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STICKY CAPITAL CONTROLS

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ABSTRACT

We build a new dataset using textual analysis, from which we document a set of stylized facts regarding the use of capital controls, along their intensive and extensive margins for 21 emerging markets, with a focus on priced-based controls. We document that capital controls are “sticky”; that is, changes do not occur frequently, and when they do, they remain in place for a long time. Overall, price-based capital controls have not been used systematically across countries or time, and there has been considerable heterogeneity across countries in terms of the intensity with which they have been used. We then present a model of capital controls relying on pecuniary externalities augmented by including an (S; s) cost of implementing such policies and illustrate how this friction goes a long way toward bringing the model closer to the data. When the extended model is calibrated for each of the countries in the new dataset, we find that the size of these costs is large, thus substantially reducing the welfare-enhancing effects of capital controls compared with the frictionless Ramsey benchmark. We conclude with a discussion of the structural interpretations of such costs, which calls for a richer set of policy constraints when considering the use of capital controls in models of pecuniary externalities.

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1 Introduction

Following the Global Financial Crisis, a body of research has taken a closer look at the use of unconventional policy tools aimed at curbing potential imbalances that can trigger financial crises and sudden stops in cross-border capital flows. Capital controls, or capital flow management policies, are arguably among the instruments that have drawn the most attention (see [Erten et al. 2021](#)). In this paper we build a novel quarterly dataset on de jure capital controls along intensive and extensive margins. The dataset covers a panel of 21 emerging market economies (EMEs) for the period 1995–2015.² We focus on two types of quantitative capital controls: unremunerated reserve requirement (URRs) rates applicable to cross-border flows, and tax rates applicable to cross-border inflows and outflows.

We uncover six stylized facts from the new dataset that taken together point to a large degree of “stickiness” of capital controls. First, price-based capital controls have not been systematically used in their intensive margin across countries or time. Second, when they have been used, these controls display considerable heterogeneity across countries in terms of the intensity with which they have been used. Third, changes to price-based capital controls do not occur frequently, and when they do occur, they remain in place for a long time (i.e., longer than a typical business cycle). As a result, these instruments display very high serial autocorrelation. Fourth, the cyclicity of these capital controls differs sharply across instruments, with URRs having been used countercyclically during episodes of large economic booms, and taxes on both inflows and outflows having been used in the contractionary phase of the GDP cycle. Fifth, analysis of the joint dynamics of capital controls and other macroprudential policies reveals little evidence of complementarity.³ If anything, they appear to have been substitutes. When distinguishing the extensive from the intensive margins, we differentiate controls of a quantitative nature (as the two that we focus on) from those of a qualitative nature (e.g., authorizations and other kinds of regulations that do not directly target market prices or volumes). We label the latter type of measures as non-price-based

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²During our period of analysis, most developed nations limited their use of capital controls (see [Fernández et al. 2016](#)).

³We further complement the dataset with information on other macroprudential instruments from earlier work by [Cerutti et al. \(2017\)](#), as well as that in [Federico et al. \(2014\)](#), which we also extend as explained in the next section.

capital controls. Sixth, while extensive measures of capital controls capture more non-price-based policy measures, they also display a considerable degree of persistence.

As it is well known a standard small open economy with collateral constraints of the kind introduced by [Mendoza \(2002\)](#) although providing rationale for capital controls, implies in a highly active and cyclical use of these instruments, which is at odds with the stickiness documented data.⁴ The normative prescriptions of most of these models rely heavily on a complex use of controls in certain states of nature (extensive margin) but, more importantly, at the intensive margin with magnitudes that vary with the probability and severity of future crises. The lack of data on the intensive margin has made it difficult to bring models of optimal capital controls closer to the data. As noted by [Hernandez and Mendoza \(2017\)](#), “the optimal policy is too complex to be feasible operationally, but arbitrarily chosen policy rules can be harmful.”

In the second part of the paper we study whether minimal additional frictions—in reduced form—might be incorporated into the benchmark model to better account for the stylized facts that we uncover. In particular, we consider the stickiness of controls documented in the empirical part of our work. Of course, there are many reasons why positive and normative implications may differ. We naturally turn to (S, s) costs, which have served as a quintessential device for economists seeking to generate inaction regions in models where consumers and firms make decisions, and which have successfully generated stickiness in variables ranging from prices to investment ([Caplin and Leahy, 2010](#)). Our work extends this concept to a policy variable, namely capital controls.

We modify the baseline model by introducing a fixed cost (of policymaking) in the tradition of (S, s) models, whereby policymakers equate their policy instrument to its optimal value only when the benefit of doing so surpasses its (S, s) cost. Otherwise the (policy) cost is large enough to deter policymakers from adjusting the policy instrument, staying in an inaction region, and inducing stickiness.⁵ Our analysis begins with a simple illustration

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⁴[Korinek and Mendoza 2014](#) overview a class of models based on an occasionally binding credit constraint that limits debt to a fraction of the market value of incomes or assets used as collateral. See also [Mendoza and Smith 2006](#), [Uribe 2006](#), [Lorenzoni 2008](#), [Bianchi 2011](#), [Farhi and Werning 2014](#), [Benigno et al. 2011](#), [Korinek 2018](#), [Bianchi and Mendoza 2018](#), [Schmitt-Grohé and Uribe 2017](#), and [Schmitt-Grohé and Uribe 2020](#), among others).

⁵While the use of (S, s) costs is intuitive, we do consider other types of (convex and concave) costs. In the Appendix, we document how, when compared with (S, s) costs, such alternative cost specifications do

of the quantitative effects of varying levels of (S, s) costs on the equilibrium dynamics in an economy calibrated as in the aforementioned literature, hence taking no stance on the size of such costs. We document that (S, s) costs allow us to bring the model closer to the data along four dimensions that characterize the stickiness in capital controls. First, the extended model has the ability to reduce the share of time during which the tax is active, with higher (S, s) costs further reducing this share—unlike in the baseline case, where controls are counterfactually always active. Second, the presence of (S, s) costs is shown to reduce the frequency of changes in capital controls with values that are more aligned to those observed in the data. Third, (S, s) costs also generate episodes when capital controls are used in a highly non-linear way, where taxes remain inactive for a long time, then jump to high levels with a considerable persistence. Hence, such costs can generate the high serial autocorrelation of capital controls documented in the data, the fourth dimension that characterizes stickiness in these policy instruments.

Our work then considers a more detailed calibration of the (S, s) costs for each of the 21 EMEs in the dataset considering country-specific endowment processes, the parameters that govern the collateral constraints and the (S, s) costs. The average value for (S, s) costs calibrated is large and allows the extended model to account for the low frequency of changes in capital controls in the data. In the data, controls changed 1.4 times for every 20 years; the extended model matches that quite closely by generating, on average, 1.6 changes for every 20 years simulated. In contrast, the calibrated baseline model with no (S, s) costs predicts, on average, 13.8 changes in capital controls for every 20 years. Importantly, other non-targeted moments are also much more in line with the data, such as the share of time that controls are predicted to be active; the value of the tax used; the non-mean reversion observed in episodes when controls have been used; and their serial autocorrelation.

Calibrated (S, s) costs are also large when we assess their impact on welfare. Using the Ramsey planner who implements controls at no cost as benchmark, imposing capital controls bring about welfare gains for agents in the unregulated economy. However, such gains for agents in a model with (S, s) costs are about 4/5 of those in the unregulated economy. This implies that the magnitude of (S, s) costs calibrated is large enough to eliminate most—

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not help the baseline model in a meaningful way to better replicate the data.

though not all—of the welfare gains obtained after imposing controls.

This paper relates to several strands of the literature. On the empirical front, seminal empirical works that have measured capital controls and their use include [Quinn \(1997\)](#), [Chinn and Ito \(2006\)](#), [Schindler \(2009\)](#), among others. [Klein \(2012\)](#) studies the use of episodic controls on capital inflows and concludes that, 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. [Fernández et al. \(2015\)](#) do not find evidence of capital controls implemented as macroprudential tools in the period 1995–2011. We build on these empirical works and complement them by adding an intensive dimension of capital controls to the analysis. To our knowledge, this is the first cross-country panel dataset on the extensive and intensive margins of capital controls using textual analysis of official regulations from multilateral and national sources. We also contribute to this literature by first documenting stickiness of capital controls both at the extensive and intensive margin.

