \sum_{t=0}^{\infty} \beta^t u \left[c_t^{Ramsey} \right] \tag{14}$$

Where *Ramsey* is the baseline setup of a regulated economy with no costs of policy making ($K = 0$), and λ^{Ss} is the percentage increase in the consumption stream of a representative individual living in the S-s economy, with costs of policy-making equal to K, that would make her as happy as living in the Ramsey economy.

Table 2 shows the results of both welfare measures for 4 different values of K. The first value, $K = 0$, is that of the baseline Ramsey Planner's (regulated) economy. The second value $K = 0.01$ is a small value of K with which the model does not resemble the data very well at the quantitative level, and $K = 0.02$ is a value in which for the model better resembles the data (however, our conclusions regarding welfare and its relationship with K remain the same if we include all the values of K shown in the figures of section 3.2.3). The last value, $K = 0.1$, is a sufficiently large value such that the capital control tax never activates, so any value of $K \geq 0.1$ generates complete inaction, which is the same as the baseline decentralized (and unregulated) economy. Notice that, as mentioned at the end of section 3.2.1, indeed the higher the value of K the lower the welfare gain is compared to the unregulated economy.

The results in Table 2 show that the presence of S-s costs has welfare reducing implications. These are in the order of 0.04% relative to the Ramsey case with no adjustment costs when one considers the level of costs that better matches the frequency of adjustment in the intensive margin ($K = 0.02$).

Still, for that level of K, welfare enhancing implications are about twice the cost, 0.07%, when compared to the unregulated case (0.04%).

3.2.5 Robustness

Financial crisis

Typically, in models of pecuniary externalities with capital controls most of the action is in periods about a financial crisis. We explore how robust are our results in the extended model when constraining the capital control tax to periods of time where there is a financial crisis. Specifically, we now consider the properties of the tax for every 20 periods of time (such that the crisis occurs in period 10).

The dark bars in Figure 28 show how many of those 20 periods about a financial crisis is the tax activated (for different values of K). The result is that, as in the uncondtional (on financial crisis) model, the higher the Ss cost, the lower amount of periods is the tax activated. Naturally, since these are periods where there is a crisis, the mean value of the tax is higher than when considering all periods, as shown in Figure 23.

Figure 24 shows the number of changes also for periods about a financial crisis. Again, a higher K implies lower number of changes and bring this statistic closer to the data. This lower frequency of changes, even with financial crisis, implies also a high autocorrelation of the tax during them, as shown in Figure 25.

Since our definition of activation is the same as in the empirical section, the episodes in which the tax is activated are always in periods about financial crisis. Thus, Figure 32, which shows the episodes of activation in the tax about financial crisis, is the same as Figure 26. Meaning that, by construction, capital controls will increase and remain in place for several periods of time for some values of K, regardless of whether one constrains the series of τ to periods of financial crisis or not.

Considering the fact that the cyclicality of capital controls during crisis has already be shown to be procyclical by Schmitt-Grohé and Uribe (2017), which is summarized by Figure 27, this result also holds in our model.

Taken together these results show that, even when constraining the series of τ only to periods of financial crisis, our extended model generates differences with respect to the baseline model that bring it closer to the data.

Alternative costs of policy making

It is natural to conjecture that there may be other cost structures of policy making that may deliver sticky capital controls. We explore this possibility by now assuming that, instead of an S-s structure, there is a continuous and either convex or concave cost of adjustment $C(\tau_t)$ paid by the government in terms of tradable goods. This is a sunk cost of adjusting that depends on the value of the tax.

The Government budget constraint is now:

$$\tau_t \frac{d_{t+1}}{1+r} = l_1 + C(\tau_t)$$

The first order conditions do not change. But the household's budget constraint in equilibrium now becomes:

$$c_t^T + p_t c_t^N + d_t = y_t^T + p_t y_t^N + \frac{d_{t+1}}{1+r_t} - C(\tau_t)$$

However, the first order conditions of the Ramsey Planners problem now change, as shown in the Appendix.

Now, the equilibrium equations are different than those of the baseline model, however the structure of these equations shows that τ_t keeps its dynamic structure as long as it exists.

We perform a recursive simulation of a simple three-period model. For the convex cost of adjustment we assume that $C(\tau_i) = \tau_t^2$, and for the concave cost we assume that $C(\tau_i) = \tau_t^{1/2}$.

In the case of a convex cost Figure 34 shows for different values of the tradable good in period 2 (assuming that in periods one and three is equal to 1) what is the value of the optimal value of τ in periods 1 and 2 (left and right panel respectively). Aside from the fact that now it is negative, the Figure shows that the tax does not exhibit the stickiness described in the stylized facts.

For the concave costs of adjustment, the solution for each value of tradable goods is imaginary. As a result we constrain each imaginary value to be equal to zero. Figure 35 shows this result. Again, this type of costs does not explain stickiness in capital controls.

Our main takeaway from this exercise is that, hardly other type of reduced form cost-structure, different than an Ss set up, is able to provide a rationale that explains the observed stickiness in capital controls.

3.3 A Discussion

Clearly reduced form, Ss costs may capture a large set of constraints that policy makers face and that are absent from the current analytical framework. As mentioned, positive and normative implications may differ for various reasons. Policymakers may have different objectives beyond managing pecuniary externalities on inflows, more complex cost benefit analysis incorporating additional considerations and unintended consequences not picked up by standard models. More generally political economy considerations may drive policy making, while credibility and signaling concerns may also affect policy choices. Lastly, model robustness and perceptions of lack of ineffectiveness may also play a role in policymaker´s cautious use of these instruments.

The case for capital controls primarily rests on prudential measures designed to mitigate the volatility of foreign capital inflows. In December of 2012, the IMF released an official statement endorsing a limited use of capital controls (IMF 2012): "*For countries that have to manage the risks associated with inflow surges or disruptive outflows, a key role needs to be played by macroeconomic policies, as well as by sound financial supervision and regulation, and strong institutions. In certain circumstances, capital flow management measures can be useful. They should not, however, substitute for warranted macroeconomic adjustment.*"

The relationship between domestic and international financial crises stems in part from the fact that policy makers face a difficult trade-off among three objectives: monetary policy autonomy, a stable exchange rate, and free capital mobility. Also known as the "irreconcilable trilogy," the "incompatible trinity," and, in more radical circles, the "unholy trinity," the trilemma postulates that only two of the three goals can be reached simultaneously. (see Rey 2015 for a dilemma view of this policy trade off). If capital movements are restricted, countries can pursue more autonomous monetary policies while maintaining fixed exchange rates. But if countries allow free capital mobility while attempting to maintain fixed exchange rates, they must use monetary policy to defend the currency peg. When capital outflows surge, a central bank that does not want the currency to depreciate must either increase interest rates to attract capital or purchase its own currency using foreign exchange reserves. If the flows of capital are large, a central bank might very quickly exhaust its foreign exchange reserves with little influence over the market outcome. Increasing interest rates, on the other hand, can have negative consequences for economic activity and employment. In a country where the financial sector is weak, the consequences can be devastating.[17] Similarly, countries experiencing net capital inflows face appreciating exchange rates that often fuel bubbles in asset prices. Popping these bubbles can bankrupt the financial systems of countries with weak domestic banks. Although central banks can "sterilize" increases in international reserves by selling government bonds and thereby reducing domestic credit, this tends to keep interest rates high. Because the government pays a higher interest rate on its bonds than it receives on its foreign reserve holdings, sterilization represents a non-trivial cost to the government of encouraging continued capital inflows (Alfaro and Kanczuk, 2009).

Reinhart and Smith (2002) note that counter-cyclical capital control policy against temporary shocks to the international interest rate could have welfare benefits. However, as they mention, restrictions on capital controls must be extremely restrictive to have significant effects, otherwise the potential benefits of such counter-cyclical policies are very small. As

[17]Currency mismatches such as dollar liabilities versus domestic-currency assets, for example, can fuel exchange rate volatility and increase systemic risk. Developing countries are often characterized by their inability to borrow externally in their own currencies as well as by their extensive domestic liability of dollarization/indexation. This exacerbates problems related to large exchange rate movements. For example, a large depreciation of the domestic currency can lead to an increase in the value of debts relative to assets (in contrast, for example, to the United States, which can issue debt in local currency). This accounts for the tendency of emerging market floaters to be guided more heavily than industrial countries by exchange-market developments, a reduced monetary autonomy phenomenon that Calvo and Reinhart (2002) have labeled "fear of floating."

capital controls are usually left in place longer than the temporary shock, they offset any benefit from the policy.

There is also an implicit aspect of controls that is protectionist in nature aimed at maintaining persistent currency undervaluation (Magud et al., 2018). In recent years, several policy makers from emerging Asia and Latin America, for example, have expressed concerns that massive foreign capital inflows can lead to appreciation of the exchange rate with potential lasting effects on the export sector.

Another set of explanations as to why policy makers opt to impose controls on capital flows centers around the distributive consequences of policies. While an economy as a whole can benefit from opening up to international markets, some groups may lose in the absence of necessary compensating transfers. Alesina and Tabellini (1989) consider distributional issues when explaining capital controls. In a two-period general equilibrium model with two government types with conflicting distributional goals, they show that left-wing parties are more prone to restrict capital outflows than right-wing governments. Private capital flight is explained as an insurance against the risk of future taxation. However, in their model, capital controls always make capitalists worse off. In the model presented in this paper, the outcome depends on the characteristics of the economy. Rodrik and Van Ypersele (2001) address the issue that capital mobility may be politically unsustainable even though it enhances efficiency. They require, in a one period model, that no group be a net loser. This constraint raises the possibility that the compensatory adjustments in the national tax rates may not be feasible in the absence of coordination among countries. In Alfaro and Kanczuk (2004) political decisions are shaped by the risk over capital and labor returns. The authors characterize different possible equilibrium outcomes: economies that eventually remain open, those that eventually remain closed, and those that cycle between open and closed. In line with the stylized facts, cycles are more common in economies with moderate development level.

Thus, political economy considerations (broadly defined) may provide incentives to policy makers to follow different objectives beyond managing pecuniary externalities on inflows (e.g. maintain a fixed exchange rate, as noted in Magud et al. 2018; Ilzetzki et al. 2019).

Policy makers may worry as well about the general perception of policies. Bartolini and Drazen (1997) for example, argue that countries that lift capital controls can signal "good behavior", while those that impose them could be perceived as following inconsistent policies that would reduce credibility. There may also be spillovers and interactions across markets (Cole and Kehoe, 1998).

On the other hand, policy makers may consider the effectiveness of controls when considering imposing these measures. Evidence suggests limited effectiveness of controls (Klein 2012; Baba and Kokenyne 2011; De Gregorio et al. 2000; Goldfajn and Minella 2005; Carvalho and Garcia 2008; etc.), with some exceptions in particular draconian cases (e.g. Argentina, Venezuela) or "walls" (China). Others may worry about the negative effects and unintended consequences. Most countries aim to maintain/develop financial markets, and thus choose not to impose draconian measures. Capital controls negatively affect liquidity and reduce firms financing (Forbes 2007; Alfaro et al. 2017; Andreasen et al. 2019).

More generally, policy makers may be concerned that complexities surrounding the transmission mechanism of capital controls are not well understood and thus hard to capture in standards frameworks. Most models, for example, tend to focus on consumption smoothing benefits with non-contingent assets while abstracting from different interactions and variables: debt/equity financing/hedging and contingent assets; capital accumulation, firm financing, and the development of financial markets. Another concern is that regulations do not properly discriminate between short-term and long-term capital flows. Short-term loans are often rolled over, while long-term assets can be sold in secondary markets. Controls designed to influence flows of portfolio capital may inadvertently deter foreign direct investors. Even when controls are effectively implemented, they impose administrative costs. There are also concerns regarding model robustness: Multiple equilibria, timing of constraints, under-borrowing, etc. (Schmitt-Grohé and Uribe 2016; Benigno et al. 2011).

Policy makers also have other levers such as fiscal policy and, in general, there are complementarities-substitutions to other policies. Although the inherent fragility of financial intermediaries—such as the mismatch between their liquid liabilities and illiquid assets—suggests the need for some government protection from volatile capital flows, for example, prudential domestic regulation and effective monetary and fiscal policies can fulfill this role.

McKinnon and Pill (1996) note, "*often indirect methods will suffice. Reserve requirements (implicit taxes on intermediation) imposed on the banks' foreign borrowing, plus very tight rules governing the net foreign exchange exposure of banks and other financial institutions, can reduce risk taking directly while having the incidental effect of restricting capital inflows.*" Banks in Latin America, for example, have dealt with currency mismatch with regulation. Hedging markets have also slowly developed, Brazil being an important example (Upper and Valli, 2016).

4 Concluding Remarks

In policy circles, one of the legacies of the Global Financial Crisis has been a reassessment of the potential for non-conventional policy tools to curb imbalances that can trigger financial crises and sudden stops. Because of this new view, capital controls have, once again, been seen as a policy tool worth considering in the toolbox. Such a view has been backed by academic work that characterizes environments in which cyclical capital controls are desirable for their welfare implications by reducing the probability of financial crises. This view, however, is far from being accepted by the profession and much debate remains in terms of the effectiveness of these policy instruments.

In this paper we have aimed at contributing to this debate by addressing both positive and normative features of capital controls. On the positive front, our strongest efforts were devoted to describing the key stylized facts observed from a brand new dataset on the use of *de jure* controls for a panel of EMEs along the intensive margin so as to get a better picture of how these policy tools have been used. Our view is that any meaningful test for a theory of capital controls needs to able to account for these stylized facts.

The key finding in our work is that controls display certain statistical properties that makes us label them as "sticky" and that the workhorse model of pecuniary externalities is, by and large, unable to reproduce. Furthermore, we show that a simple extension based on (reduced form) Ss costs has the ability to get the model much closer to the data.

Our broad view of this result is *not* that the workhorse model is unsuitable for empirical analysis. Instead we subscribe to a more benign view that calls for a richer set of policy constraints needed when considering optimal use of optimal capital controls, which we believe the Ss costs capture in a reduced form.

Our work has, nonetheless, been silent about the formal microfoundations of such costs and went only as far as to discuss some of the possible deeper causes. In that regard, an obvious further avenue that comes out of our work is the formal modeling of these costs.

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Tables and Figures

Table 1: Baseline Parameters

Parameter	Value	Description
κ	0.3328	Parameter of collateral constraint
σ	2	Inverse of intertemporal elast. of subst.
β	0.91	Subjective discount factor
r	0.04	Annual interest rate
ζ	0.83	Intratemporal elast. of subst.
a	0.31	Weight on tradables in CES aggregator

Note: These are the same parameters as in in Bianchi (2011).