As mentioned above, a growing theoretical macro literature posits pecuniary externalities to motivate the use of capital controls. The lack of data on the intensive margin has precluded evaluating the performance of these models empirically, to which we contribute in this paper. Our work further complements these theoretical frameworks by adding a friction—in the form of an (S, s) cost—which is shown to improve the performance of models relying on these types of externalities. Structural interpretations of the kind of (S, s) costs that we put forth can be viewed as a call for future theoretical work to include a richer set of policy constraints when considering the use of capital controls in models of pecuniary externalities. There are several reasons why models of optimal capital controls may be at odds with the data, and the reduced form specification with which we try to capture several of these reasons through an (S, s) cost is, at best, a crude approximation for them. 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.

The paper proceeds as follows. Section 2 presents the new dataset, while Section 3 documents the stylized facts. Section 4 presents the baseline model of capital controls,

postulates the extension including (S, s) costs, and discusses the solution method used. Section 5 presents the quantitative analysis by first illustrating the effects of varying (S, s) costs on the equilibrium dynamics, then calibrating the (S, s) costs for the countries in the dataset and computing welfare gains. The last section concludes.

2 A New Dataset

We build a novel cross-country panel dataset of *de jure* measures on capital controls with both the extensive margin—when controls are used not—and also, importantly, the intensive margin (i.e., the rates at which capital controls are set when implemented or active). The frequency of observations is quarterly and covers 21 EMEs over the period 1995–2015. We focus on price-based capital controls and complement our data with other forms of capital controls and with macroprudential instruments from alternative data sources. In this section, we describe the set of controls documented in our dataset, the methodology used to build it, and its coverage. For further details, we refer the reader to the online dataset’s Technical Appendix.

2.1 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 a policy designed to limit or redirect transactions on a country’s financial account. In terms of *de jure* capital controls, the International Monetary Fund (IMF) distinguishes between market-based and administrative restrictions. Market-based controls include price-based measures such as taxes on cross-border capital movements, unremunerated requirements on cross-border flows, and dual exchange-rate systems. Administrative controls include, for example, required-prior-approvals for certain capital account transactions.

In our analysis, we focus on two *de jure* price-based measures of capital controls that capture the intensive margin of these instruments: taxes and unremunerated reserve requirements on cross-border flows. In addition to these quantitative measures, we add information documenting other quantitative restrictions and prohibitions as well as qualitative (or non-

price-based) administrative measures.⁶

2.1.1 Capital Controls: Quantitative and Qualitative Measures

Quantitative Measures. Within the quantitative measures, we focus on two *price-based* capital controls.

1. *Unremunerated reserve requirements* (URRs). These are recorded as rates applicable to cross-border inflows. They are requirements to constitute a compulsory deposit of a non-zero fraction of the intended transaction for a legally mandated period. For this measure, we also calculate the tax equivalent cost of the URR as in [De Gregorio et al. \(2000\)](#).
2. *Tax rates* on cross-border inflows and outflows. These are compulsory contributions that are levied on transactions that imply cross-border flows and are payable to the national tax authorities. We collect this information across various types of assets, including bonds and stocks.⁷

For completeness, we include in the analysis *restrictions*. These measures account for any limit or restrictions on quantities, maturity or percentages that affect cross-border flows. We also consider *prohibitions* when there is an explicit allusion indicating that a certain activity was not allowed at all.

Qualitative Measures. We consider two types of qualitative measures or controls. *Authorizations* are special permits that are required to perform certain flows. We also include an *Others* residual category that includes specific cases for each particular country, as detailed in the Appendix.

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⁶Another way to classify capital controls is according to their direction. Chile, for example, regulated capital inflows during the 1990s while Thailand imposed controls on capital outflows in 1997 as a response to the Asian financial crisis. Of course, it is often difficult for policymakers 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 into countries that restrict their exit. For capital controls in the form of taxes on cross-border flows, we also explore the direction of flow in the dataset.

⁷This comes at a cost. Since we do not have the balance of payments data of each asset class, our analysis is silent about volumes of flows.

2.1.2 Complementing the Data: Macroprudential Measures

We complement our dataset with macroprudential measures, defined as measures directed to the domestic financial system. We expand on work by [Federico et al. \(2014\)](#) on reserve requirements to include additional countries needed to complete those in our dataset, and we include information about reserve requirements on foreign exchange deposits. For additional macroprudential measures, we use the dataset in [Cerutti et al. \(2017\)](#) covering changes across several other macroprudential instruments such as capital buffer requirements of banks, concentration limits, interbank exposure, and loan-to-value caps. Note that these are considered macroprudential measures and not capital controls.

Section II of the online dataset’s Technical Appendix describes in detail the list of variables studied with their respective definitions and acronyms.

2.2 Methodology

In building the dataset, we followed these steps:⁸

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 any regulation that was not specific to capital controls or did not provide a quantitative measure of the intensive margin. Trade measures (e.g., tariffs) were a recurrent example of a regulation that was included in 1 but excluded in 2.
3. *National sources.* For each country, we analyze legal documentation on capital control regulations (e.g., decrees and any other country-specific economic legislation) to confirm, complement, or correct information found in 1. and 2. Whenever we found

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⁸Section III in the online dataset’s Technical Appendix explains in detail the general rules and criteria used for each instrument; Section IV shows how we calculated the tax equivalent of URR; Section V shows the consistency check with other dataset; and Section VI documents the cases where we found discrepancies between multilateral and national sources.

discrepancies across sources, we made a case-by-case analysis. We recorded each of those cases in the online dataset’s Technical Appendix.

4. *Cross-validation.* We cross-validated the data using two previous academic works on capital controls ([Magud et al. 2018](#) and [Ghosh et al. 2018](#)). Additionally, we consulted with each of the central banks of the EMEs considered in our sample for them to validate the policy measures recorded in the dataset.⁹

2.2.1 Coverage

We cover 21 conventional emerging market countries as during our period of analysis, most developed nations did not implement capital controls, ([BIS \(2011\)](#), [Fernández et al. 2016](#)). They countries included are conventional in the sense that they have been classified as emerging economies by multilateral organizations and rating agencies (IMF, WB, MSCI, JP Morgan) or have been included in the most recent peer-reviewed studies of EMEs’ business cycles (see [Caballero et al. 2019](#)). Importantly, these were *not* chosen by any criteria of ex ante use of capital controls (or other macroprudential instruments).

Those countries, grouped by region, are:

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

The four-step methodology described above is applied to form an unbalanced panel dataset with quarterly frequency from 1995 to 2015.¹⁰ It begins in 1995, as this is the year when the IMF’s AREAERs first introduced detailed information about policy measures

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⁹More than half of the central banks we contacted responded to our inquiries. None objected to the dataset we had found. In a few cases, they complemented it with additional regulations. In addition, we systematically compared our data against the work of [Magud et al. \(2018\)](#) and [Ghosh et al. \(2018\)](#) and found an overlap of 95% of the policy measures, conditional on the same countries, years, and types of controls.

¹⁰Daily frequency is also partially available on some policy measures. Our analysis, however, is conducted at the quarterly frequency unless otherwise specified.

on cross-border flows, disaggregated by direction of flows and type of assets, among other characteristics. To avoid truncation, whenever a policy measure is in place at the beginning or the end of the dataset, we use national sources to extend the time series coverage so as to document the enactment of the control or its repeal, hence the unbalanced structure of the dataset.

There are a total of 1,712 quarterly observations recorded for URRs and 1,680 for taxes on capital flows across 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 as a tax on inflows; and 445 (26.4%) had it in the form of a tax on outflows. The online dataset’s Technical Appendix presents further descriptive statistics on the coverage of the dataset (Section VI of this Appendix presents details regarding each country).

3 Stylized Facts

In this section, we document six stylized facts on the properties of the intensive margin of capital controls from the new dataset: (1) *use* of these instruments across countries and time; (2) *intensity* with which they have been used; (3) *frequency of adjustment*; (4) *cyclical-ity* with other macro variables; (5) *complementarity* with other macroprudential instruments; and (6) *consistency* with measures of the extensive margin of capital controls.

Taken together, these stylized facts point to a large degree of “stickiness” in capital controls, which materializes in countries not relying on these tools systematically along the business cycle. When countries have relied on them, we observe that such policy tools have displayed little mean reversion and, hence, high persistence over time. This is consistent with broader definitions of capital controls that include more qualitative/administrative controls in measures of the extensive margin of these policy tools. Such stickiness also appears to manifest in these tools being substitutes with alternative macroprudential measures. It is thus pertinent to explore whether current state-of-the-art models of optimal capital controls can account for this stickiness, which we undertake in the next section.

Fact 1. *The **use** of (price-based) capital controls has not been systematic across countries or time.*

The top panel of [Figure 1](#) shows, for each instrument (horizontal axis), the share of countries that have used the two *price-based* capital controls in our dataset; that is, rates have been strictly positive (vertical axis). Out of the 21 EMEs considered in the dataset, only six countries (29%) used URRs or taxes on inflows at some point during the period covered, while ten (48%) used controls on outflows. The bottom panel of [Figure 1](#) shows the cross-country average share of time during which each instrument was active. Their use has been limited to a small fraction of the period covered by the dataset: taxes on inflows (outflows) were above zero in less than 20% (25%) of the quarterly time series of the dataset, and URRs in less than 10%.

Additional results in the Appendix contrast these findings with the use of other macro-prudential instruments such as reserve requirements in domestic and foreign currency deposits. More than 90% of the countries have imposed reserve requirements on accounts in domestic currency, 80% on accounts in foreign currency, and have been used 75% and 95% of the time, respectively. Marginal reserve requirements are much less pervasive, being used by 13% of the countries and less than 5% of the time.

Fact 2. *The **intensity** with which price-based capital controls have been used displays considerable heterogeneity across countries.*

The top two panels in [Figure 2](#) document the mean intensities of URRs and their tax equivalent for each country in the sample. Countries with no bars are those for which no use of capital controls was found along the intensive margin. The bottom two panels document the same information for taxes on inflows and taxes on outflows, respectively. Among the countries that did implement capital controls, there is considerable dispersion of the intensity with which capital controls were used. While URRs 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% and those on outflows have been used across more countries and more intensively, with the average tax variation ranging from 0.3% to 55%.

Figure 1: Use of Capital Controls: URRs and Taxes

Notes: Data for 21 Emerging Markets for unremunerated reserve requirements (URRs) and taxes on inflows (Tax'in) and outflows (Tax'out) from 1995q1 to 2015q4.

In Panel A, the bars depict the share of countries that have used capital controls (i.e. value of the instrument is not 0), at least during one quarter of our sample. In panel B, the bars depict the share of periods in which an instrument was used. The maximum total of quarters is 80 (100%). See Section 2 and Data Appendix for detailed description of the data.

Other macroprudential tools, documented in the Appendix, have been employed more homogeneously across countries. For instance, reserve requirements in domestic and foreign currency deposits display variations between 5%-10% and 4%-10%, respectively.

Fact 3. *Changes to price-based capital controls occur infrequently.*

Figure 3 presents the frequency of changes across the three instruments of capital controls in the dataset (URRs and taxes on capital inflows and outflows).¹¹ For the three instruments, the bulk of the distribution is skewed toward the origin, implying that changes to capital controls occur infrequently, if at all. Conditional on their use, the average number of changes to capital controls (in the quarterly frequency) is small: between 4 for URRs, and 6 (4) for taxes on inflows (outflows) during the 20 years covered by our dataset.¹² In

¹¹A change is any instance when the value recorded for an instrument changes from one quarter to the next.

¹²Brazil, a case usually discussed in policy circle, has displayed—in contrast with the average use of controls by other countries—episodes of high intensive adoption of price-based capital controls with frequent changes

Figure 2: The Intensive Margin of Capital Controls: URRs and Taxes

Notes: Data for 21 emerging markets. Each panel corresponds to a different instrument: unremunerated reserve requirements (URRs), URR-tax equivalent, taxes on inflows, and taxes on outflows. The bars represent the value of the instrument in each country. Only the periods in which the instrument was active were considered. Countries with no bars are those for which the corresponding instrument was never used in the period considered. See Section 2 and Data Appendix for detailed description of the data.

contrast, other macroprudential tools exhibit larger frequency of changes than capital control instruments. For instance, reserve requirements in domestic and foreign currency deposits display a quarterly frequency of changes up to 37 times in 20 years.

Figure 4 further documents the time series behavior of capital controls in episodes when these instruments have been forcefully used, which we define as cases when they display an increase of more than 10% from one quarter to the next, or when they are activated (from no use to positive values). The figure presents the simple averages across all episodes, denoting time index “ t ” as the moment this condition is met in each episode. The first panel shows the followed by periods of limited reliance, see [Alfaro et al. \(2017\)](#).

behavior of the three instruments at a yearly frequency, while the second panel shows it at a quarterly frequency. The evidence points to a large degree of persistence following these large movements in capital controls: episodes identified in taxes on inflows (outflows) display large increases, on average from 1% to 3% (0% to 25%); and 12 quarters later, they continue to exhibit values above 2.5% (20%). In fact, the annual frequency plot shows that, on average, these measures remain high after 7 to 8 years following the episode identified. As a result, capital controls display very high serial autocorrelation, as documented in [Figure 5](#).¹³

Figure 3: Frequency of Changes in Capital Controls: URRs and Taxes

Notes: Data for 21 Emerging Markets for unremunerated reserve requirements (URRs) and taxes on inflows and outflows. A change occurs when the value of an instrument in t was different than in $t - 1$. 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 2015q4 sample are coded in red. The countries that did not use the instrument at any time in the sample are shown in blue. See Section 2 and Data Appendix for detailed description of the data.

¹³In the Appendix, we document the persistence of changes in capital controls to be robust across different exchange rate regimes.

Figure 4: Episodes of Capital Controls: URRs and Taxes

Notes: Notes: Data for 21 Emerging Markets for unremunerated reserve requirements (URRs), URR-Tax equivalent, taxes on inflows and outflows. The beginning of an episode was defined when for a given policy instrument at period 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 first row shows episodes of activation in the controls at a yearly frequency, and the second row shows such episodes at a quarterly frequency. There are six episodes for URRs, five for taxes on inflows, and eight for taxes on outflows.

Fact 4. *The **cyclicality** of priced-based capital controls differs sharply across instrument.*

Figure 6 documents the (demeaned) average deviation of GDP growth (right axis) around the episodes of capital controls presented in Figure 4. While URRs have been used countercyclically during episodes of large economic booms, taxes on both inflows and outflows have been implemented in the contractionary phase of the GDP cycle.¹⁴

Fact 5. Complementarity *in the use of price-based capital controls and other macroprudential tools has been limited; if anything, the two type of instruments tend to be substitutes.*

Figure 7 compares the evolution of domestic macroprudential instruments (right axis) around the same episodes in which capital controls are used or active (left axis). The index

¹⁴The Appendix extends the results to the current account and real exchange rate.

Figure 5: Serial Correlation of Capital Controls: URRs and Taxes

Notes: Data for 21 Emerging Markets. The dotted line corresponds to URRs. The solid line represents the yearly cross-country mean autocorrelation of order $t - j$ of taxes on inflows. The dashed line represents the same variables on taxes on outflows. See Section 2 and Data Appendix for detailed description of the data.

of macroprudential instruments is from [Cerutti et al. \(2017\)](#).¹⁵ As can be seen, capital controls do not move in tandem with the other macroprudential instruments, implying limited complementarity between the two types of instruments. In fact, as the intensity in capital controls falls, the use of macroprudential instruments intensifies, signaling that, if anything, the two have been substitutes. Indeed, the correlation between macroprudential indices and our measures of capital controls is relatively low: -0.05 for URRs; 0.03 for controls on inflows; and 0.45 for controls on outflows.¹⁶ Additional evidence is gathered in the Appendix, where we break down the cyclicalities in macroprudential tools between those countries that have used capital controls and those that have not (identified in Fact 2). The evidence indicates that the cyclicalities of macroprudential instruments has been stronger in the latter group of countries relative to that in the former group, reinforcing the substitutability between the two types of instruments.

¹⁵The index covers the changes across several macroprudential instruments: capital buffer requirements of banks lending mortgages and others types of loans; concentration limits; interbank exposure; loan-to-value caps; and reserve requirements in foreign and domestic currency.