Table 2: Welfare analysis

	Consumption equivalence	
K	λ^{UR}	λ^{S-s}
0	0.135%	0.000%
0.01	0.082%	0.019%
0.02	**0.066%**	**0.037%**
0.1	0.000%	0.135%

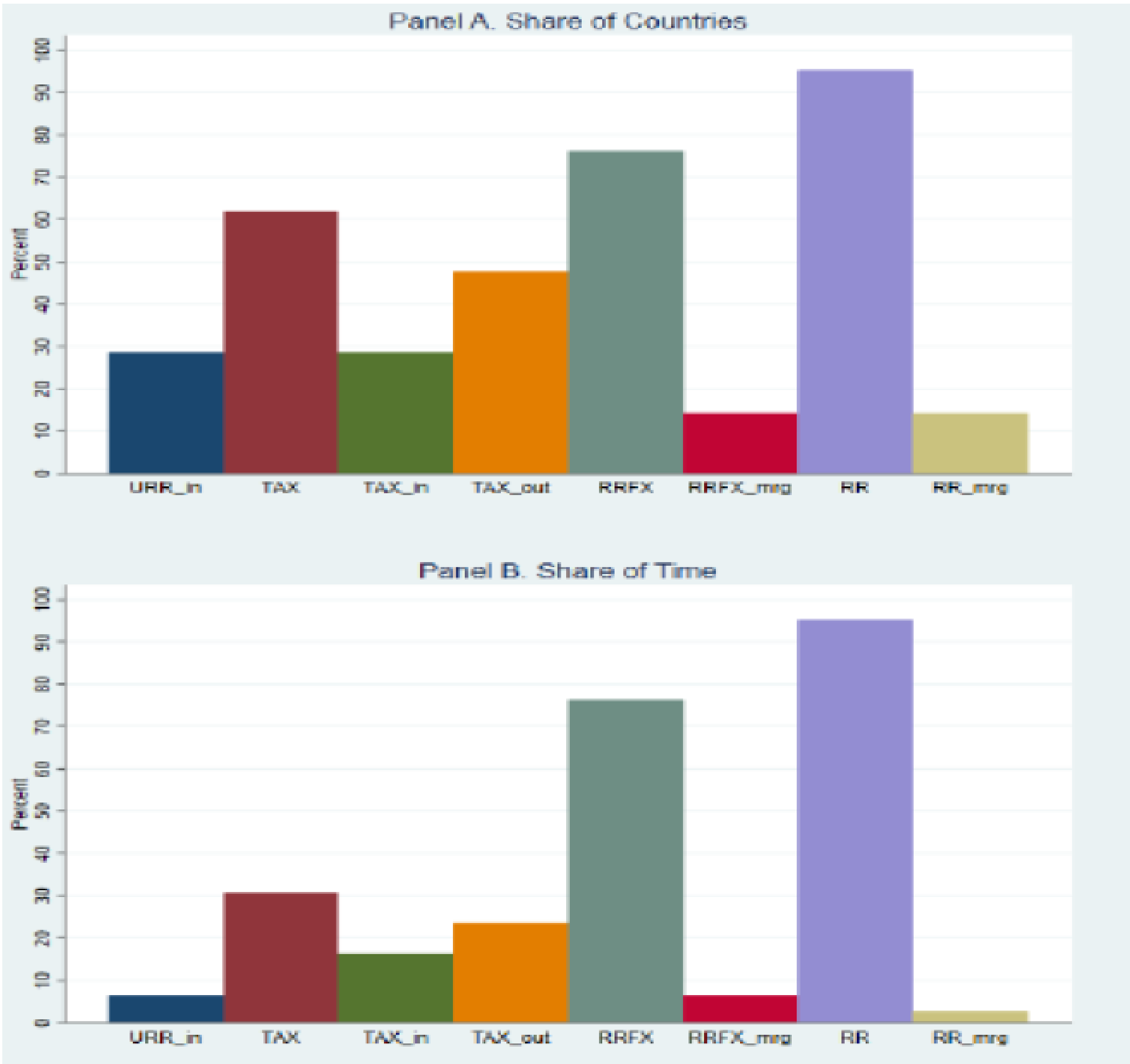
Note: The first column reffers to different values of the fixed (S-s) cost, K. The case for $K = 0$ is the same as the Ramsey's Planner economy in the baseline model. When $K = 0.1$, there is no activation in any period of time, which is isomorphic to the unregulated economy in the baseline model. The second column, λ^{UR}, shows the consumption equivalence for the unregulated economy to have the same welfare than the S-s economy with parameter K. The third column, λ^{S-s}, shows the consumption equivalence for the S-s economy, for each value of K, to have the same welfare than the Ramsey Planner's economy in the Baseline model.

Table 3: Share of each capital control instrument over the total amount of instruments per country.

	Price-Based				Non Price-Based	
Country	URR	Taxes	Quantitative	Prohibitions	Authorizations	Others
Argentina	16.40%	0.00%	27.87%	0.00%	28.31%	27.42%
Brazil	0.00%	13.20%	15.40%	8.56%	17.85%	44.99%
Chile	5.68%	8.65%	21.89%	16.49%	32.97%	14.32%
China	0.00%	0.00%	14.40%	19.15%	30.33%	36.12%
Colombia	7.05%	0.00%	18.27%	3.21%	28.53%	42.95%
Czech Republic	0.00%	0.00%	23.63%	0.00%	15.38%	60.99%
Ecuador	0.00%	32.29%	27.08%	0.00%	0.00%	40.63%
Hungary	0.00%	0.00%	15.00%	0.00%	30.00%	55.00%
India	0.00%	0.00%	28.15%	10.18%	28.38%	33.30%
Indonesia	0.00%	0.00%	29.01%	25.00%	4.94%	41.05%
Israel	4.35%	0.00%	36.23%	14.49%	18.84%	26.09%
Korea	0.00%	0.00%	27.71%	3.03%	36.36%	32.90%
Malaysia	0.00%	1.41%	34.81%	3.53%	32.86%	27.39%
Mexico	0.00%	0.00%	25.75%	9.51%	18.79%	45.94%
Peru	0.00%	37.50%	37.50%	0.00%	0.00%	25.00%
Philippines	0.00%	0.00%	16.78%	9.80%	30.07%	43.36%
Poland	0.00%	0.00%	21.78%	3.51%	38.41%	36.30%
Russia	0.00%	0.00%	15.65%	3.67%	36.92%	43.77%
South Africa	0.00%	0.00%	28.04%	2.17%	40.43%	29.35%
Thailand	0.00%	0.00%	33.98%	7.04%	36.62%	22.36%
Turkey	0.00%	0.00%	32.88%	7.80%	11.86%	47.46%
All (Average)	1.52%	1.63%	24.45%	8.29%	28.35%	35.77%

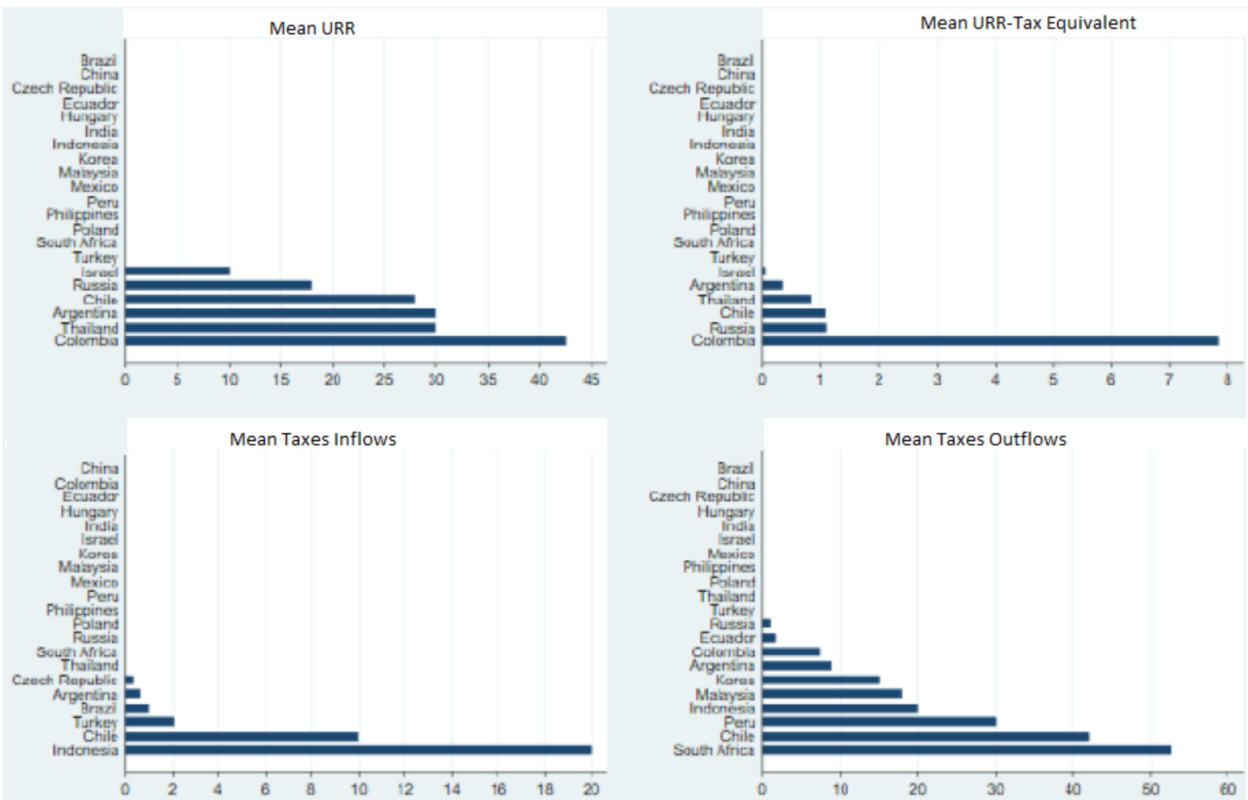
Note: The sable shows for each country the share of each instrument over the total. Thus, for each country, the sum of each row is equal to one. The first for instruments correspond to Price-based capital controls, and the last two to Non-priced based.

Figure 1: Use of Capital Control & Macro Prudential Instruments



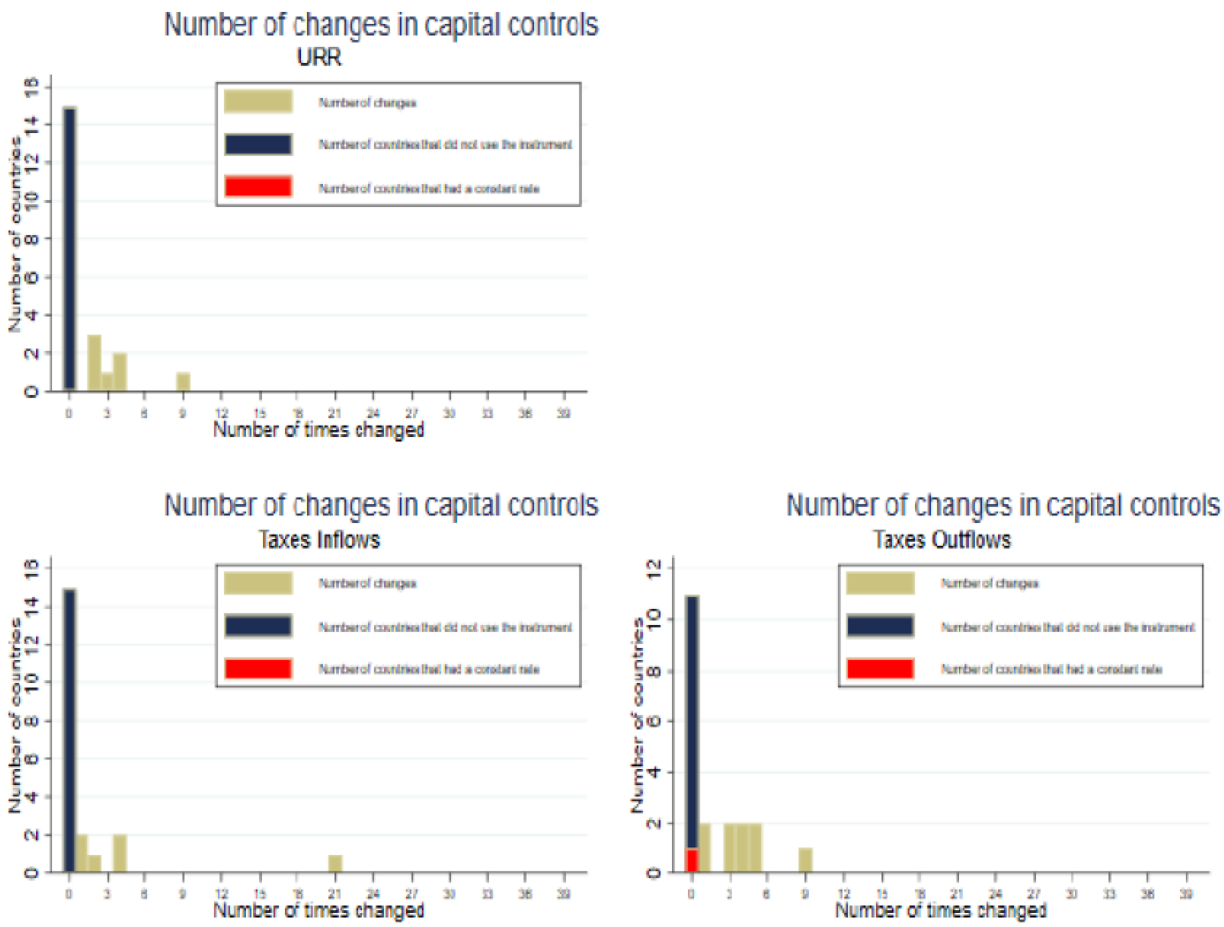
Note: In Panel A, the bars depict the share of countries that have used (i.e. instrument is not 0), even for a single quarter, any of the instruments out of the 21 countries in the sample. In panel B, the bars depict the share of periods in which an instrument was used. The sample was taken from 1995q1 to 2014q4, the maximum total of quarters is 80 (100%).

Figure 2: The Intensive Margin of Capital Control & Macro Prudential Instruments



Note: Each of the panels correspond to a different instrument (URR, URR-Tax equivalent, Taxes on Inflows and Taxes on Outflows). The bars represent the average value of the instrument for the entire sample in each country. Only the periods in which the instrument was active were considered.

Figure 3: Frequency of changes in capital controls

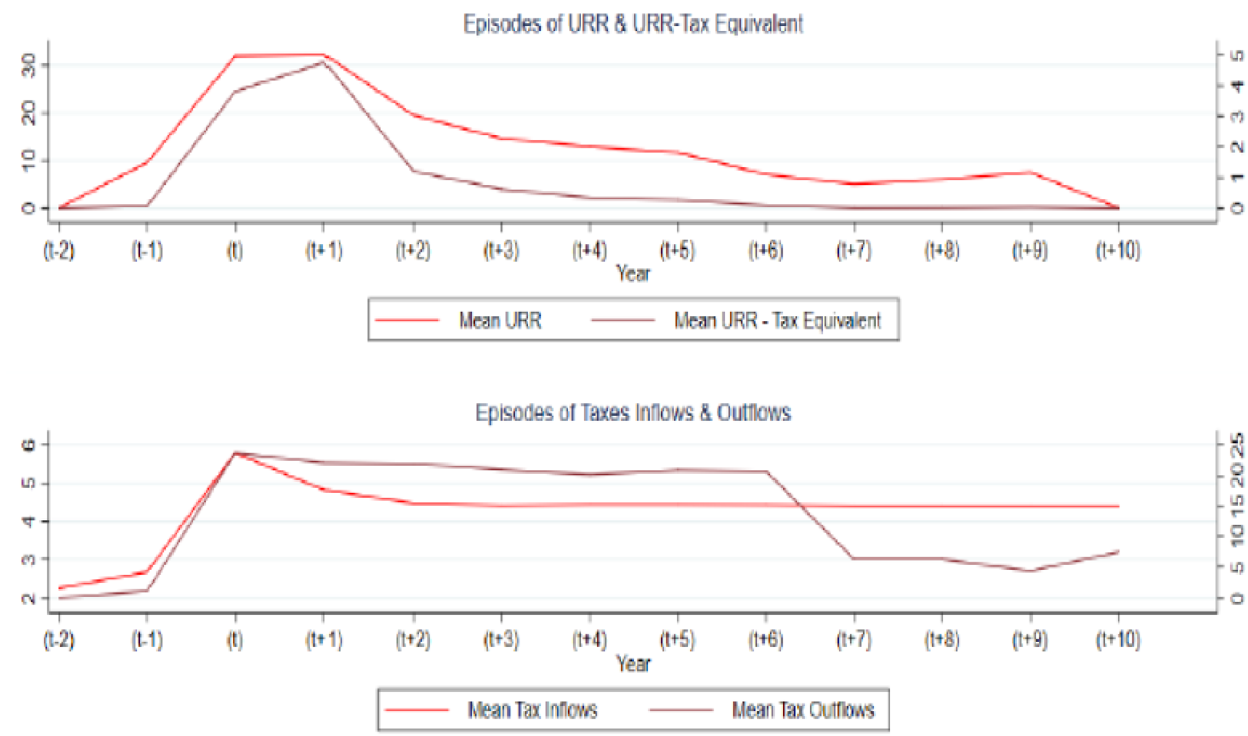


Note: A movement is shown when the value of an instrument in t was different than in $t-1$. For example, a country that used the instrument once during the sample must show 2 movements (cream bars). The countries that at the beginning of the sample, 1995-Q1, had the instrument turned on and did not make any changes until the end of the 2014-Q4 sample are coded in red. The countries that did not use the instrument at any time in the sample are shown in blue.

Figure 4: Quarterly Episodes of Capital Controls

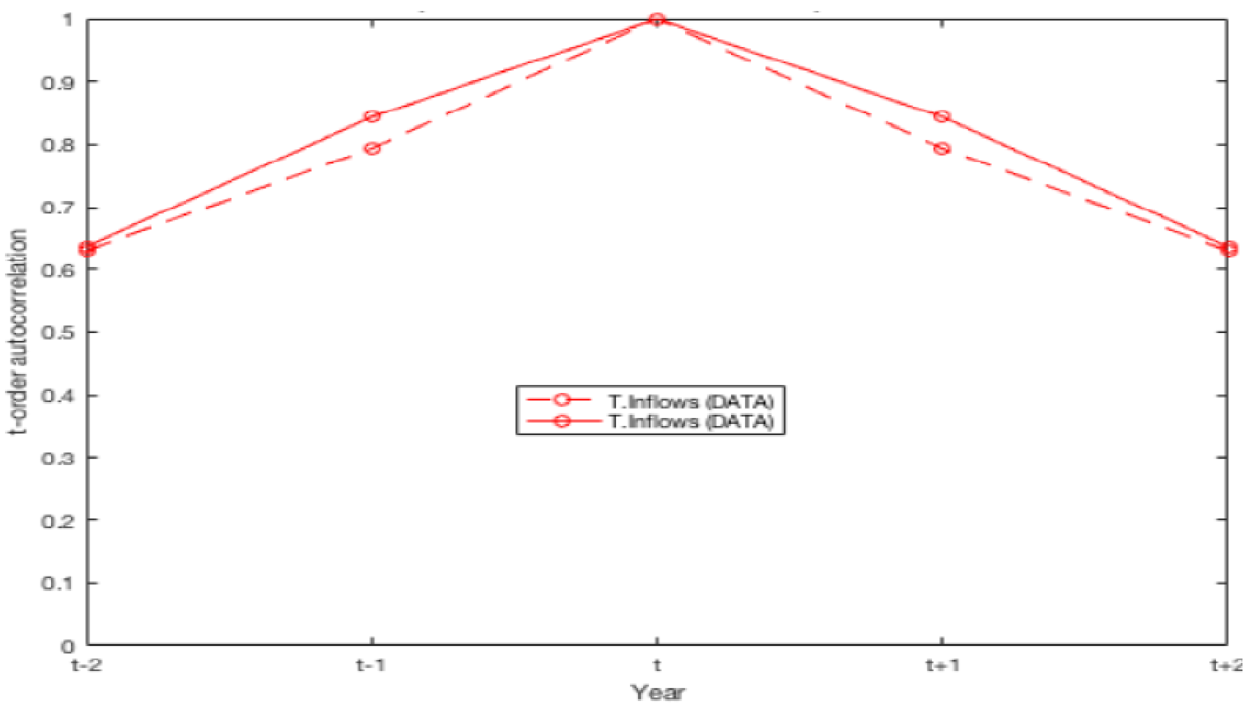
Note: The beginning of an episode was defined when for a given policy instrument at quarter t, x_t, we have that: $x_t > 1.1x_{t-1}$. Then the values of each episode were averaged from $t-2$ to $t+10$.

Figure 5: Annual Episodes of Capital Controls



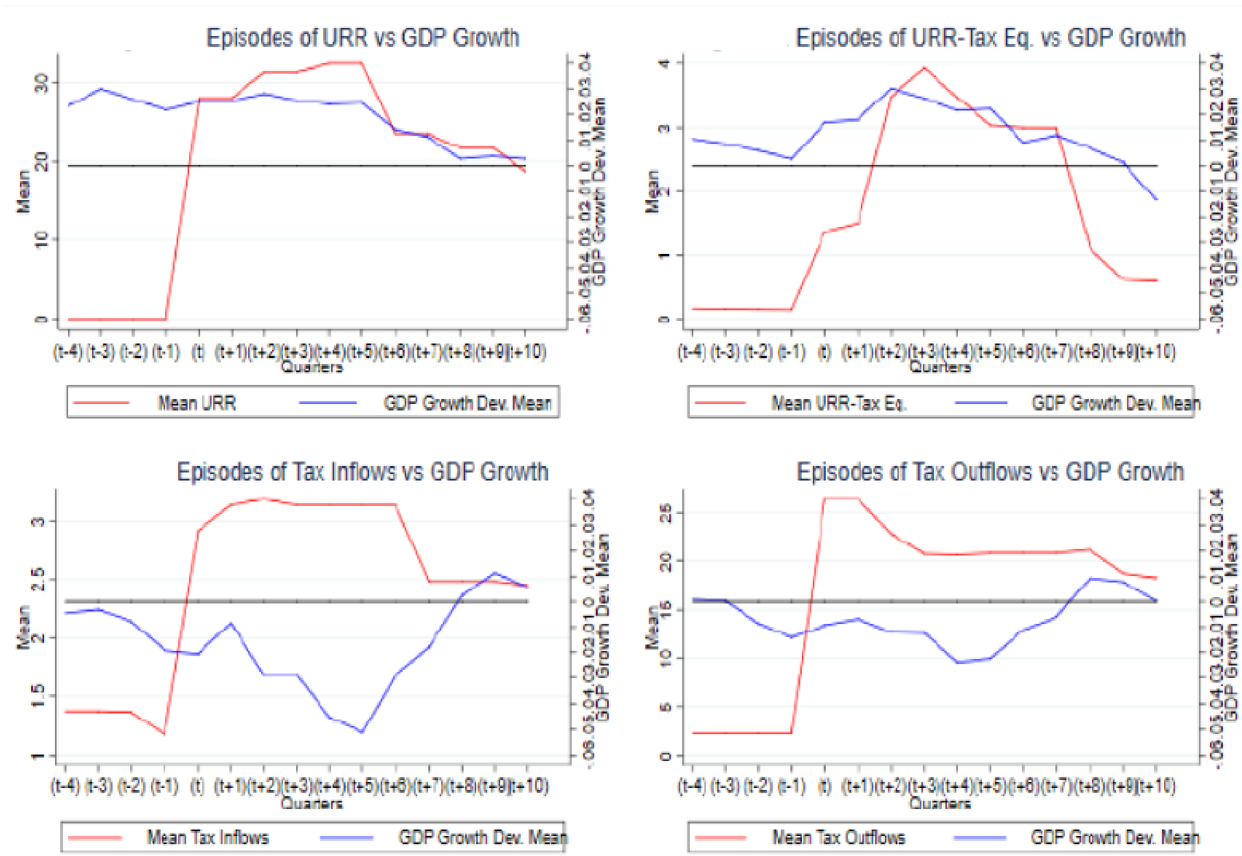
Note: The beginning of an episode was defined when for a given policy instrument at year t, x_t, we have that: $x_t > 1.1x_{t-1}$. Then the values of each episode were averaged from $t-2$ to $t+10$.

Figure 6: Serial Correlation of Capital Controls



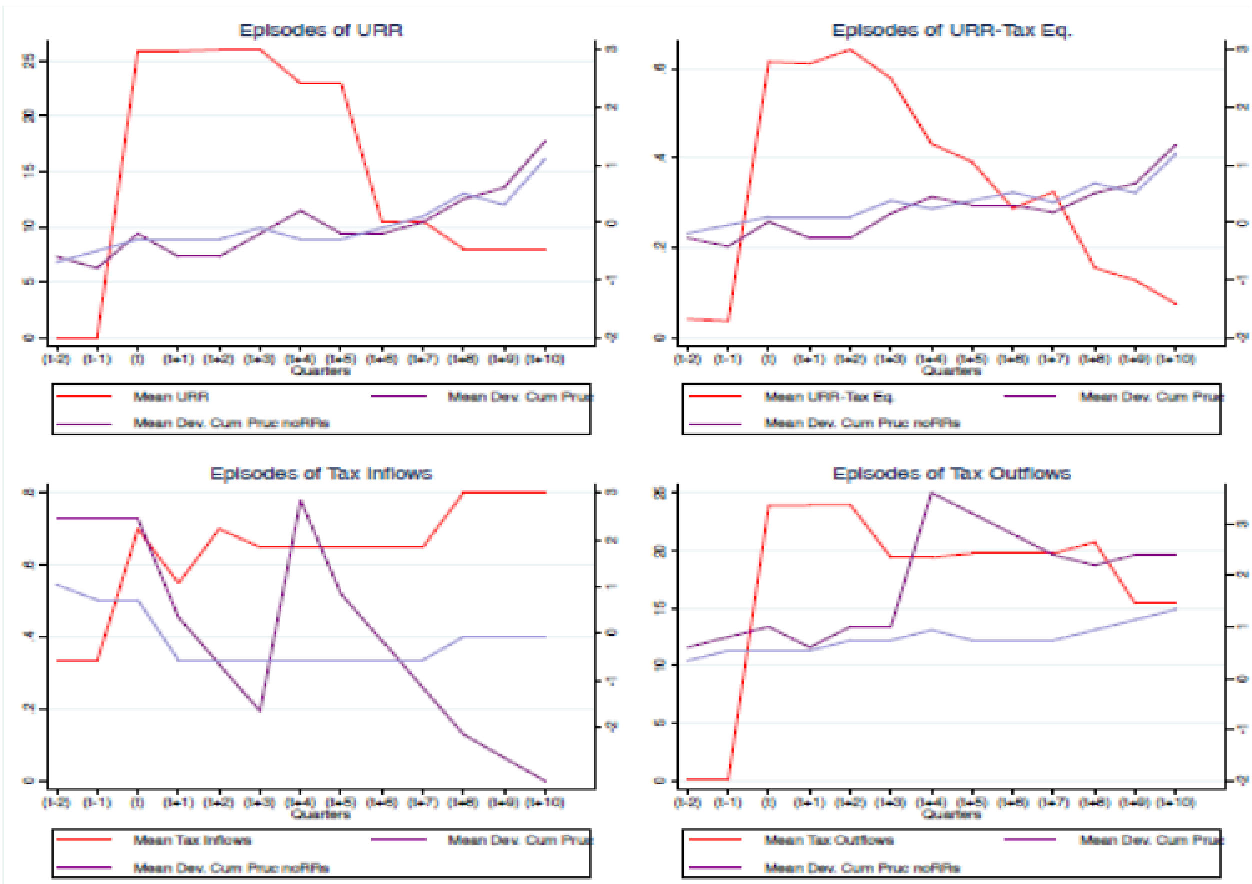
Note: The solid line represents the cross-country mean autocorrelation of order $t-j$ of taxes on inflows. The dashed line represents the same variables on taxes on outflows.

Figure 7: Episodes of Capital Control & Macro Prudential Instruments and the Business Cycle



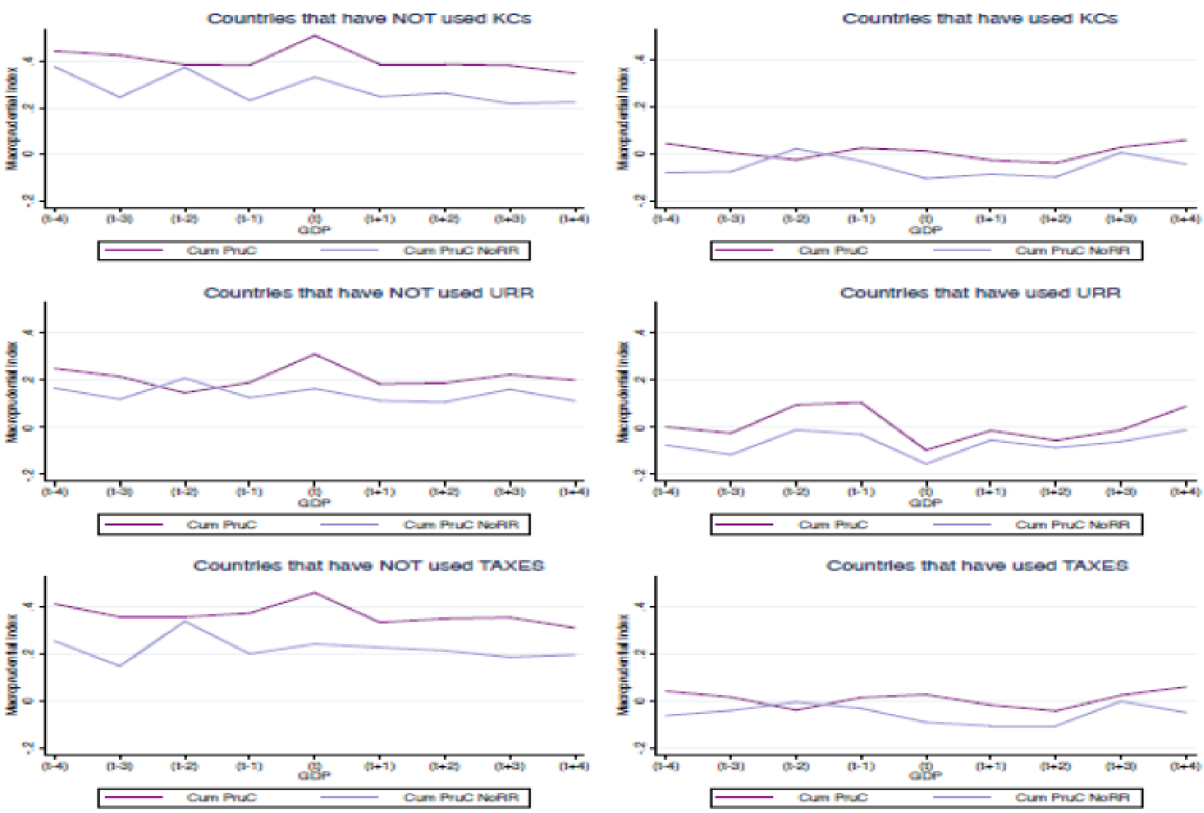
Note: The Figure shows the episodes described in Figure 4along with the cross-country mean deviation from the average GDP growth. The plots shown the following number of episodes: URR and URR-Tax equivalent (7), Taxes on Inflows (6) and Taxes on Outflows (11).

Figure 8: Episodes of Capital Control & Broader Macro Prudential Instruments



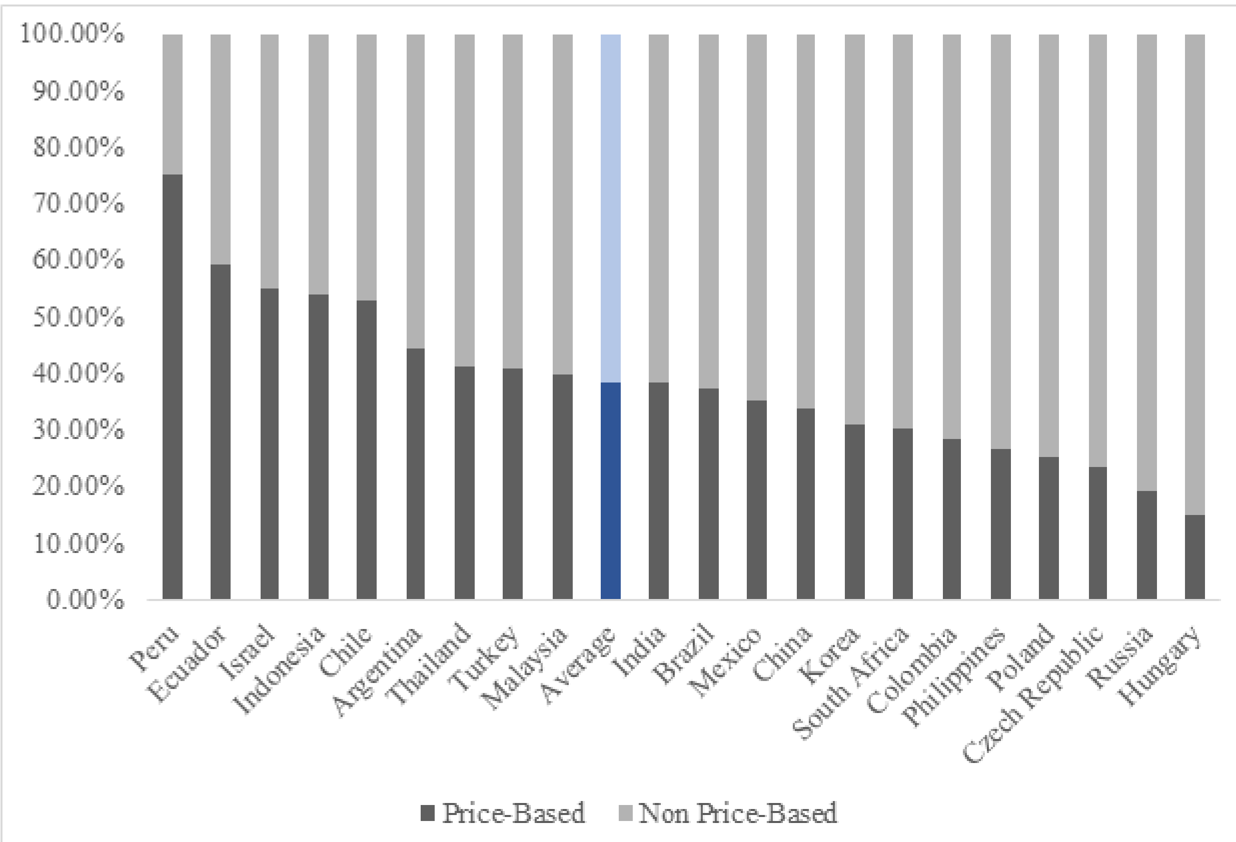
Note: The beginning of an episode (episodes are depicted by red lines) was defined when when for a given policy instrument at quarter t, x_t, we have that: $x_t > 1.1x_{t-1}$. Then the values of each episode were averaged from $t-2$ to $t+10$. The sample of episodes from 2000q1 to 2014q4 was restricted, given that the data of Cerutti et al. (2017) to match their periods. Deviations were plotted against the average of the two accumulated Indexes of Macroprudential Instruments. The first, Cum Pruc (dark purple lines), includes the 9 instruments of the database of Cerutti et al. (2017). The second, Cum Pruc noRRs (light purple lines), includes only 7 instruments omitting Reserve Requirement and Reserve Requirement in foreign exchange.