¹⁶See [Korinek and Sandri 2016](#) for an analysis incorporating both capital controls and macroprudential policies.

Figure 6: Episodes of Capital Controls and the Business Cycle: URRs and Taxes

Notes: Data for 21 Emerging Markets for unremunerated reserve requirements (URRs) and taxes on inflows and outflows. Each plot shows the episodes described in Figure 4 along with the cross-country mean deviation from the average GDP growth. See Section 2 and Data Appendix for detailed description of the data.

Fact 6. *Extensive measures of capital controls, which capture non-price policy measures, display a considerable degree of stickiness.*

We now explore the overlap between the intensive margin captured in the new dataset and standing measures of the extensive margin. For that purpose, we employed 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 all policy measures accounted in their dataset in terms of price-based, akin to those in our dataset, and non-priced-based, such as authorization requirements and other bureaucratic measures that do not directly affect the relative cost of cross-border flows.

[Table 1](#) summarizes the results. It documents that priced-based measures, including

Figure 7: Episodes of Capital Controls (URRs and Taxes) & Broader Macro Prudential Instruments

Notes: Data for 21 Emerging Markets for unremunerated reserve requirements (URRs) and taxes on inflows and outflows complemented with measures from Cerutti et al., (2017). Sample of episodes restricted from 2000q1 to 2015q4 to match the time periods in their data. The beginning of an episode (episodes are depicted by red lines) was defined when for a given policy instrument at quarter t , x_t , we have that $x_t > 1.1x_{t-1}$. The values of each episode were then averaged from $t - 2$ to $t + 10$. Deviations were plotted against the average of the accumulated Index of Macprudential Instruments from the database of Cerutti et al., (2017). This index (purple line) includes the nine instruments on that database. See Section 2 and Data Appendix for detailed description of the data.

URR and taxes (and prohibitions, which implicitly is a tax of 100%) represent on average less than half (36%) of all instruments. Regarding the remaining 64% of measures that are non-price-based, a little less than half of those (28%) are authorization requirements and the rest are classified as other bureaucratic red tape that hinders the cross-border flow of capital.

Table 1: Price-Based and Non-Price-Based Capital Controls

	Price-Based		Non-Price-Based	
	URRs - Taxes - Quant	Prohibitions	Authorizations	Others
Avg	27.7 %	8.3 %	28.4 %	35.6 %

Notes: The table shows the cross-country average of the share of the use of each instrument over the total for 21 emerging markets. The first two columns of instruments correspond to price-based capital controls, and the last two to non-price-based capital controls. See Section 2 and Data Appendix for detailed description of the data.

Broader Regulations and Non-Price Based Capital Controls. A natural question is thus whether the previous stylized facts documented on the intensive margin are robust to a broader set of regulations captured in the extensive margin of capital controls, most of which account for non-price-based measures. [Figure 8](#) reproduces the methodology in [Figure 4](#) by identifying episodes of large increases in the indices of inflow and outflow controls in [Fernández et al. \(2016\)](#) and reporting the average time series dynamics around them. Since now we are analyzing the extensive margin, the vertical axis is not a rate, as in [Figure 4](#), but rather a scale that goes from 0 (when no controls exist in either of the asset categories) and 1 (where controls exist in all categories). Results are quite robust. Indeed, neither of the two indices displays any mean reversion, and the level of controls is still higher several years after the initial increase in year “ t .”

4 Models of Capital Controls

4.1 Baseline Model

In this section, we present our baseline model of optimal capital controls. Our starting point is a small open economy with collateral constraints posited in [Mendoza \(2002\)](#), which gives rise to pecuniary externalities that, in turn, are widely viewed as a benchmark theory for rationalizing the use of capital controls.¹⁷ We present the unregulated economy case, the Ramsey problem and the optimal capital control derived from it. We further describe that

¹⁷Our setup is cast in an infinite dynamic stochastic environment as in [Mendoza and Smith \(2006\)](#), [Uribe \(2006\)](#), [Bianchi \(2011\)](#), [Benigno et al. \(2016\)](#), [Korinek \(2018\)](#), [Bianchi and Mendoza \(2018\)](#), [Schmitt-Grohé and Uribe \(2017\)](#), and [Schmitt-Grohé and Uribe \(2020\)](#), among others.

Figure 8: Episodes of Broader Measures of Capital Controls (Priced-Based and Non-Price Based): The Extensive Margin

Notes: Data for 21 Emerging Markets for the extensive margin of capital controls (priced-based and non-priced based) in Fernandez et al. (2016). The beginning of an episode was defined when for a given policy instrument at year t , x_t , we have that: $x_t > (1 + stdev(x_{t-1}))$. The values of each episode were then averaged from $t - 2$ to $t + 10$. See Section 2 and Data Appendix for detailed description of the data.

this optimal policy is not designed to account for the stickiness documented in the data. As the model has become standard in the literature, our exposition aims to be brief. We then present a minimal extension to this setup incorporating (S, s) costs. In the next section, we quantitatively evaluate the role of this additional friction in improving the baseline model along several dimension of the documented facts.

4.1.1 The Unregulated Economy

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

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

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, non-state contingent 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:

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

where d_{t+1} represents the amount of debt incurred 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 tradable and non-tradable goods, respectively, and are the only source of uncertainty. Notice that debt is equivalent to negative holdings of the aforementioned internationally traded bond.

The (flow) collateral constraint is given by:

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

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 on 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. This leads households to borrow more than they would have had they internalized this externality. The literature refers to this as overborrowing.¹⁸

Households choose a set of processes $\{c_t^T, c_t^N, p_t, d_{t+1}\}_{t=0}^\infty$ to maximize (1) subject to (2)

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¹⁸[Schmitt-Grohé and Uribe \(2020\)](#) show that, under certain parametrizations, multiple equilibrium could lead to self-fulfilling financial crisis and underborrowing. [Benigno et al. \(2016\)](#) show that modeling production also leads to underborrowing. As we will explain in the Calibration section, to compare to the literature, we abstract from this scenario by following a calibration that does not exhibit underborrowing.

and (3) given the initial debt position d_0 .¹⁹

4.1.2 The Ramsey Planner

The Ramsey planner internalizes the effects that households' decisions have over the relative price, p_t . Thus, by replacing p_t from the first-order conditions of the unregulated economy (see Appendix), the recursive planner's problem in this economy is to choose c^T and d' such that²⁰:

$$v(y^T, r, d) = \max\{U(A(c_t^T, c_t^N)) + \beta E[v(y^{T'}, r', d)']\} \quad (4)$$

Subject to:

$$c^T + d = y^T + \frac{d'}{1+r} \quad (5)$$

$$d' \leq \kappa \left[y^T + \frac{1-a}{a} \left(\frac{c^T}{y^N} \right)^{1/\zeta} y^N \right] \quad (6)$$

Since the planner internalizes the effect that current borrowing has over the collateral constraint in future periods, she borrows on average less than the household, leading to a lower frequency of financial crises—defined here as episodes where the constraint binds—and higher welfare. As an application of the second welfare theorem, there exists a capital control tax (i.e., a tax on debt) that makes households as well off as those living under the Ramsey planner, to which we turn next.

4.1.3 Optimal Capital Control Tax

With the introduction of a capital control tax, τ , the new budget constraints on households and the government become, in recursive format, respectively:

$$\tau \frac{d'}{1+r} = l \quad (7)$$

and

$$c^T + pc^N + d = y^T + py^N + (1-\tau) \frac{d'}{1+r} + l, \quad (8)$$

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¹⁹The Appendix contains a full derivation of the equilibrium in this economy.

²⁰Henceforth, we use a recursive notation where prime variables denote the next period and the rest the current period.

where l is a lump-sum transfer from the government to the household.

Combining the equilibrium conditions of the unregulated and Ramsey economies yields the optimal capital control tax:

$$\tau^* = 1 - \frac{E_t \lambda'^R}{E_t \lambda'^R (1 - \mu'^R \Psi')}, \quad (9)$$

where λ'^R is the Lagrange multiplier of the budget constraint for the Ramsey planner, μ'^R is the Lagrange multiplier associated with the collateral constraint, and $\Psi = \kappa \frac{1-a}{a} \frac{1}{\zeta} \left(\frac{c^T}{y^N} \right)^{1/\zeta - 1}$.²¹

The optimal tax depicted in [Equation 9](#) provides important insights as to the use of this instrument within this setup. As can be seen, as long as the probability of a crisis is not zero, the optimal policy will call for a capital control. Moreover, any change in the probability, be it small or large, will trigger a change in the intensity with which this instrument is deployed, implying that controls will actively be called upon along the business cycle.²² The baseline model not designed to properly account for the does not easily account for the stickiness in the data documented in Section 2—which we further verify in the quantitative analysis below—. This disconnect between the baseline model and the stylized facts regarding the dynamic behavior of capital controls suggests that a friction is needed in the ability with which this instrument is employed. We next postulate an extension to the baseline model that incorporates such a friction.

4.2 Extended Model with (S, s) Costs

There is a long tradition in economics using (S, s) -type costs to explain inertia in durable goods consumption, investment, money demand and, perhaps most notably, in providing a rationale for price stickiness ([Caplin and Leahy, 2010](#)). We therefore borrow this rationalization of stickiness in economic decision-making and extend it to the choice of imposing capital controls. This section extends the baseline setup by introducing a friction that, we conjecture, has the ability to bring the model closer to the data, while at the same

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²¹In the Appendix, we provide the first-order conditions in the Ramsey economy, as well as the derivation of the optimal capital control's tax.

²²The welfare implications of these models, as a guidance for optimal policy making, have been found not to be robust however due to concerns related to multiple equilibria, see for example [Schmitt-Grohé and Uribe \(2020\)](#), [Bianchi and Mendoza \(2018\)](#), [Benigno et al. \(2016\)](#), [Hernandez and Mendoza \(2017\)](#).

time capturing other features that the literature has highlighted about capital controls. The friction that we postulate is a cost of imposing and further adjusting capital controls along the intensive margin. This cost has an (S, s) structure, which has the ability to induce an inaction region that resembles that observed in the data. In general terms, with an (S, s) -type framework, agents remain in an inaction region until their losses generated by this choice surpass a particular threshold, which then triggers an adjustment to a latent optimal value for their state. The environment that we postulate is similar but adapted to the Ramsey planner, who internalizes a (reduced-form) cost in terms of utility when capital controls are adjusted. The planner is thus confronted at every moment with the choice between setting the level of capital controls to their optimal level and hence paying the cost, or not adjusting the instrument and not incurring such cost.

While reduced form, the (S, s) cost structure captures deeper trade-offs that policy-makers face when confronted by the choice of using capital controls that are absent in the baseline model. In the next section, we explore the validity of our conjecture that this friction can help the model get closer to the data by calibrating the model, including the size of the (S, s) cost, and assess the quantitative performance of the extended model. It is natural to ask how other cost structures different from the (S, s) form would perform. We explore this possibility in the Appendix by assuming that, instead of an (S, s) structure, there is a continuous convex or concave cost of adjustment $C(\tau_t)$ paid by the government in terms of tradable goods. Neither of the two costs features the highly non-linear feature of the (S, s) structure.²³ In the final section of the paper, we discuss possible deeper causes that could give rise to such costs and relate them to the literature.

4.2.1 Setup

The inclusion of an (S, s) cost into the Ramsey planner problem implies that she now has to choose between two value functions, one associated with adjusting the value of the capital control tax and the other associated with not adjusting it. Formally, the recursive formulation of the planner's problem in this environment becomes:

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²³Our main takeaway from this exercise is that other types of reduced-form cost structures different than an (S, s) setup are not able to provide empirical approximations to the observed stickiness in capital controls.

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

subject to:

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

$$d' \leq \kappa \left[y^T + \frac{1-a}{a} \left(\frac{c^T}{y^N} \right)^{1/\zeta} y^N \right], \quad (12)$$

where we define V^A as the value of adjusting the capital control tax from its initial value to the one that is optimal in the absence of (S, s) costs, τ^* . This adjustment carries out a fixed (utility) cost K :

$$V^A(y^T, r, d, \tau) = [U(c^T(\tau^*)) - K] + \beta E[\text{Max}(V^A(y'^T, r', d', \tau'), V^{NA}(y'^T, r', d', \tau'))], \quad (13)$$

and V^{NA} captures the value of not adjusting the instrument and hence not incurring the cost K :

$$V^{NA}(y^T, r, d, \tau) = U(c^T(\tau)) + \beta E[\text{Max}(V^A(y'^T, r', d', \tau'), V^{NA}(y'^T, r', d', \tau'))] \quad (14)$$

Under this new environment, the previous period's capital control tax becomes a state variable. An inaction region for this instrument exists for states when $V^{NA} > V^A$, therefore giving the model a better chance to account for the stickiness observed in the empirical counterparts of capital controls.

Note that the extended model encompasses, as two extreme cases, the unregulated economy and the Ramsey planner cases described in the previous section. On one hand, the case when $K = 0$ is equivalent to the Ramsey planner's world in the baseline model and yields the largest gains in terms of welfare. On the other hand, [Equation 13](#) 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 and yields the lowest possible welfare. As a result, welfare in the extended model is bounded between the decentralized case in the baseline model and the Ramsey planner without (S, s) costs. We solve the solve

the model using a recursive algorithm that we describe in the appendix.²⁴

One usual concern with models featuring pecuniary externalities is that of time-inconsistency. Bianchi and Mendoza (2018) show that in models with stock collateral constraints, depending on endogenous asset prices, the optimal policy under commitment is time-inconsistent.²⁵ However, as these authors show, this problem does not arise in models where borrowing capacity is determined by a static condition (Lorenzoni 2008, Bianchi 2011, among others), such as the price of non-tradable goods, which is our case.

5 Quantitative Analysis

In this section, we run a quantitative analysis of the extended model presented above. We begin with a simple illustration of the effects that varying levels of (S, s) costs have on the equilibrium dynamics of the extended model using a standard calibration from the literature. Next we undertake a formal, more comprehensive exercise where we calibrate the extended model for each of the 21 EMEs in the dataset and assess the performance of the model in matching the stylized facts from Section 3.

5.1 Illustrating the Effects of (S, s) Costs

To illustrate the effects of varying levels of (S, s) costs in the extended model, we set our main parameters to those traditionally used in the literature (Bianchi (2011), Schmitt-Grohé and Uribe (2017)) and document the results with alternative values for K . In particular, we set the inverse of the elasticity of substitution (σ) to 2, the discount factor (β) to 0.91, the annual real interest rate (r) takes the value of 4%, intratemporal elasticity of substitution (ζ) is calibrated to 0.83; while the the share of tradables in the CES aggregator (a) is set at

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²⁴Our algorithm, that relies on setting the value of τ to the optimal value in absence of (S, s) cost, τ^* , is more computationally efficient than applying value function iteration (VFI). However, one might be concerned that the planner in the (S, s) economy adjusts the tax to an even higher value than τ^* to avoid future costs of adjustment. To consider this possibility, we also use a VFI method to solve the model calibrated for Argentina, such that the adjusted value of τ does not have to be τ^* . In this case, the results are virtually the same than in our computational algorithm, and we do not observe such overshooting of the capital control's tax.

²⁵In this framework, when the constraint binds the planner promises lower consumption to increase asset prices and borrowing capacity, which is sub-optimal ex post.

0.31. Parameters are summarized in the top panel of [Table 2](#). When assessing the results, we pay particular attention to the dimensions directly linked to the stickiness in capital controls uncovered in the stylized facts in Section 3.

To illustrate the effects of (S, s) costs, first we compare the policy functions of the baseline model with those of the extended model. [Figure 9](#) shows different policy functions for τ , given different states of debt. Each policy function corresponds to a different state of endowments, depicted in each panel of the figure. The left panel shows the policy functions for the baseline model, such that the (S, s) -cost K is nil, and the right panel shows the policy functions for the (S, s) economy assuming a value of K that lies between the range considered ($K = 0.014$). Two important features of the model emerge from this figure. First, for the lower states of debt levels, when the tax is on in the baseline economy, this is not necessarily the case in the (S, s) economy. Second, as opposed to the baseline model, the policy functions of the extended model show that different states of debt may map into the same level of the tax. In other words, contrary to the baseline model, in the (S, s) economy higher levels of debt do not necessarily imply higher levels of taxes. This is originated directly by the presence of a non-trivial value of K , which ultimately leads to the stickiness documented before.