Figure 9: Serial Correlation: Broader Macro Prudential Instruments & Business Cycle



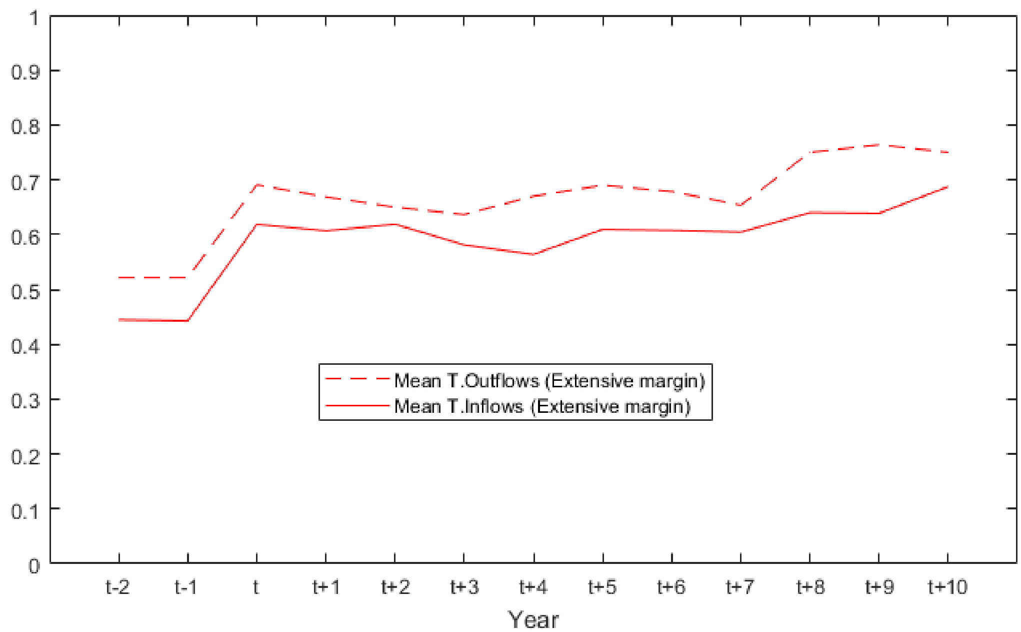
Note: The figure shows the serial correlation of the Macroprudential Instruments' Indexes and the GDP growth for each category, broken down into countries that have not used the instruments (left column of graphs) and countries that have (right column). The episodes of boom and bust correspond to the period from 2000q1 to 2014q4, given the availability of data from macroprudential instruments.

Figure 10: Share of instruments that are Price-Based and Non Priced-Based



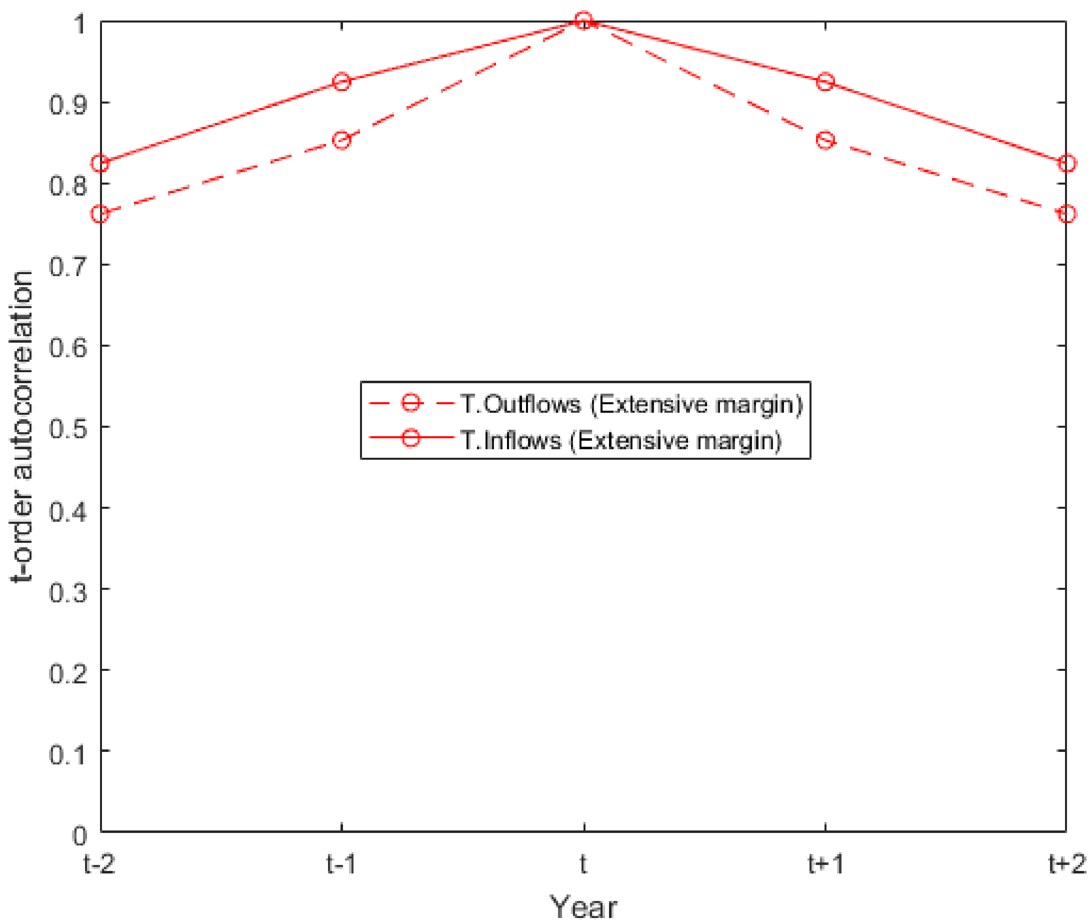
Note: The bars show, for each country, what share of instruments corresponds to non-priced based measures (dark shade) and to priced based measures (light-shade). This is based on data for the extensive margin of all instruments.

Figure 11: Annual Episodes of Capital Controls - Extensive Margin Including All Instruments (Priced-Based and Non Priced-Based)



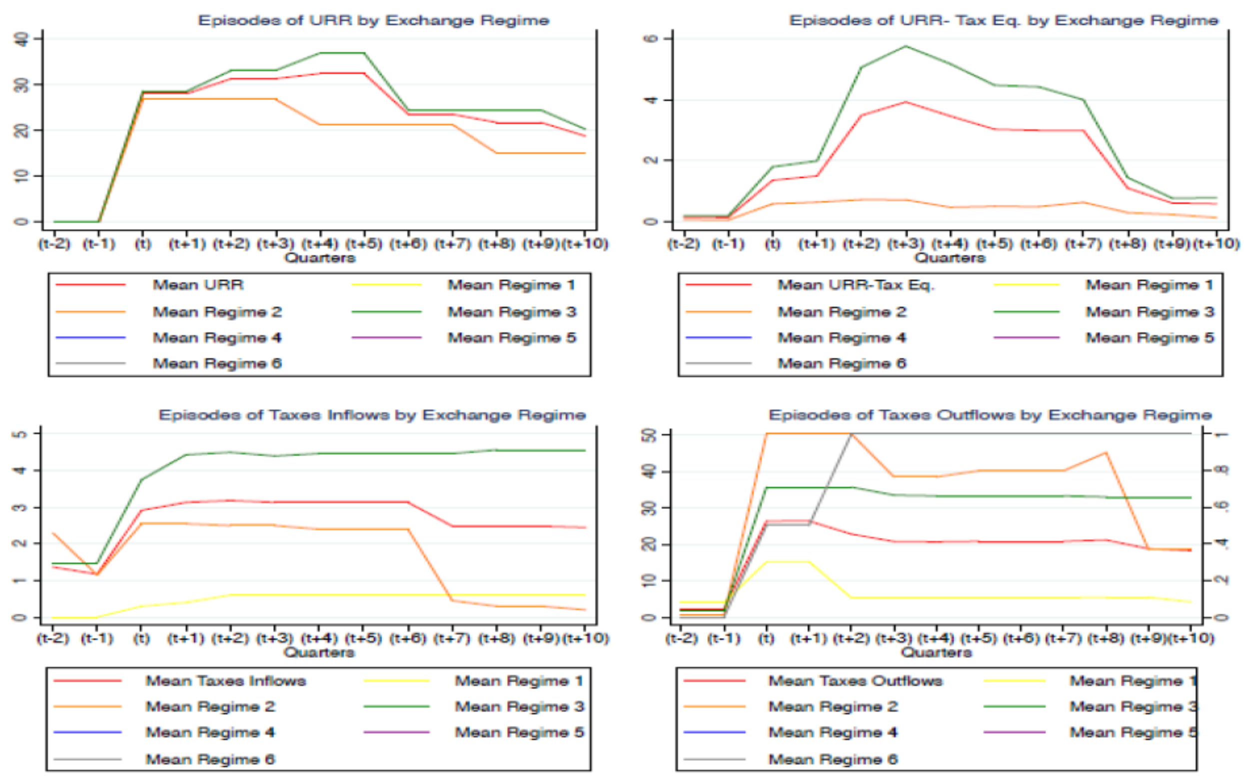
Note: The beginning of an episode was defined when for a given policy instrument at year t, x_t, we have that: $x_t > (1 + stdev(x_{t-1}))$. Then the values of each episode were average from $t-2$ to $t+10$.

Figure 12: Serial Correlation of Capital Controls - Extensive Margin Including All Instruments (Priced-Based and Non Priced-Based)



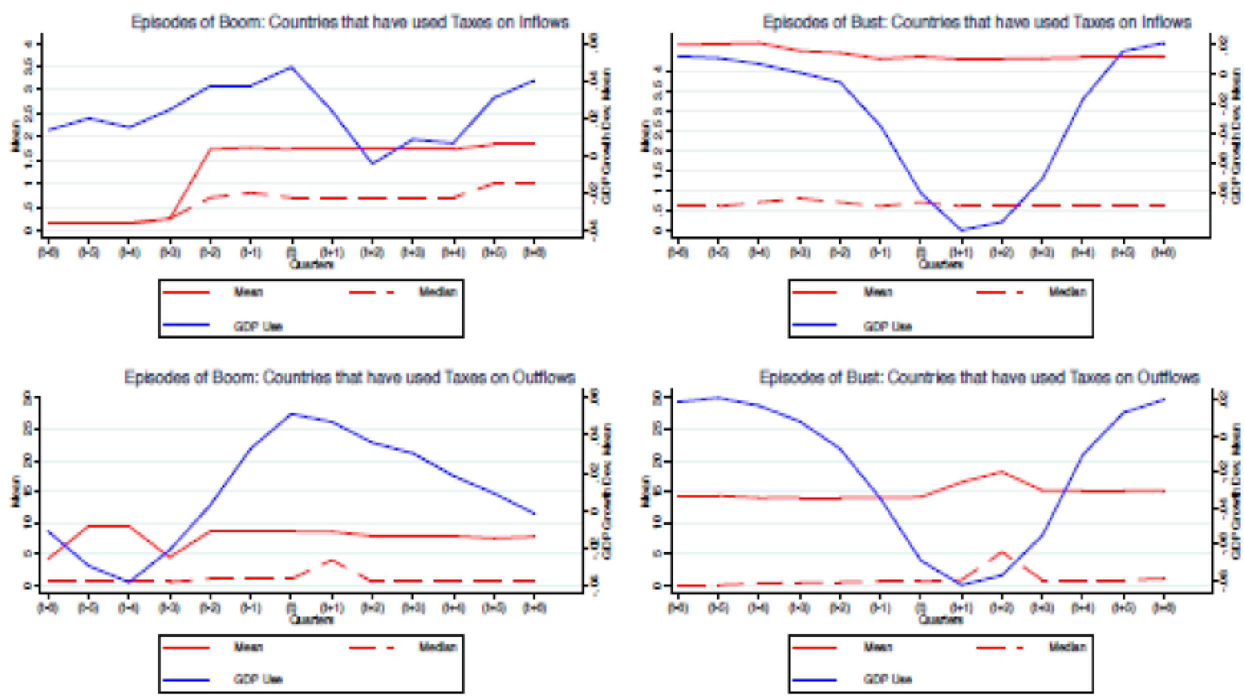
Note: The solid line represents the cross-country mean autocorrelation of order $t-j$ of the extensive margin (considering both priced-based and non-priced based instruments) of taxes on inflows. The dashed line represents the same variable on taxes on outflows.

Figure 13: Episodes of Capital Control & Macro Prudential Instruments by Exchange Rate Regime



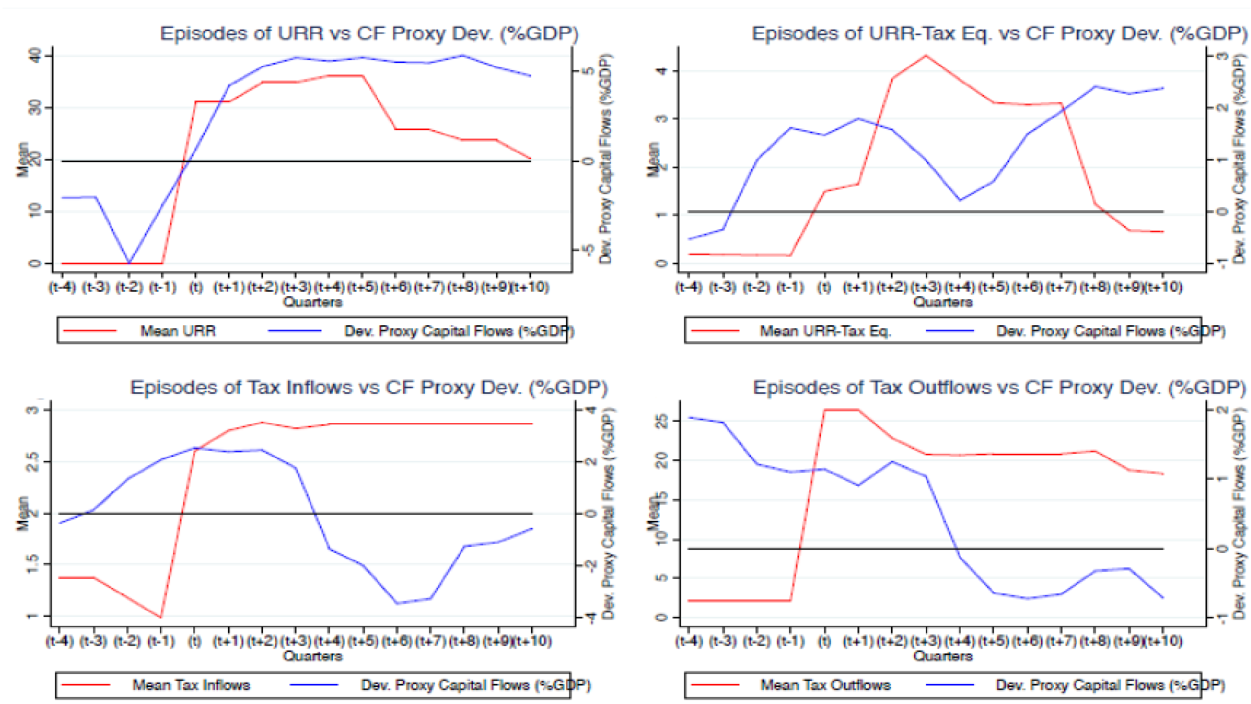
Note: The figure above shows the episodes of Figure 4, controlling by the type of exchange rate regime in accordance with Ilzetzki-Reinhart-Rogoff (IRR).

Figure 14: Episodes of Boom/Bust in GDP Growth and Capital Controls & Macro Prudential Instruments



Note: Note: The Figure shows the episodes described in Figure 4 along with the cross-country mean deviation from the average GDP growth. Here we show the episodes of booms (left column) and busts (left column) on taxes on inflows (top row) and taxes on outflows (bottom row).

Figure 15: Episodes of Capital Control& Macro Prudential Instruments and the Capital Flows Cycle



Note: The figure shows the episodes described in Figure 5 along with the deviations from the average of Capital Flows as a share of GDP.