Second, we show how different values of K affect the policy function of τ . [Figure 10](#) shows how such policy functions differ for a given state of endowments. The policy function corresponding to the baseline model (i.e. $K = 0$), exhibits an increasing tax with debt once it is activated. However, the policy functions corresponding to $K = 0.014$ and $K = 0.018$ show that there is a delay in the use of the tax and, as in the previous figure, different states of debt can map into the same tax. This stickiness leads the highest value of taxes in the (S, s) economy to be lower than those in the baseline model. One important feature of the model is that it nests both the baseline economy, and the decentralized economy. The latter is illustrated in the figure by the policy function corresponding to $K = 0.1$. In this case, the (S, s) cost is so high that it is never worth to activate the capital control tax, leaving the allocations the same as in the decentralized case. This means that the model can generate an ever-zero tax for a reason different than having zero probability of a financial crisis the next period.

Figure 9: Policy function of τ for different states of endowments

Notes: The left panel shows different policy functions for the capital control tax in the baseline economy, each one corresponding to a different state of endowments. The right panel shows, for the same states, different policy functions for the (S, s) economy, given a value of $K = 0.014$.

Figure 10: Policy function of τ for different (S, s) costs

Notes: The figure shows the policy functions of the capital control tax for different values of the (S, s) cost, K . The function with $K = 0$ is the same as the baseline model. The one with $K = 0.1$ leads to no tax activation, being isomorphic to the decentralized economy.

Third, we compare the ergodic distributions of debt in the (S, s) economy for three cases: the baseline model, the (S, s) economy with $K > 0$ and tax activation, and the decentralized economy (i.e. $K > 0$ and no tax activation). Figure 11 shows the three cases, which correspond respectively to $K = 0, K = 0.014$, and $K = 0.1$. The two extreme densities show the standard result in the literature. This is, agents in the decentralized economy overborrow. The presence of a policy-making cost where taxes are implemented in a sticky way, as depicted in the previous two figures, implies that borrowing of agents is somewhere in between the costless Ramsey economy and the decentralized economy. The dashed density, corresponding to $K = 0.014$, shows this case. Agents in the (S, s) economy also overborrow, but less than in the case of the decentralized economy (which is an extreme case of the (S, s) economy). Therefore, the higher the value of K , the closer the ergodic distribution of debt gets to the decentralized case. Likewise, the lower the value of K , the closer the distribution gets to the baseline case.

Figure 11: Ergodic distribution for different (S, s) costs

Notes: The figure shows the ergodic distribution of debt for the baseline model ($K = 0$), the (S, s) model with tax activation ($K = 0.014$), and the (S, s) model with no activation ($K = 0.1$) which is isomorphic to the decentralized economy.

Fourth, to gather the moments that characterize the dynamics of the capital control's tax, we employ the policy functions obtained in the solution of the models to simulate them

and report the results of the simulation in [Figure 12](#).²⁶ The upper left panel shows the average share of time during which the optimal tax is greater than zero. The first bar (light blue) corresponds to the Ramsey economy in the baseline model ($K = 0$); the last bar (yellow) corresponds to the average share of time with taxes on inflows and outflows in the data ([Figure 1](#)). The bars in between (dark blue) show the results in the extended model for arbitrarily different values of K , which are reported on the horizontal axis. While the baseline model implies that capital controls ought to be active in every period, even relatively small values of (S, s) costs give the extended model the ability to reduce the share of time in which the tax is active, with higher (S, s) costs further reducing this share, bringing it more in line with the data.

The upper right plot in [Figure 12](#) documents the effects of K over the average frequency of changes in the tax for every (nonconsecutive) 20 years in the simulation, the same duration we observe in the data. While the baseline model predicts a very active use of the policy instrument (i.e., 20 changes in each of the 20 years), thereby validating our earlier conjecture that the baseline model would fail in generating stickiness in capital controls, the extended model features a much lower frequency of changes, ranging from 6 to 1, as the (S, s) costs increase, which is more in line with the empirical moment documented earlier. In other words, (S, s) costs go a long way toward giving the model the chance to reproduce the stickiness in the data of capital controls.

The lower left panel reproduces episodes of a forceful use of capital controls in the simulated data, akin to those found in the dataset and presented in [Figure 4](#). The results of the simulation document a strong non-linearity in the behavior of capital controls in the (S, s) model as K increases. For values of K lower than a certain threshold, episodes of activation of this tool resemble those in the data: the tax begins the episode at 0% (or close to that value) and forcefully increases above 10%. However, for values of K above that threshold, (S, s) costs are so high that capital controls do not activate, which is also

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²⁶More precisely, conditional on an initial debt level and simulated series for the two endowment processes, we use the policy functions obtained in the solution to derive time series for the choice variables in the model (consumption, next-period debt) for the range of years considered in the simulation for one million years. We start our simulation with $\tau_0 = 0$, which yields an initial period of zero tax rates. This is not, however, without loss of generality, since starting at another value would yield the observed stickiness, but would affect the mean tax and the share of time when the tax is active.

Figure 12: (S, s) Costs in Capital Controls: A Quantitative Illustration

Notes: The figure shows the effects of higher (S, s) costs over the relevant moments regarding stickiness in capital controls. The first two figures in the upper row show in the blue bars for different values of K , respectively, the share of time with a positive capital control tax (left figure) and the number of changes in it (right figure). The yellow bars correspond to the cross-country average between the tax on inflows and the tax on outflows. The two figures in the lower row show for different values of K , respectively, the episodes of activation in the controls (left figure) and their serial autocorrelation (right figure). The red lines correspond to the cross-country averages for the mean between taxes on inflows and outflows.

reminiscent of the stylized facts presented above in that capital controls have not been used by several of the countries considered.

Lastly, the lower right panel documents the effects of varying levels of (S, s) costs on the serial autocorrelation of capital controls of one and two years. It illustrates how higher levels of K help increase the autocorrelations of the tax, bringing the simulated moments closer to the high values in the data.

5.2 Calibration

The results in the previous section are useful for illustrating the quantitative effects of alternative (S, s) costs. In this section, we perform a more detailed calibration of these costs to further assess their empirical relevance in the the different countries. We now undertake this task by calibrating the extended model to each of the 21 EMEs in the dataset.

Our calibration strategy is summarized in [Table 2](#). It involves fixing a subset of the parameters across countries and then having a country-specific calibration for the remaining subset. For the first subset of parameters that are equal across countries we follow [Schmitt-Grohé and Uribe \(2017\)](#), as in our simulation exercise, and set $\sigma = 2$; $\beta = 0.91$; $r = 4\%$; $\zeta = 0.83$; and $a = 0.31$.

Table 2: Baseline Calibration

Parameter	Value	Description
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
Mean κ Baseline Model	0.3131	Parameter of collateral constraint
Mean K Baseline Model	0	(S, s) cost of policymaking
Mean κ (S, s) Model	{0.3257}	Parameter of collateral constraint
Mean K (S, s) Model	{0.0102}	(S, s) cost of policymaking

Targeted Moments

	Frequency of Crisis	Changes in τ
Data	18.8	1.4
Baseline Model (Mean)	18.36	13.88
(S, s) Model (Mean)	19.62	1.64

Notes: The second and third rows in the upper panel of the table show, respectively, the cross-country mean values of κ and K calibrated in the baseline model (the latter is zero by definition). The third and fourth rows show, respectively, the same two cross-country mean parameters calibrated in the (S, s) model. The lower panel of the table shows in the row for Data the two targeted moments used to calibrated κ and K in the (S, s) model. The last two rows show the cross-country means for two two moments generated by both the baseline model and the (S, s) model.

The second subset of parameters that we calibrate on a country-by-country basis comprises the two endowment processes for tradable and non-tradable income $\{y^T; y^N\}$ that

constitute the driving forces of the model and the parameters that govern the strength of the collateral constraint (κ) and the stickiness in capital controls (K). Regarding $\{y^T ; y^N\}$, we build tradable and non-tradable time series for each country from World Development Indicators. We followed [Schmitt-Grohé and Uribe \(2017\)](#) and defined y^T as the sum of manufacturing and agriculture, while y^N was the residual from subtracting y^T from total GDP. As these authors do, we estimate a 2-variable vector autoregression for both variables, and discretize the process into a 4-state Markov chain.

The calibration strategy for κ and K selects values for these two parameters such that the distance between model and data along two key moments is minimized: the frequency of adjustment in the intensive margin of capital controls from the new dataset, and the frequency of occurrence of financial crises. The rationale for this strategy is as follows. On one hand, as we illustrated in the previous section, the frequency of changes in capital controls can be informative about the extent to which (S, s) costs (K) are relevant. On the other hand, the frequency of financial crises in the data can provide information regarding κ . Indeed, higher values of this parameter will imply, *ceteris paribus*, a less restrictive collateral constraint and therefore fewer states where the constraint binds (a financial crisis in the model).

[Figure 13](#) further validates our calibration strategy for these two parameters. The panels document how, in the model, both κ and K relate to the frequency of crisis, defined as the share of time that the constraint binds in our simulations. Other things being equal, a higher κ yields a lower frequency of crisis (upper left panel). Likewise, lower values of K yield a lower share of years in crisis as capital controls can be deployed with more flexibility, thereby allowing the economy to be more insulated against crises (lower left panel). This warrants our choice of the two moments to jointly pin down both parameters.

The upper right panel in [Figure 13](#) presents the relationship between our estimates of intensity in capital controls from the new dataset and the empirical estimates for the incidence of financial crises that we use in our calibration, taken from [Reinhart \(2010\)](#). While this work provides estimates for the incidence of a variety of crises on a panel of countries, we focus on their measure of currency crisis (i.e., large depreciations), which we believe is closest to the kind of financial crises in the extended model, since episodes when the

Figure 13: Calibrating (S, s) Costs

Notes: The upper left figure shows how a higher κ in the collateral constraint leads to, other things being equal, lower frequency of crisis (measured as share of years in crisis on the vertical axis). The upper right figure shows the mean capital control taxes on inflows and outflows (horizontal axis) for each country in our sample, compared to the number of currency crises during the period 1995–2010 taken from [Reinhart \(2010\)](#). The last figure shows how a higher (S, s) cost of policy-making K leads to, other things equal, higher frequency of crisis (measured as share of years in crisis on the vertical axis).

financial constraint binds are accompanied by large movements in the relative price of non-tradables. There are two things worth noting in the scatter plot. First, there is a negative and statistically significant correlation between the intensity of controls and the incidence of crises. Second, and perhaps more important for the relevance of (S, s) costs, virtually all countries that did not make use of the intensive margin of capital controls (i.e., those on top of the vertical axis of the plot) still exhibit a relatively high incidence of currency

crises. It is therefore plausible to argue that, for those countries, an additional friction may have been present that prevented them from using capital controls despite the occurrence of crises, which would be captured in our (S, s) cost.²⁷

Table 2 presents the average values for K and κ across the 21 EMEs in the dataset, as well as the performance of the extended model along the two targeted moments. The Appendix contains the country-by-country results. The table also presents the results of calibrating the baseline model with no (S, s) costs and its performance along the same two moments. In the latter case, the mean value of κ is 0.31 and the frequency of crisis is 18.4%, similar to the empirical counterpart of 18.8%. However, the baseline model predicts a very active use of capital controls by implying that such instruments change, on average, 13.8 times for every 20 years simulated. This is at odds with the data by an order of magnitude where, on average, controls are only changed 1.4 times for every 20 years. In contrast, in the extended model, the average κ is 0.33 and the mean value of (S, s) costs (K) is 0.01. This delivers a much better fit in terms of the number of changes in capital controls delivered by the model (1.6 times every 20 years) without a cost in terms of the performance of the model when accounting for the frequency of crisis (19.6%).

5.3 Results

We assess the performance of the extended model in matching more dimensions in the data that were not directly targeted in the calibration and that relate to the aforementioned stickiness of capital controls. For comparison, we also present the results of the baseline model.²⁸

Figure 14 summarizes the results of the various comparisons. Results are averages

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²⁷Out of the 21 EMEs in our dataset, there are three exceptions to this claim. Two of them—Israel and the Czech Republic, which are included in our dataset—are not in the scatter plot as Reinhart (2010) does not provide data of the incidence of crises in these two countries. The third, China, is the only country that does not have a financial crisis, while no use of the intensive margin of capital controls was recorded in our dataset (i.e, it is the only point in the origin of the scatter plot). This can be explained by recalling that, as documented in Section 3, a large fraction of the regulations on capital controls in China are non-price-based, as was further documented in Fernández et al. (2016).

²⁸When comparing model and data, for the latter we use the mean of taxes on inflows and outflows since the model does not distinguish between gross inflows and outflows. However, results are robust if we compare the model with taxes on inflows and outflows separately. This is due to the fact that, in our dataset, controls on inflows and outflows comove—a result that was previously documented by Fernández et al. (2015) using the extensive margin of capital controls over a large panel of countries.

across the models calibrated for each of the countries in the dataset (the Appendix contains country-by-country results). The panel in the upper left corner documents the share of time that controls are predicted to be active (strictly positive) by each model. It shows how the presence of (S, s) costs brings the model closer to the data: while the baseline model continues to assume a very active use of controls, being active at every period in the simulation, the extended model predicts controls to be active only above 40% of the time, closer to the 20% in the data.

The upper right panel presents the results in terms of the mean value of the tax, capturing the intensity with which capital controls were used. The baseline model predicts an average τ of about 5.5%, far above the 3% in the data. The extended model predicts a lower τ of about 2%, closer to the cross-country mean for taxes on inflows and outflows in the data.

The middle left panel represents the number of changes in both the baseline and extended model—which, as mentioned above, was a moment targeted in the calibration. The middle right panel depicts episodes of forceful use of controls identified in the simulated data in the same way that episodes were identified in the new dataset (Figure 4), which we replicate for comparison. Again, results show that (S, s) costs help to account for the stickiness in capital controls: while the baseline model (dotted line) does not yield periods of inaction in the use of controls, which change rather frequently, the extended model with (S, s) costs (dashed line) exhibits initial periods of inactive controls that do not revert to their mean when they become active.

Lastly, the lower left panel further documents the mean reversion properties of the models by reproducing the first and second-order serial autocorrelations implied by both frameworks and comparing them with the one in the data presented earlier (Figure 5). In this dimension, the difference between the baseline model (dotted line) and the extended model (dashed line) is starker. While the former yields a counterfactual negative first-order serial correlation, the latter more closely resembles the relatively high value in the data (solid line).

Figure 14: Quantitative Results: Calibrated Model

Notes: The first figure compares how the share of time with the capital control's tax is activated in the data (third bar) with respect to the baseline and (S, s) models (first and second bars, respectively). The second figure (first row) does the same than the first one, but for the mean value of the capital control tax. The first figure in the second row shows such comparison for the number of changes in the tax. The second figure in the second row depicts the episodes of activation of capital controls in the data (solid line), the baseline model (dotted line), and the (S, s) model (dashed line). The last figure has the same format of the previous one, and shows the serial autocorrelation of the capital control taxes up to two years. For all figures, the data bar/line is the cross-country average of the mean between taxes on inflows and outflows. Likewise, the canonical model and (S, s) model bars are the cross-country averages of the capital control's tax.

5.4 Welfare Analysis

We compute the welfare gains of implementing capital controls in the baseline model and contrast them with those in the extended model, given the calibrated values of (S, s) costs presented above. By construction welfare gains will be in between those in the frictionless economy and those of the decentralized equilibrium. Hence a relevant practical question is, given the calibrated (S, s) costs how close to each of these two cases will the extended model be? The welfare gains that we compute are consumption-equivalent factors that make households in both the unregulated baseline economy and the (S, s) economy to be as well off as in the Ramsey economy with frictionless capital controls. Formally, we calculate λ^{UR} and λ^{Ss} such that:

$$\sum_{t=0}^{\infty} \beta^t u [C_t^{UR} (1 + \lambda^{UR})] = \sum_{t=0}^{\infty} \beta^t u [C_t^R] \quad (15)$$

and

$$\sum_{t=0}^{\infty} \beta^t u [C_t^{Ss} (1 + \lambda^{Ss})] = \sum_{t=0}^{\infty} \beta^t u [C_t^R] \quad (16)$$

The cross-country means of λ^{UR} and λ^{Ss} are 0.94% and 0.76%, respectively.²⁹ These results (summarized in Table 3) document how, on one hand, there are sizable gains in terms of welfare when implementing capital controls in a frictionless environment. Indeed, consumption by agents in the unregulated economy would have to be close to one percentage point higher for them to be as well off as those living under the Ramsey planner with no (S, s) costs.