Figure 16: Share of time with $\tau > 0$ - All periods - Benchmark Model vs Data (Unconditional)

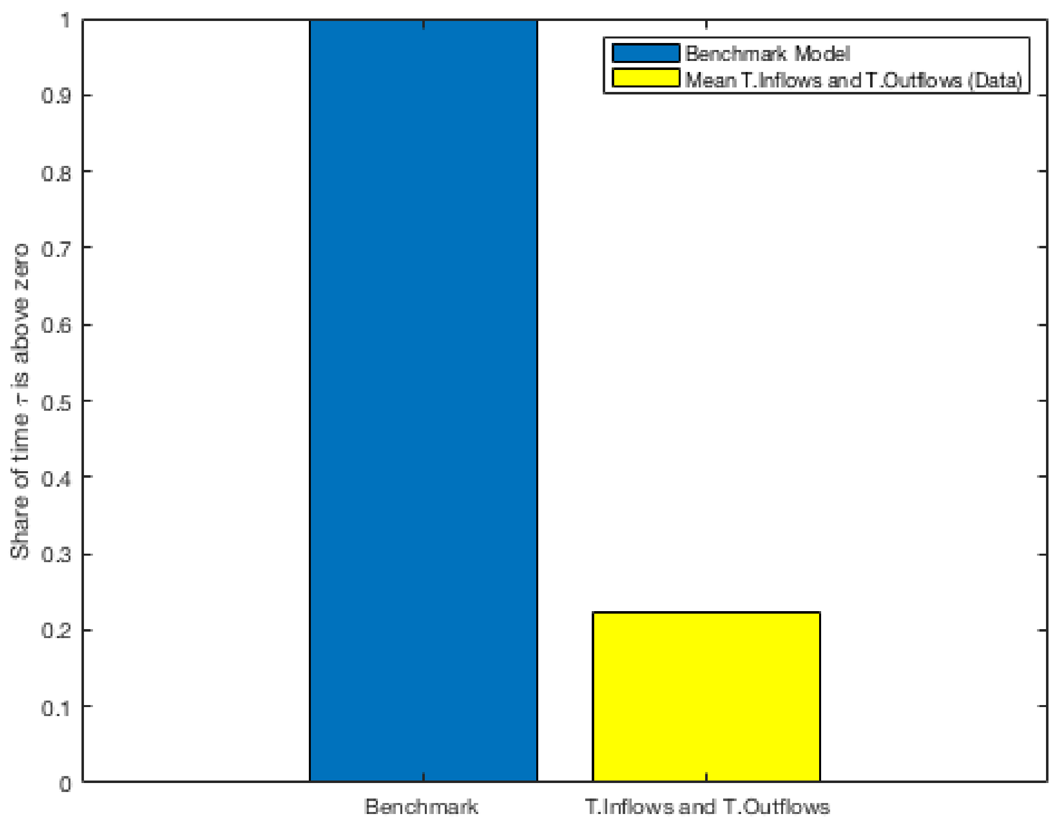


Figure 17: Mean value of τ - All periods - Benchmark Model vs Data (Unconditional)

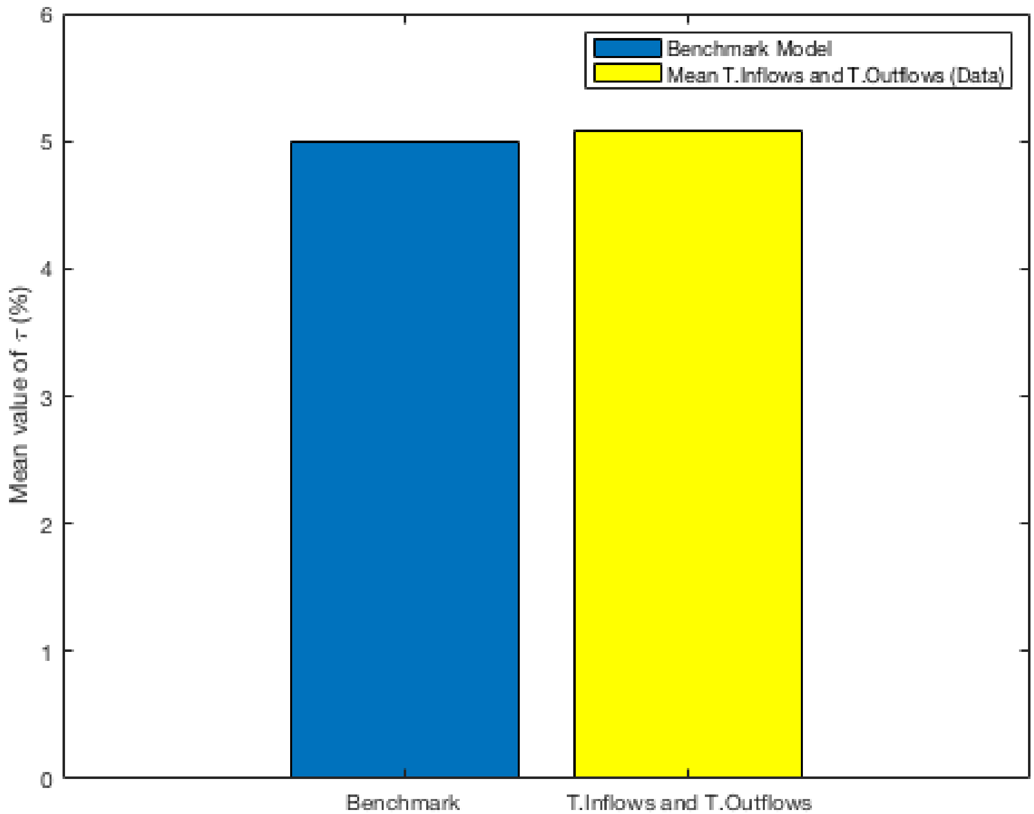


Figure 18: Number of changes in τ (20-year mean) - All periods - Benchmark Model vs Data (Unconditional)

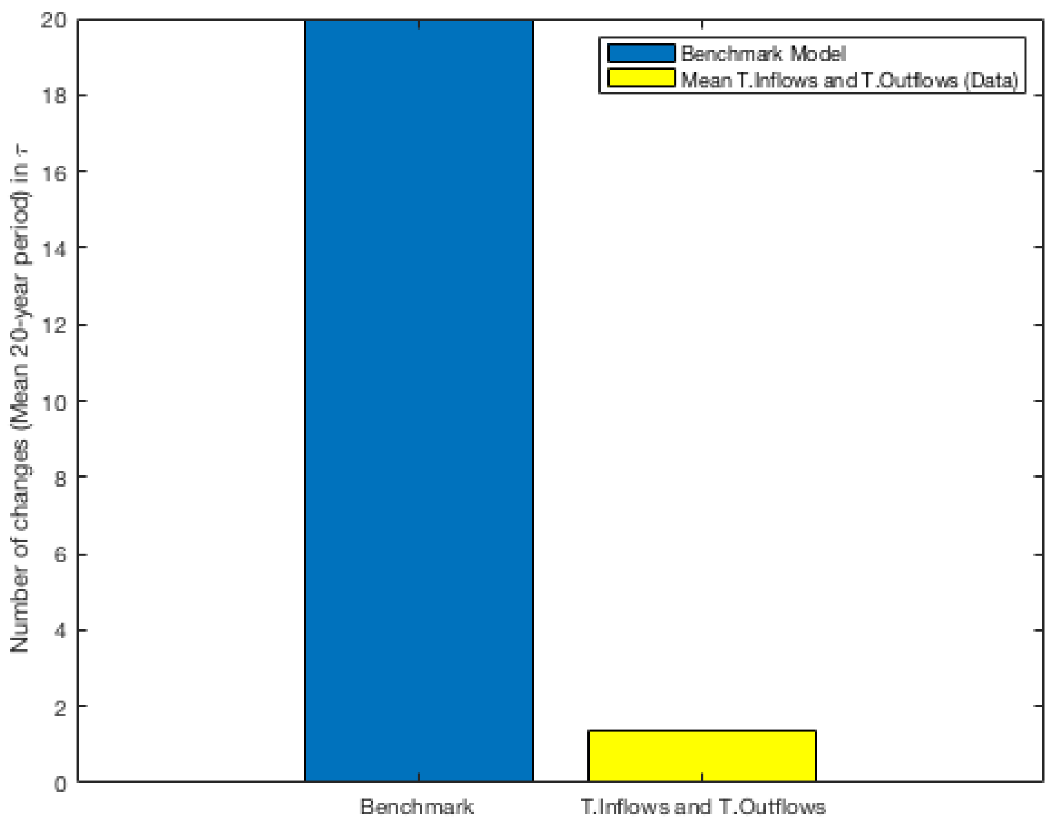


Figure 19: Autocorrelation of order t+j of τ, $j = \{-2, -1, ..., +2\}$.

Benchmark model vs Data: All periods

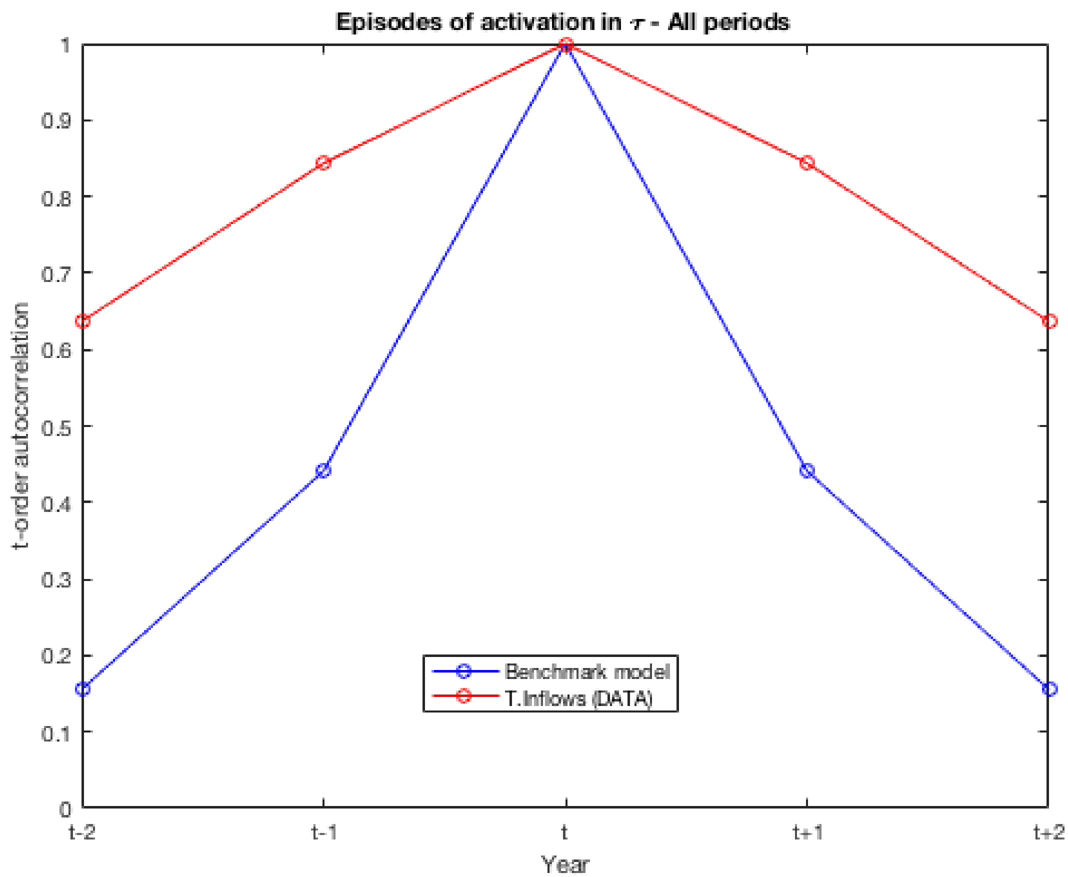


Figure 20: 20-year mean of τ in the Benchmark Model vs Episodes of use of capital controls in the data (mean of T. Inflows and T.Outflows) - All periods

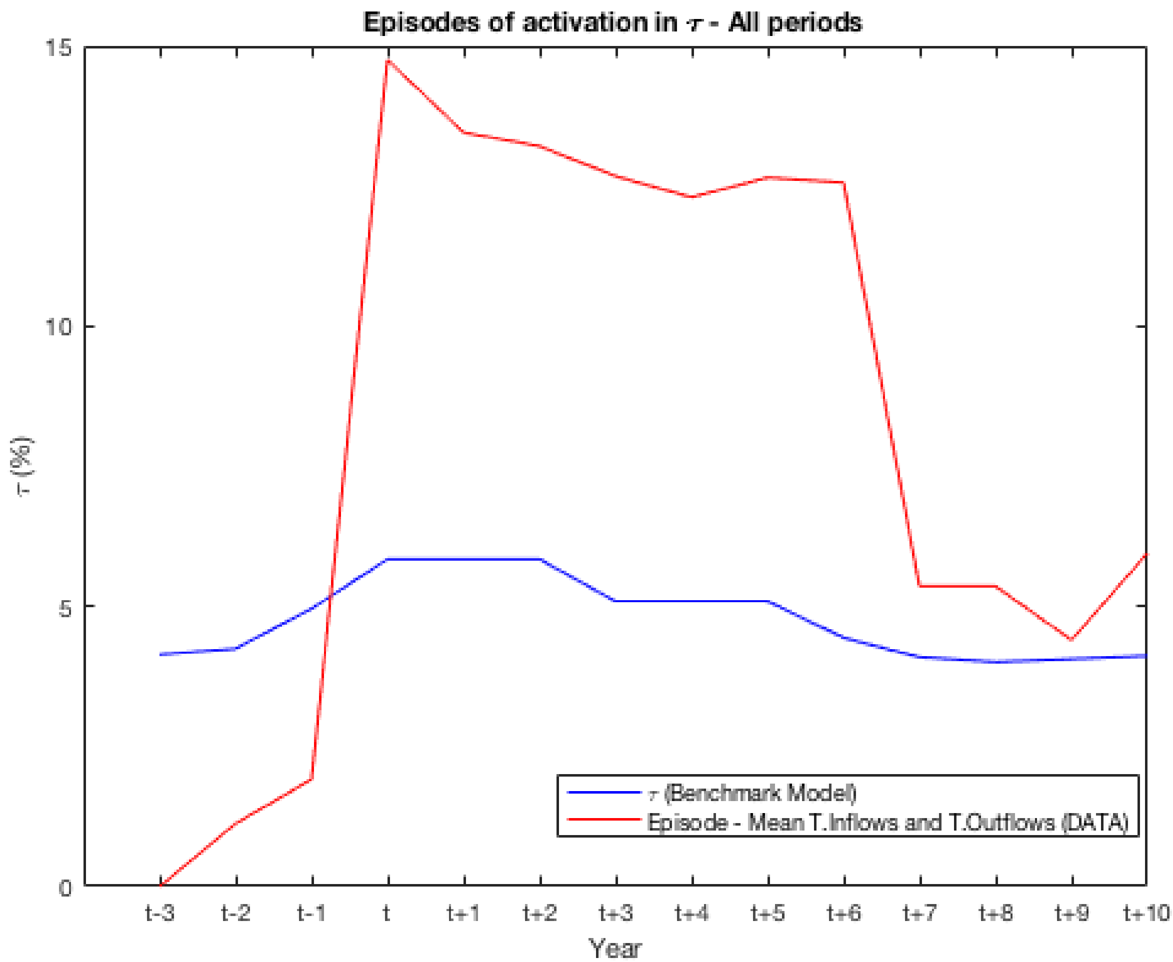


Figure 21: 20-year mean of τ vs y^T - Benchmark Model: All periods

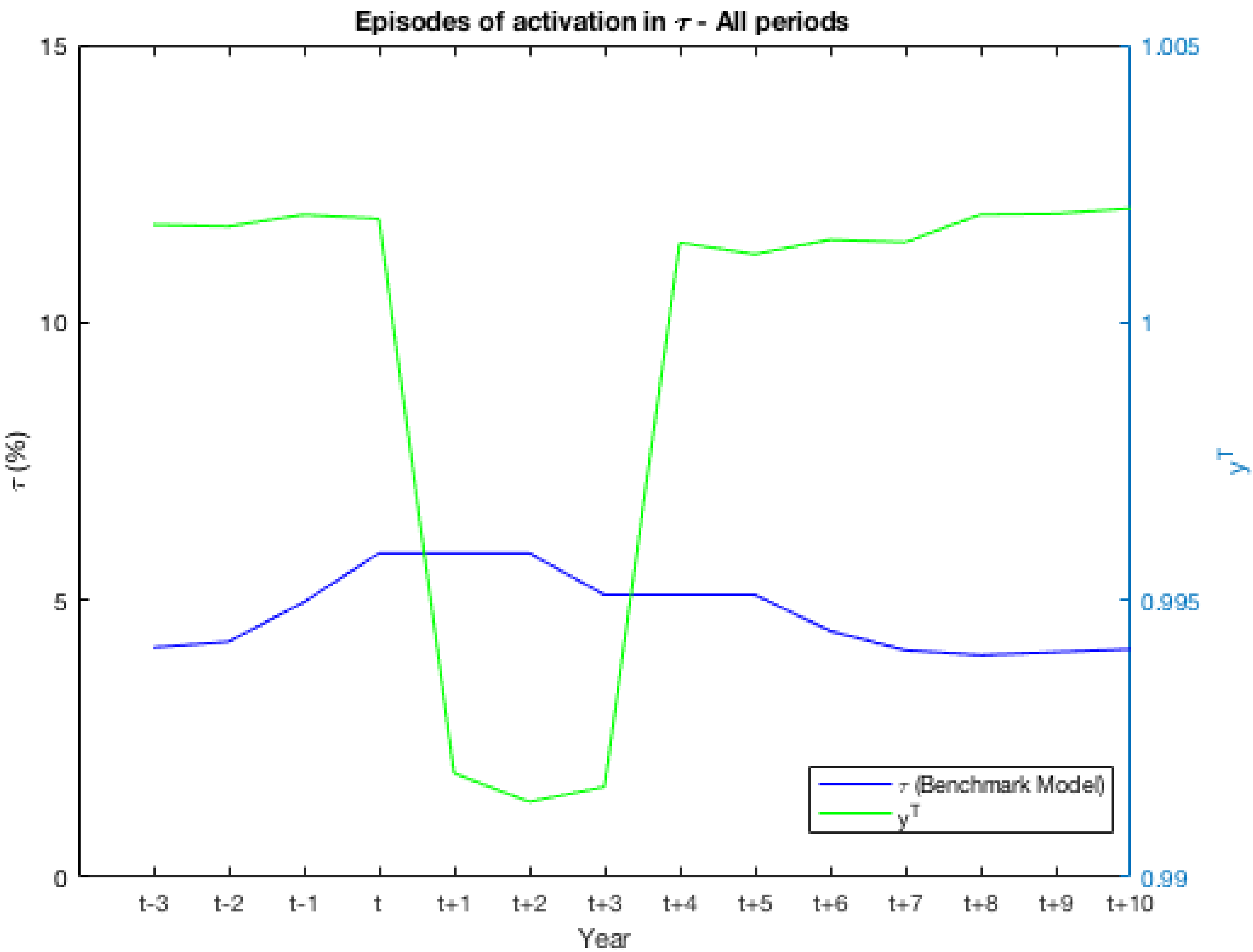


Figure 22: Share of time with $\tau > 0$ - All periods - Benchmark Model vs S-s Model vs Data (Unconditional)

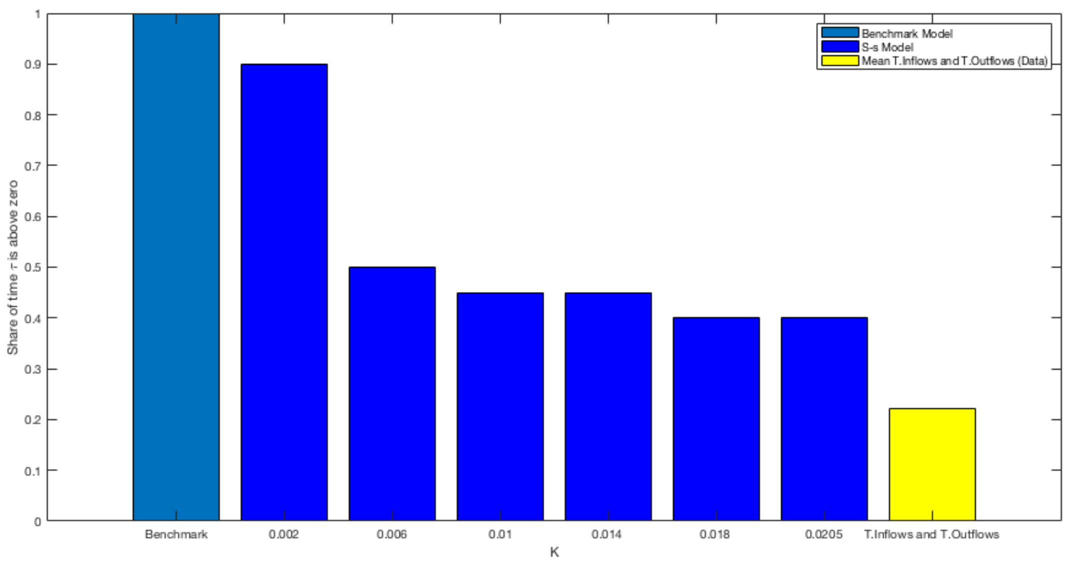


Figure 23: Mean value of τ - All periods - Benchmark Model vs S-s Model vs Data (Unconditional)

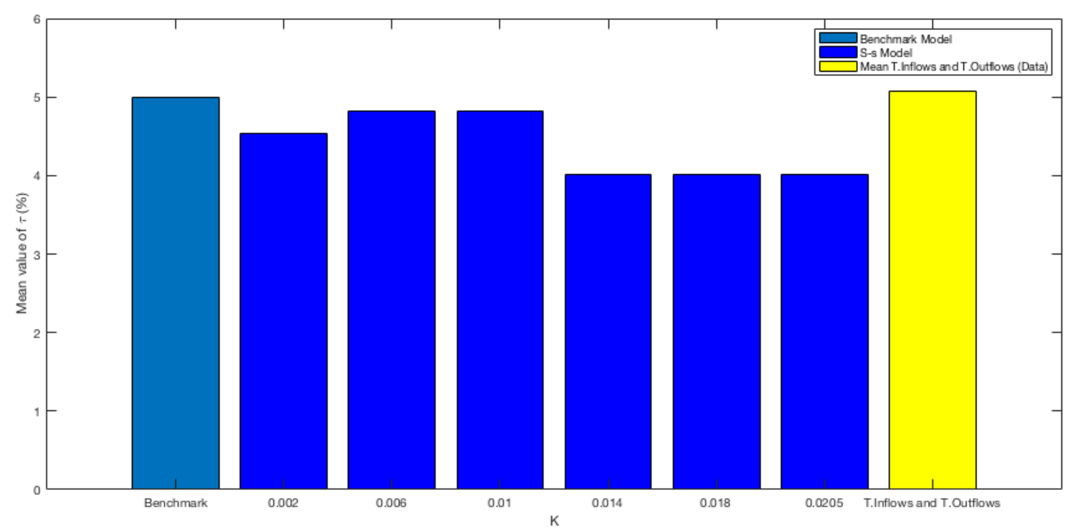


Figure 24: Number of changes in τ (20-year mean) - All periods - Benchmark Model vs S-s Model vs Data (Unconditional)

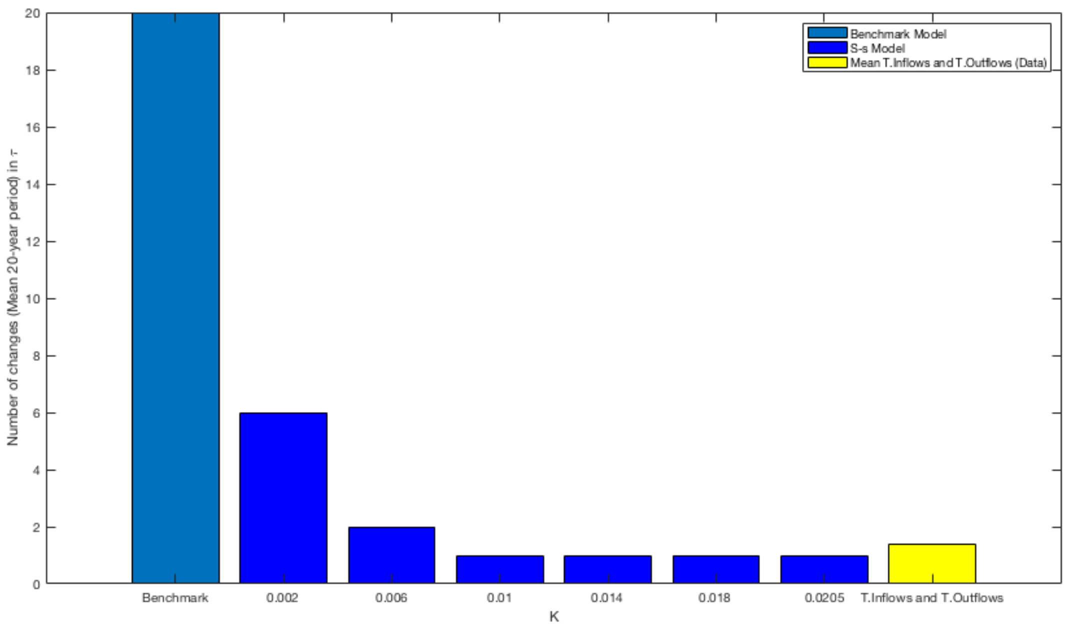


Figure 25: Autocorrelation of order t+j of τ, $j = \{-2, -1, ..., +2\}$.

Benchmark model vs S-s model vs Data: All periods

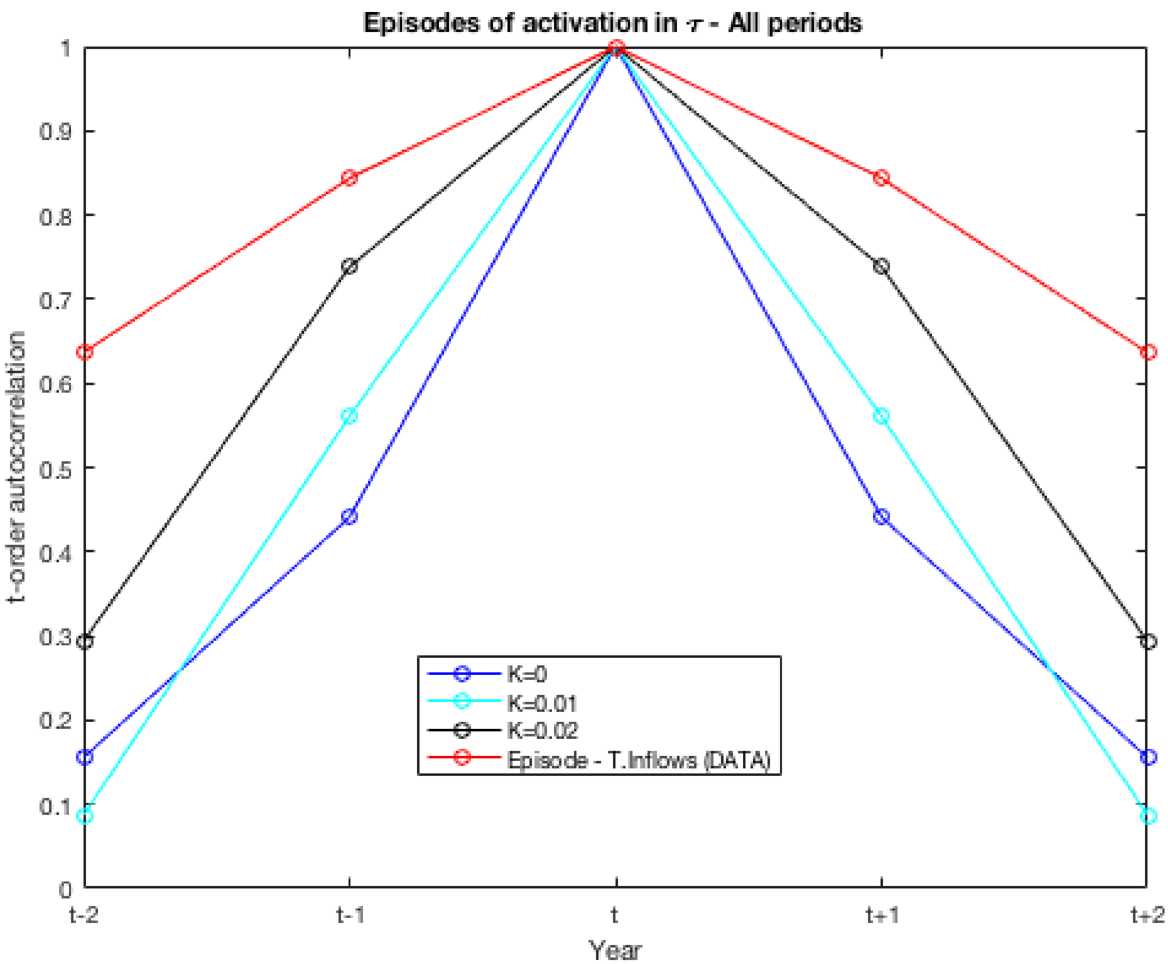


Figure 26: Mean of τ in the Benchmark Model vs S-s Model vs Episodes of use of capital controls in the data - Episodes of activation (all periods)

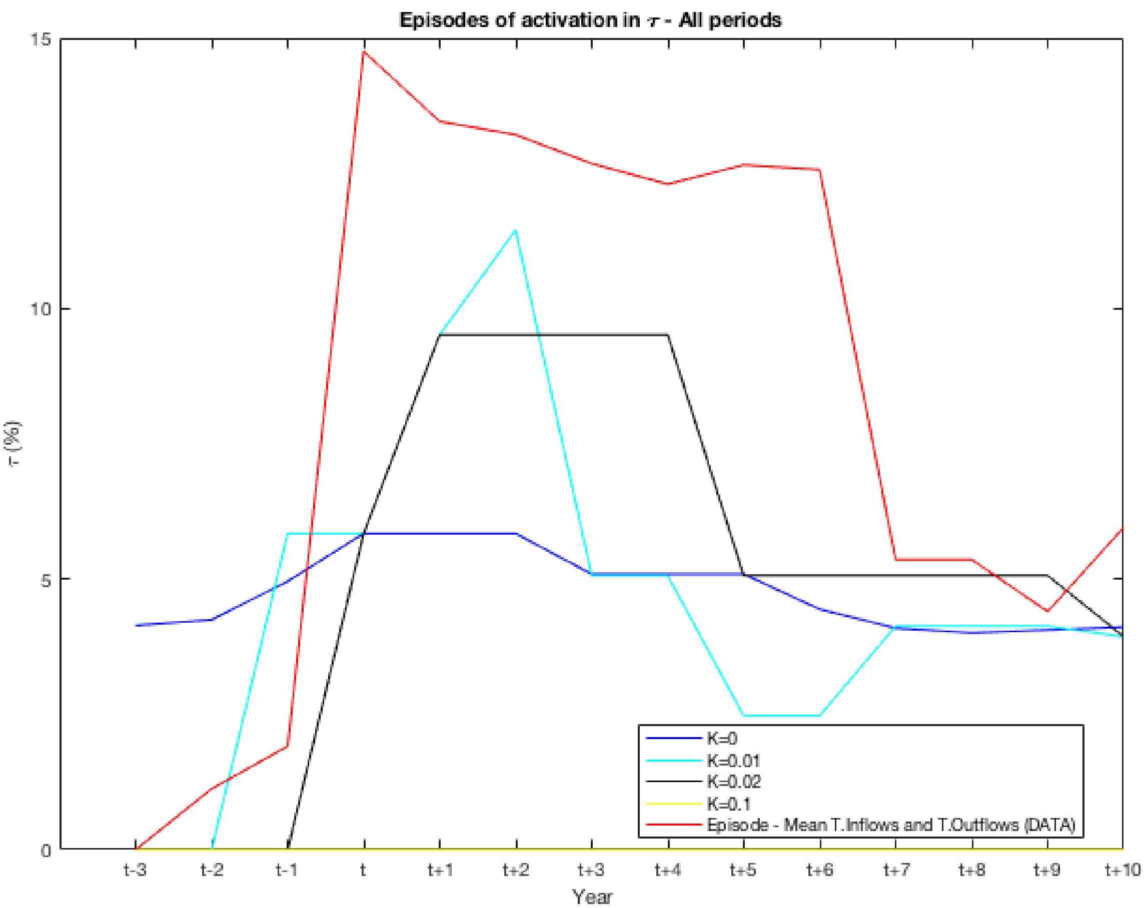


Figure 27: Mean value of τ in the S-s Model vs y_t^T

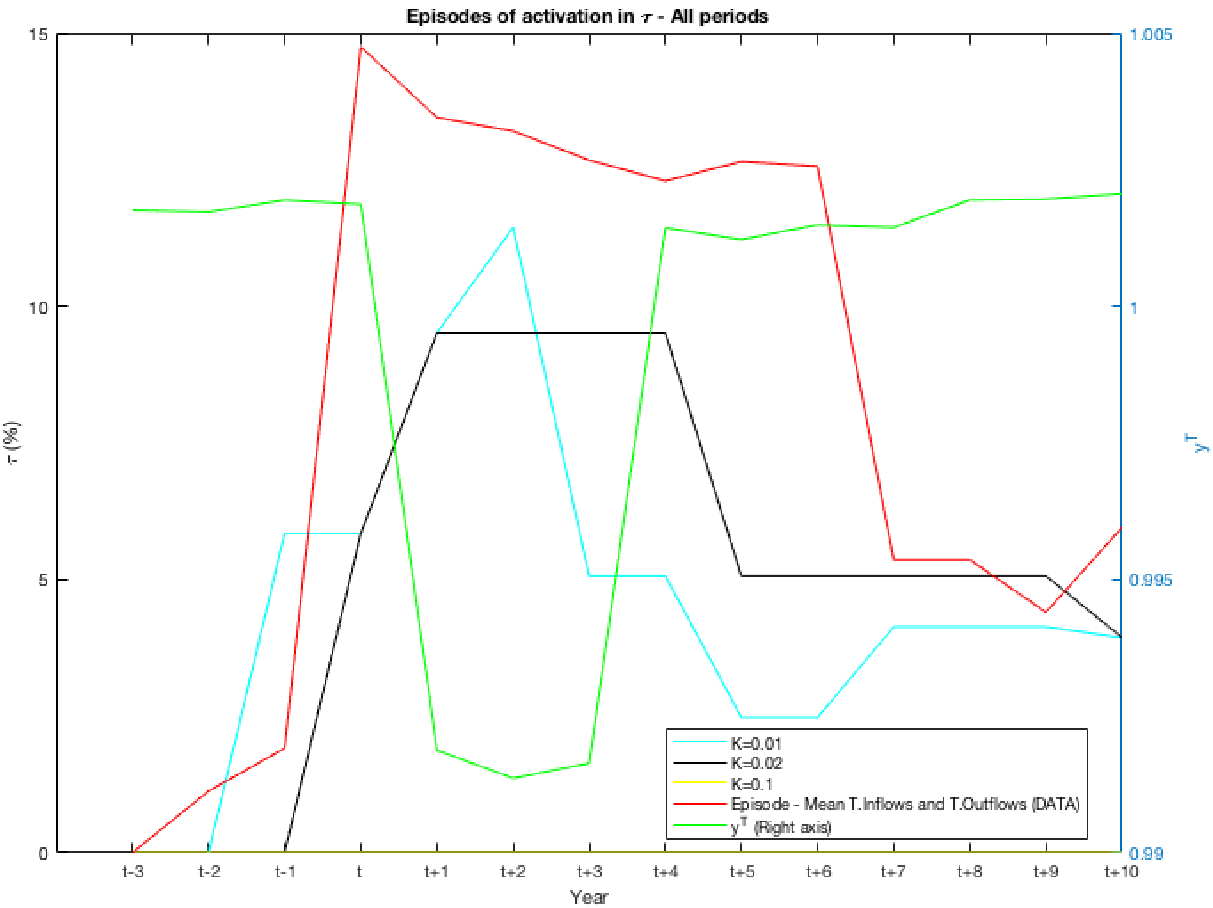


Figure 28: Share of time with $\tau > 0$ - All periods - Benchmark Model vs S-s Model vs Data (Unconditional and Conditional on Financial Crisis)

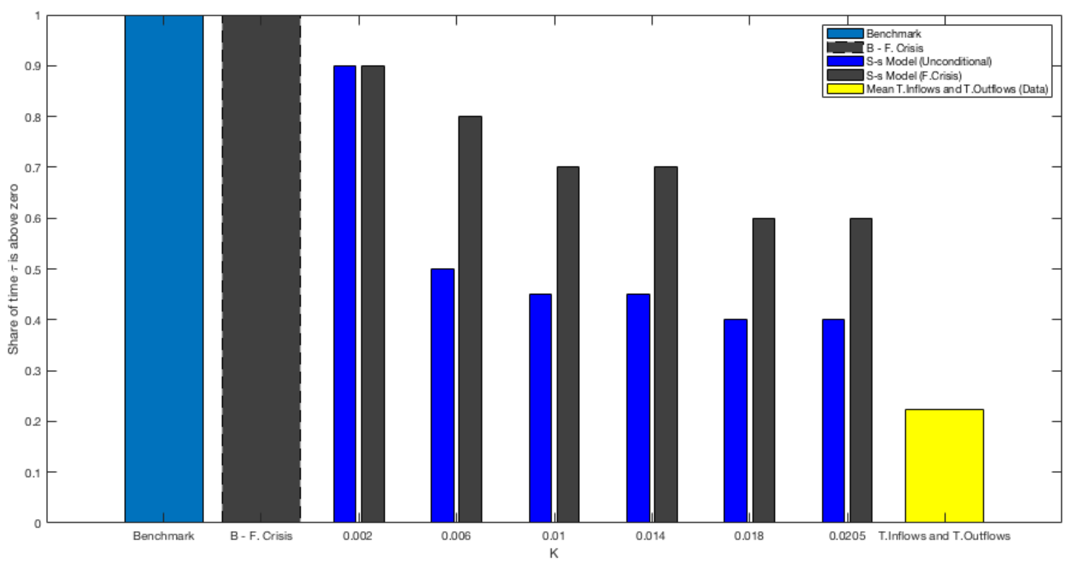


Figure 29: Mean value of τ - All periods - Benchmark Model vs S-s Model vs Data (Unconditional and Conditional on Financial Crisis)

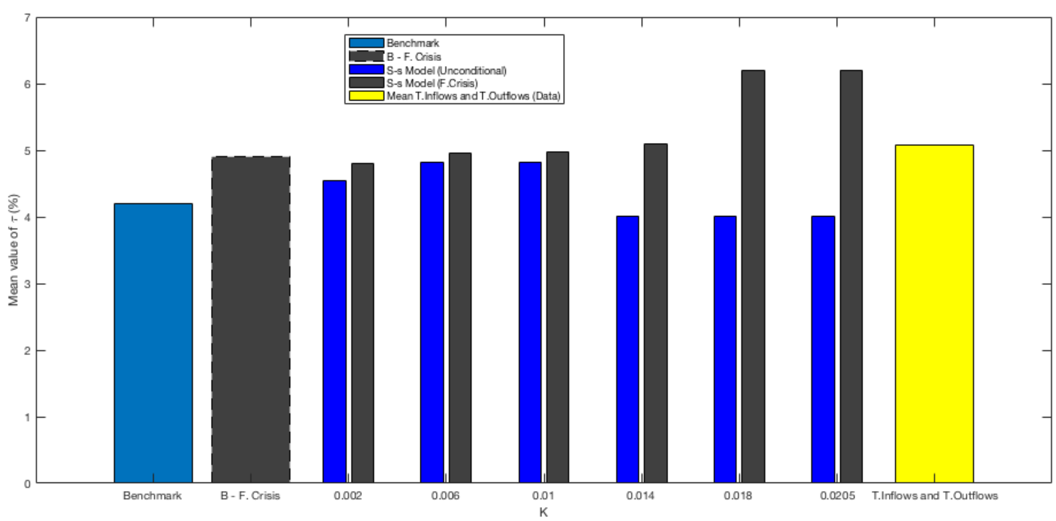


Figure 30: Number of changes in τ (20-year mean) - All periods - Benchmark Model vs S-s Model vs Data (Unconditional and Conditional on Financial Crisis)

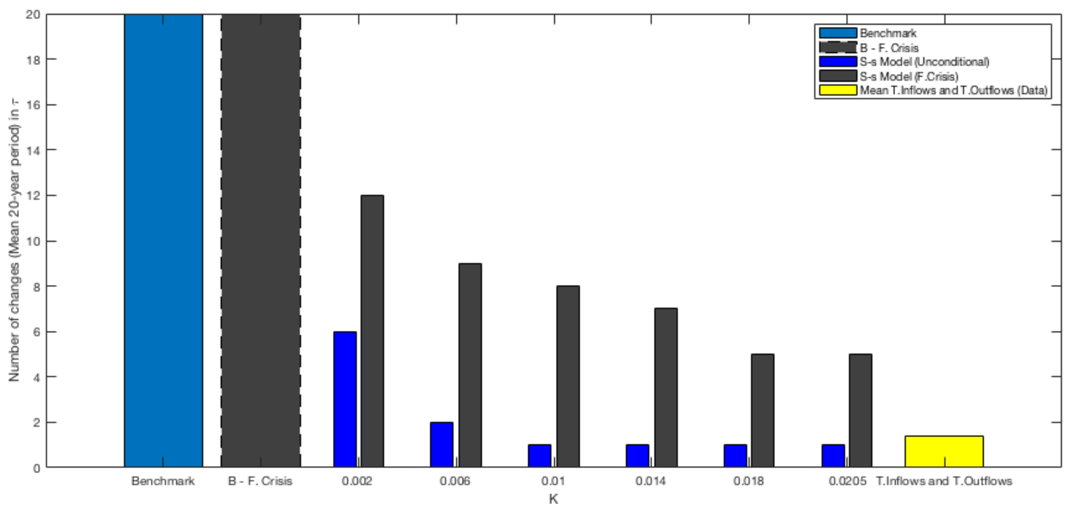


Figure 31: Autocorrelation of order t+j of τ, $j = \{-2, -1, ..., +2\}$.

Benchmark model vs S-s model vs Data: Periods Conditional on Financial Crisis

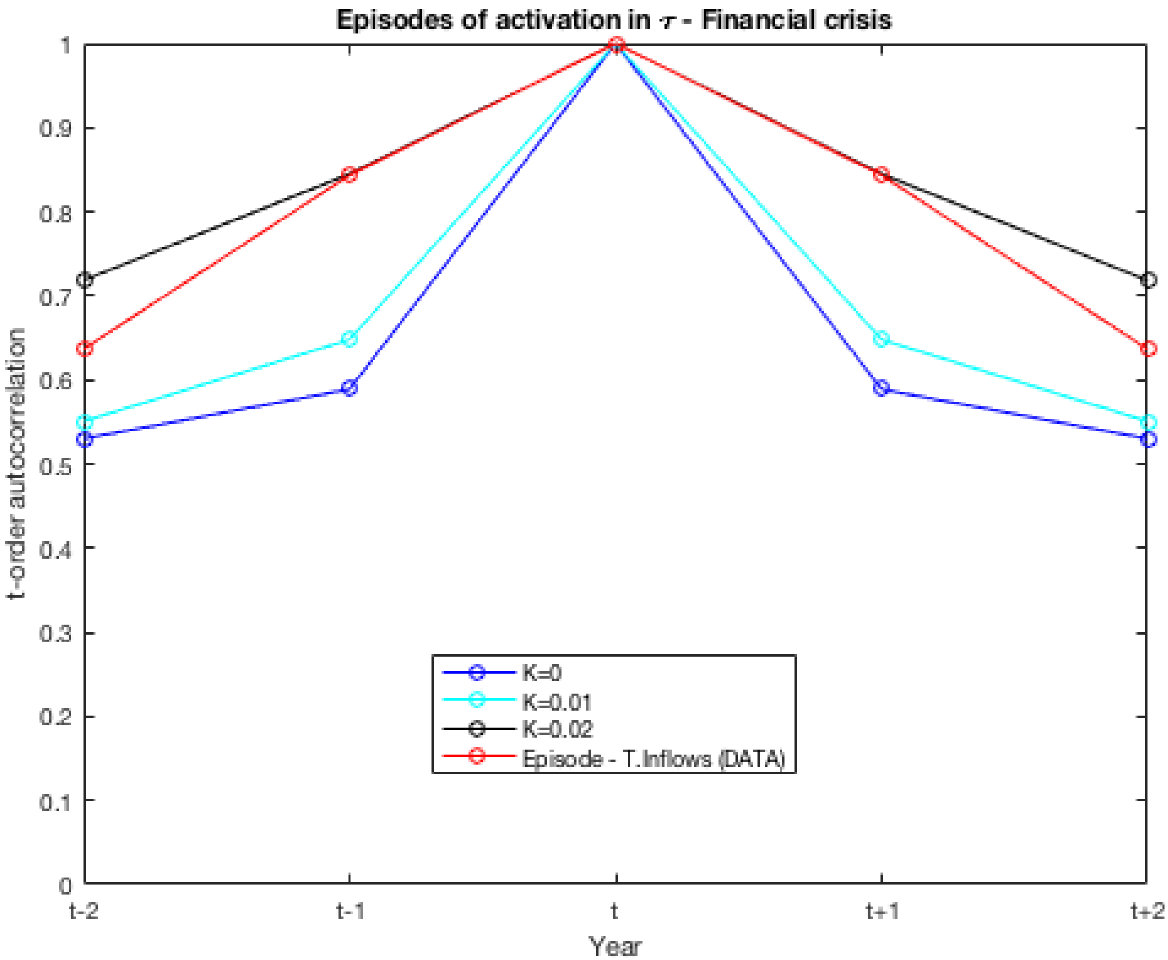


Figure 32: Mean of τ in the Benchmark Model vs S-s Model vs Episodes of use of capital controls in the data - Episodes of activation (Periods Conditional on Financial Crisis)

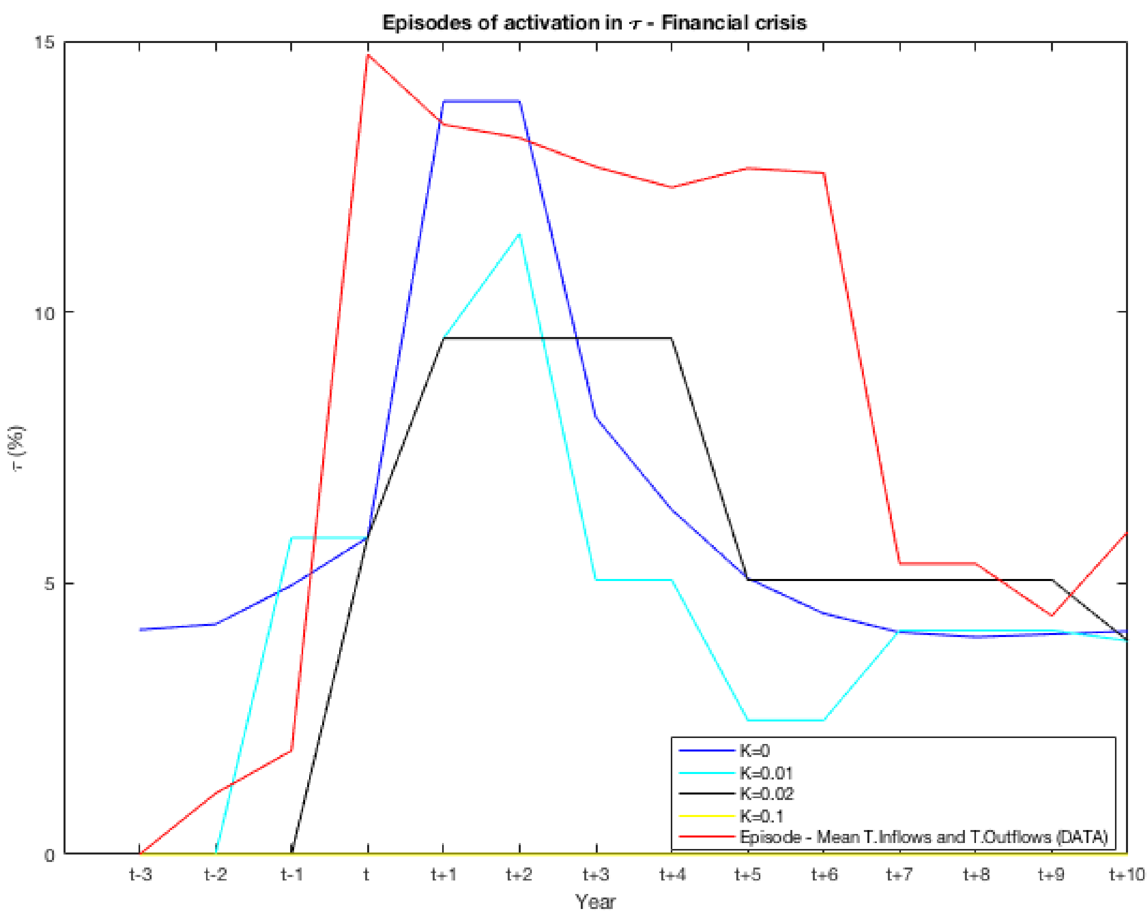


Figure 33: 20-year mean of τ vs y^T - Benchmark Model: Periods Conditional on Financial Crisis

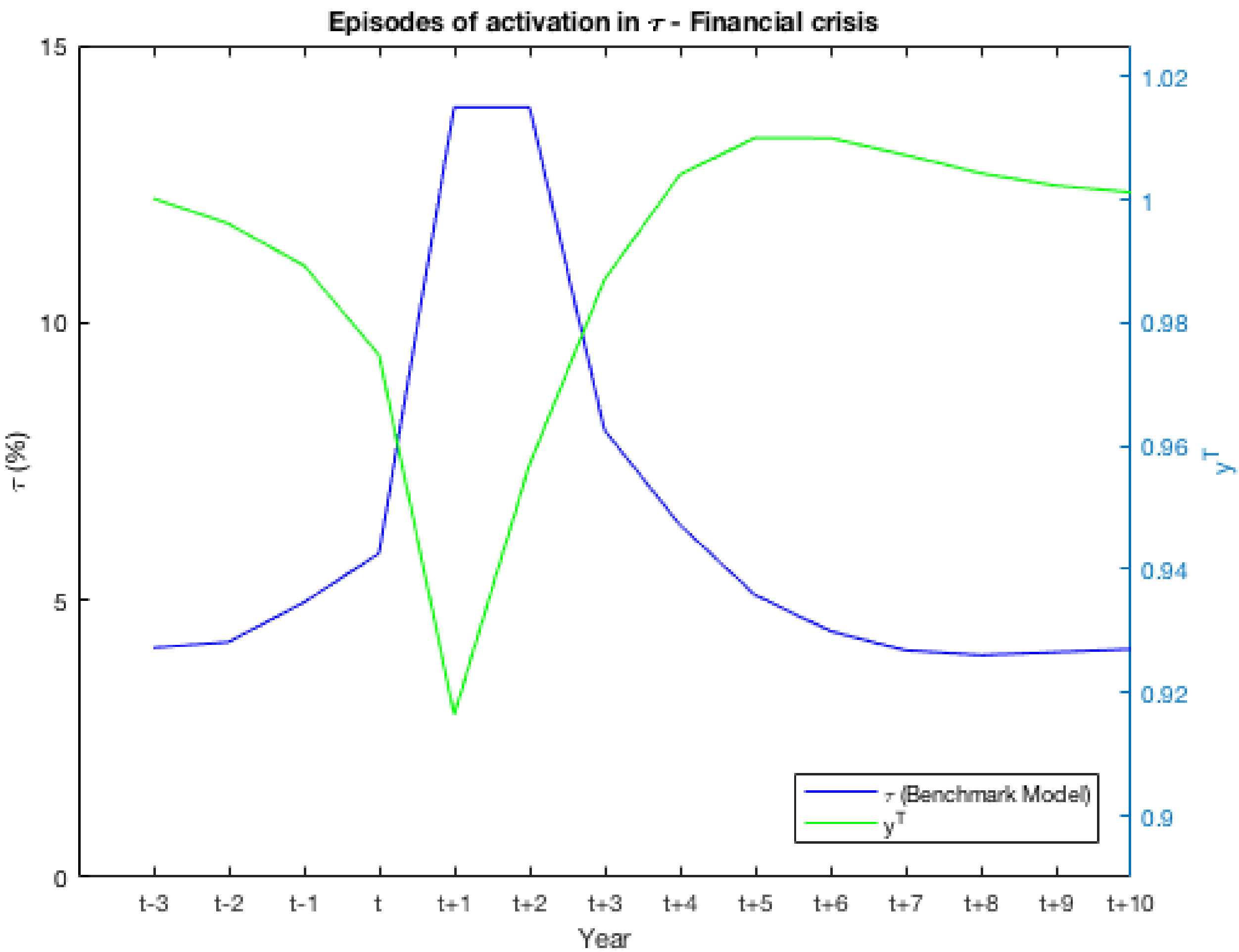


Figure 34: Locus: Optimal τ_1 and τ_2 with convex costs of adjustment

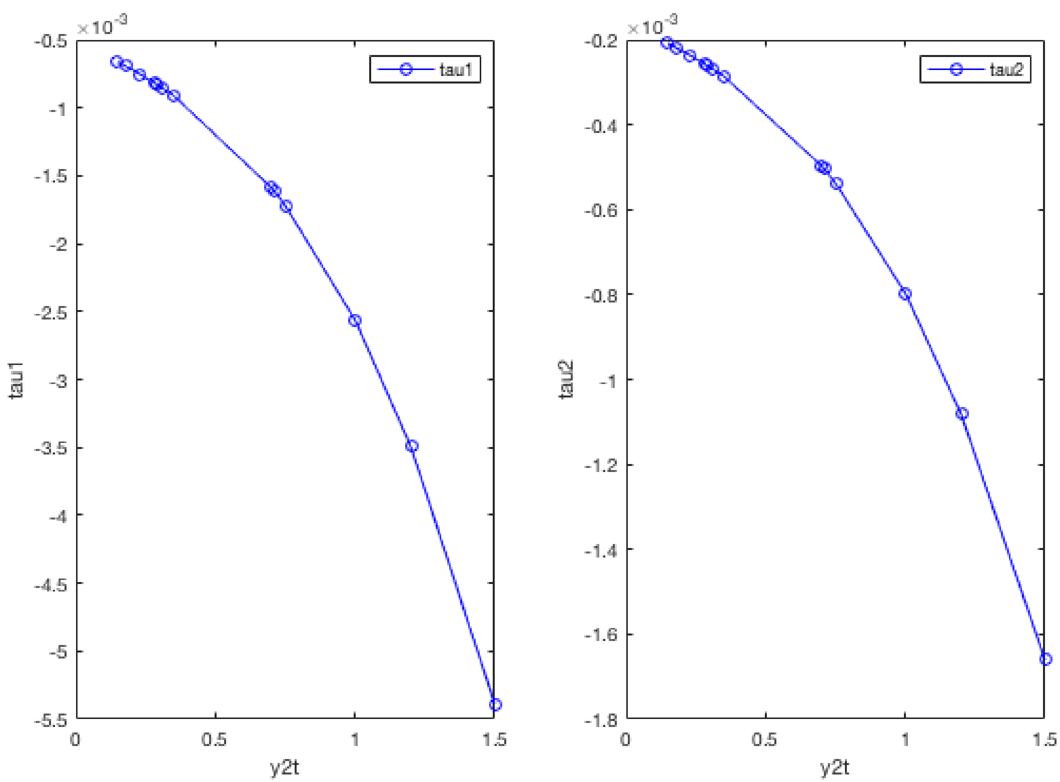
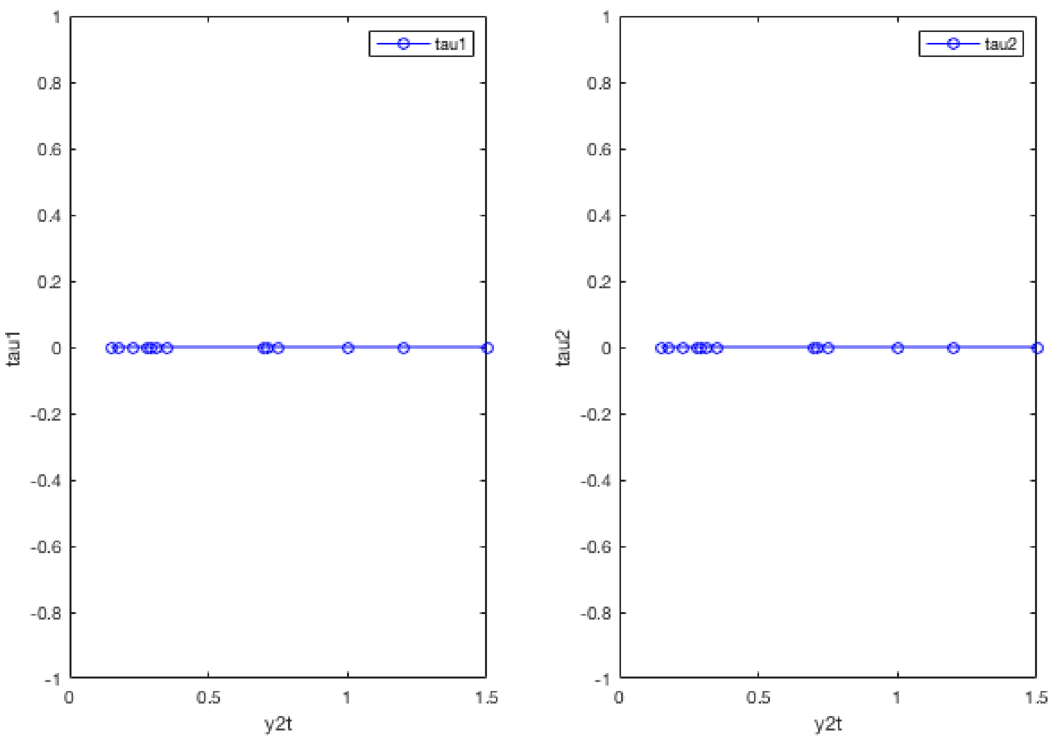


Figure 35: Locus: Optimal τ_1 and τ_2 with concave costs of adjustment



Appendix

A. Models' Derivations

A.1. Baseline (Unregulated) economy

Defining λ_t and μ_t as respectively the Lagrange multipliers on the sequential budget constraint and the collateral constraint, the Lagrangian is:

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \{U(A(c_t^T, c_t^N)) + \lambda_t [y_t^T + p_t y_t^N + \frac{d_{t+1}}{1+r_t} - c_t^T - p_t c_t^N - d_t] + \lambda_t \mu_t [\kappa(y_t^T + p_t y_t^N) - d_{t+1}]\} \tag{15}$$

The first-order conditions are (2), (3) and:

$$[c_t^T] : U'(A(c_t^T, c_t^N))A_1(c_t^T, c_t^N) = \lambda_t \tag{16}$$

$$[c_t^N] : U'(A(c_t^T, c_t^N))A_2(c_t^T, c_t^N) = p_t \lambda_t \tag{17}$$

$$[d_{t+1}] : (\frac{1}{1+r_t} - \mu_t)\lambda_t = \beta E_t \lambda_{t+1} \tag{18}$$

$$\mu_t \geq 0 \tag{19}$$

and

$$\mu_t [d_{t+1} - \kappa(y_t^T + p_t y_t^N)] = 0 \tag{20}$$

Combining (16) with (17) and using the functional forms for the utility function and the consumption aggregator, we obtain:

$$p_t = \frac{1-a}{a} (\frac{c_t^T}{c_t^N})^{1-\zeta} \tag{21}$$

The market for non-tradables clears in equilibrium:

$$c_t^N = y_t^N \tag{22}$$

We can use the results from (16) and (21) respectively into (18) and (3) and the market clearing condition into all the F.O.Cs to define the competitive equilibrium:

Definition 4.1. *Competitive equilibrium - Baseline economy.* Given the exogenous endowments and interest rate: r_t, y_t^T, y_2^N, and the initial debt position d_0, a competitive equilibrium in the baseline economy is a set of processes $c_t^T, c_t^N, d_{t+1}, \mu_t$, satisfying:

$$(\frac{1}{1+r_t} - \mu_t)U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) = \beta E_t U'(A(c_{t+1}^T, y_{t+1}^N))A_1(c_{t+1}^T, y_{+1}^N) \tag{23}$$

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t} \tag{24}$$

$$d_{t+1} \leq \kappa[y_t^T + \frac{1-a}{a}(c_t^T)^{1/\zeta}(y_t^N)^{1-1/\zeta}] \tag{25}$$

$$\mu_t \geq 0 \tag{26}$$

and,

$$\mu_t[\kappa(y_t^T + \frac{1-a}{a}(c_t^T)^{1/\zeta}(y_t^N)^{1-1/\zeta}) - d_{t+1}] = 0 \tag{27}$$

A.2. Ramsey Planner economy

For the Ramsey Planner The Lagrangian is:

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \{U(A(c_t^T, c_t^N)) + \lambda_t^R[y_t^T + \frac{d_{t+1}}{1+r_t} - c_t^T - d_t] + \lambda_t^R \mu_t^R[\kappa(y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta} y_t^N) - d_{t+1}]\} \tag{28}$$

The F.O.Cs are:

$$[c_t^T] : U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) + \lambda_t^R \mu_t^R \kappa \frac{1-a}{a}\frac{1}{\zeta}(\frac{c_t^T}{y_t^N})^{1/\zeta - 1} = \lambda_t^R \tag{29}$$

$$[d_{t+1}^T] : (\frac{1}{1+r_t} - \mu_t^R)\lambda_t^R = \beta E_t \lambda_{t+1}^R \tag{30}$$

$$\mu_t^R \kappa[y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta} y_t^N - d_{t+1}] \geq 0 \tag{31}$$

$$\mu_t^R \geq 0 \tag{32}$$

and

$$\kappa[y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta} y_t^N] - d_{t+1} \geq 0 \tag{33}$$

By comparing the first order conditions of the decentralized economy and the Ramsey Planner's economy shown in equations (16) and (29), we get the first remark obtained by Bianchi (2011): When the constraint binds, private agents undervalue wealth (equivalently, when the constraint binds, households overvalue consumption).

The result above emerges from the fact that, as shown by the second term of the left-hand side in equation (29), an additional unit of tradable consumption, reduces its marginal utility when the constrain binds, due to the fact that the agent will have to deleverage down to the point where the collateral constraint is not violated (i.e. a binding constraint implies less future consumption of tradable goods). As a result, private agents in the decentralized economy consume more by borrowing from abroad, than the Ramsey planner, which leads to the standard result of Overborrowing[18].

Given the overborrowing result, a direct application of the second welfare theorem is to implement a capital control tax (i.e. a tax on debt) such that the decentralized economy reaches the same allocations of the Ramsey Planner (which dominate in welfare)[19].

A.3. Regulated Economy - Optimal Tax

The optimality conditions (23)-(27) are unchanged except for the debt Euler equation (23), which now takes the form:

$$(\frac{1-\tau_t}{1+r} - \mu_t)\lambda_t = \beta E_t \lambda_{t+1}$$

Definition 4.2. *Competitive equilibrium - Economy with capital control taxes.* A *competitive equilibrium* in the economy with capital control taxes is then a set of processes $c_t^T, d_{t+1}, \lambda_t, \mu_t$ and p_t satisfying:

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t} \tag{34}$$

$$d_{t+1} \leq \kappa[y_t^T + p_t y_N^T] \tag{35}$$

$$\lambda_t = U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) \tag{36}$$

$$(\frac{1-\tau_t}{1+r_t} - \mu_t)\lambda_t = \beta E_t \lambda_{t+1} \tag{37}$$

$$p_t = \frac{A_2(c_t^T, y_t^N)}{A_1(c_t^T, y_t^N)} \tag{38}$$

$$\mu_t[\kappa(y_t^T + p_t y_t^N) - d_{t+1}] \tag{39}$$

and

$$\mu_t \geq 0 \tag{40}$$

Given a policy process τ_t, the exogenous process for endowments y_t^T, y_t^N, interest rate r_t and the initial level of debt d_0.

[18]Schmitt-Grohé and Uribe (2016) make a case for multiple equilibrium in this class of models, where instead of overborrowing the descentralized economy could display underborrowing (i.e., the central planner borrows more than private agents). Specifically, for $d = d_0 = \tilde{d}$ they show that there is multiple equilibrium with underborrowing when $S(\tilde{d};\tilde{d}) \equiv \kappa(\frac{1-a}{a})\frac{1}{1+r}\frac{1}{\zeta}(y^T + \frac{\tilde{d}}{1+r} - \tilde{d})^{1/\zeta - 1} > 1$. However, we use the same calibration as in Bianchi (2011), where such condition is not met, hence the economy has a unique equilibrium with overborrowing.

[19]This capital control tax is designed to reach a constrained first-best allocation in terms of welfare. However, clearly an economy without the financial friction represented by the collateral constraint welfare dominates that of the Ramsey planner.

The difference between the equilibrium described in definition 3.1 and the one described in 3.2 relies on equation (37), which is the first order condition with respect to d_{t+1} and now has τ_t reducing the marginal utility of debt.

A.4. Alternative costs of policy making - F.O.Cs

The first order conditions of the Ramsey Planner's problem become (now we need to take directly the derivative with respect to τ_t):

$$[c_t^T] : U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N)-$$
$$\theta_t^R(\frac{1-\tau_t}{1+r})\{(c_t^T)^{-1/\zeta}(\frac{-\sigma+1/\zeta}{1-1/\zeta})[a(c_t^T)^{1/(1-1/\zeta)}+(1-a)(y_t^N)^{1/(1-1/\zeta)}]^{\frac{-\sigma+1/\zeta}{1-1/\zeta}-1}(\frac{a}{1-1/\zeta})(c_t^T)^{\frac{1/\zeta}{1-1/\zeta}}$$
$$-\frac{1}{\zeta}(c_t^T)^{-1/\zeta-1}[a(c_t^T)^{1/(1-1/\zeta)}+(1-a)(y_t^N)^{1/(1-1/\zeta)}]^{\frac{-\sigma+1/\zeta}{1-1/\zeta}}\}$$
$$+\lambda_t^R\mu_t^R\kappa\frac{1-a}{a}\frac{1}{\zeta}(\frac{c_t^T}{y_t^N})^{1/\zeta-1} = \lambda_t^R \quad (41)$$

$$[d_{t+1}] : \frac{\lambda_1^R}{1+r} = \beta\lambda_{t+1}^R + \lambda_t^R\mu_t^R \quad (42)$$

$$[\tau_t] : -\lambda_t^R C'(\tau_t) + \frac{\theta_1^R}{1+r}[(c_t^T)^{-1/\zeta}[a(c_t^T)^{\frac{1}{1-1/\zeta}} + (1-a)(y_t^N)^{\frac{1}{1-1/\zeta}}]^{\frac{-\sigma+1/\zeta}{1-1/\zeta}}] = 0 \quad (43)$$

$$\mu_t^R\kappa[y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta}y_t^N - d_{t+1}] \geq 0 \quad (44)$$

$$\mu_t^R \geq 0 \quad (45)$$

and

$$\kappa[y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta}y_t^N] - d_{t+1} \geq 0 \quad (46)$$