On the other hand, the same consumption equivalent compensation for agents living in the economy with (S, s) costs is also considerable, 0.75%, about 4/5 that of agents living in the unregulated economy. This implies that the magnitude of (S, s) costs calibrated in the previous section is large enough to eliminate most—though not all—of the welfare gains obtained in an environment where capital controls can be used without cost.³⁰

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²⁹Country-by-country estimations are reported in the Appendix

³⁰An alternative way to measure the welfare implications of (S, s) costs is to derive the consumption equivalent factor (λ^{UR-alt}) that makes households in the unregulated baseline economy to be as well off as in the (S, s) economy: $\sum_{t=0}^{\infty} \beta^t u [C_t^{UR} (1 + \lambda^{UR-alt})] = \sum_{t=0}^{\infty} \beta^t u [C_t^{Ss}]$. In line with the previous result, λ^{UR-alt} is relatively small (0.11%).

Table 3: Welfare Analysis

	Unregulated Economy	(S, s) Economy
Welfare Gains	$\lambda^{UR} = 0.94\%$	$\lambda^{S-s} = 0.76\%$

Notes: The first column of the table shows the increase in consumption that would be needed for the household in the unregulated economy to have the same welfare as in the Ramsey economy with no (S, s) costs, λ^{UR} . The second column shows the increase in consumption that would be needed for the household in the (S, s) economy to have the same welfare as the Ramsey economy with no (S, s) costs, λ^{UR} . Both values are cross-country means.

6 Conclusion

One of the legacies of the 2007–2008 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. The case for capital controls rests primarily on the volatility of foreign capital inflows. As macroprudential measures, they are designed to mitigate systemic crises.³¹ Their optimal use and effectiveness, however, remain much debated. In this paper, we have aimed to contribute to this debate by addressing both positive and normative features of capital controls. On the positive front, our efforts were devoted to describing the key stylized facts observed from a new dataset on the use of *de jure* controls for a panel of EMEs along their extensive and intensive margins, with focus on price-based controls, as to improve our characterization of how these policy tools have been implemented. Our view is that any meaningful test for a theory of capital controls needs to be able to account for a richer set of stylized facts.

The key empirical finding is that controls display certain statistical properties that characterized them as “sticky.” Changes to price-based capital controls do not occur frequently, and when they do, they remain in place for a long time. Overall, they have not been used systematically across countries or time, and there has been considerable heterogeneity across countries in terms of the intensity with which they have been used. On the normative side, we then extend a model of capital controls relying on pecuniary externalities augmented to include an (S, s) cost of implementing such policies. We illustrate how this friction goes a long way toward bringing the model closer to the data. When the extended

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³¹In 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).

model is calibrated for each of the countries in the new dataset, we find that the size of these (S, s) costs is large, thus substantially reducing the welfare-enhancing effects of capital controls compared with the frictionless Ramsey benchmark.

Our broad view of the findings is *not* that the workhorse model of pecuniary externalities is unsuitable for empirical analysis. Instead, we subscribe to a view that calls for a richer set of policy constraints when considering an optimal use of optimal capital controls in models that rely on such externalities. Our work has, nonetheless, been silent about the formal microfoundations of such costs and goes only as far as to discuss some of the possible deeper causes. There are several reasons why models of optimal capital controls may be at odds with the data, and the reduced form specification with which we try to capture several of these reasons. Such costs, for example, may be capturing a more complex cost-benefit analysis made by policymakers, incorporating negative effects and/or unintended consequences of capital controls not picked up by standard models for example in the development of the financial markets, ([Forbes 2007](#); [Alfaro et al. 2017](#); [Andreasen et al. 2019](#)). These can also link to credibility and signaling issues related to the use of these tools that end up shaping policy choices over these instruments in a highly nonlinear form (e.g. [Bartolini and Drazen \(1997\)](#)). Model robustness ([Schmitt-Grohé and Uribe 2020](#) and [Benigno et al. 2011](#)) and lack of effectiveness—or perceptions—of capital controls ([Klein 2012](#); [De Gregorio et al. 2000](#); [Goldfajn and Minella 2005](#)) may also play a role in policymakers’ cautious use of these instruments, unless extreme conditions warrant their use. A recent survey performed by the Bank of International Settlement, for example, documents that most policy makers believe capital controls not to be effective. The document adds countries did not recur to capital controls during that COVID crisis and notes, more generally, that there is a recognition “that capital controls were more powerful in models than in reality and that the relative lack of proactive use of capital controls as “gates” could reveal the stigma they have as a sign of bad future policies,” ([BIS 2011](#)).

The (S, s) costs in the extended model are evidently a reduced form to capture the large set of deeper constraints that policymakers may face when confronted with the choice of using capital controls, absent from the simple environment in the model. While we believe that providing complete microfoundations of (S, s) costs is beyond the scope of this paper,

the remaining of this section offers a brief discussion of such constraints, relating them the broader literature on international finance. In that regard, an obvious further avenue that comes out of our work is the formal modeling of the primitive frictions that can give rise to the documented stylized facts documented.

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Appendix

A.1 Models' Derivations

A.1.1 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:

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \{ U(A(c_t^T, c_t^N)) + \lambda_t [y_t^T + p_t y_t^N + \frac{d_{t+1}}{1+r_t} - c_t^T - p_t c_t^N - d_t] + \lambda_t \mu_t [\kappa(y_t^T + p_t y_t^N) - d_{t+1}] \} \quad (17)$$

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

$$[c_t^T] : U'(A(c_t^T, c_t^N)) A_1(c_t^T, c_t^N) = \lambda_t \quad (18)$$

$$[c_t^N] : U'(A(c_t^T, c_t^N)) A_2(c_t^T, c_t^N) = p_t \lambda_t \quad (19)$$

$$[d_{t+1}] : (\frac{1}{1+r_t} - \mu_t) \lambda_t = \beta E_t \lambda_{t+1} \quad (20)$$

$$\mu_t \geq 0 \quad (21)$$

and

$$\mu_t [d_{t+1} - \kappa(y_t^T + p_t y_t^N)] = 0 \quad (22)$$

Combining (18) with (19) and using the functional forms for the utility function and the consumption aggregator, we obtain:

$$p_t = \frac{1-a}{a} \left(\frac{c_t^T}{c_t^N} \right)^{1-\zeta} \quad (23)$$

The market for non-tradables clears in equilibrium:

$$c_t^N = y_t^N \quad (24)$$

We can use the results from (18) and (23), respectively, into (20) and (3) and the market-clearing condition into all the first-order conditions to define the competitive equi-

librium:

Definition 6.1. *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:

$$(\frac{1}{1+r_t} - \mu_t)U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) = \beta E_t U'(A(c_{t+1}^T, y_{t+1}^N))A_1(c_{t+1}^T, y_{t+1}^N) \quad (25)$$

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1+r_t} \quad (26)$$

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

$$\mu_t \geq 0 \quad (28)$$

and

$$\mu_t[\kappa(y_t^T + \frac{1-a}{a}(c_t^T)^{1/\zeta}(y_t^N)^{1-1/\zeta}) - d_{t+1}] = 0 \quad (29)$$

A.1.2 Baseline Ramsey Planner Economy

For the Ramsey planner, the Lagrangian is:

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \{U(A(c_t^T, c_t^N)) + \lambda_t^R [y_t^T + \frac{d_{t+1}}{1+r_t} - c_t^T - d_t] + \lambda_t^R \mu_t^R [\kappa(y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta} y_t^N) - d_{t+1}]\} \quad (30)$$

The first-order conditions are:

$$[c_t^T] : U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) + \lambda_t^R \mu_t^R \kappa \frac{1-a}{a} \frac{1}{\zeta} (\frac{c_t^T}{y_t^N})^{1/\zeta-1} = \lambda_t^R \quad (31)$$

$$[d_{t+1}^T] : (\frac{1}{1+r_t} - \mu_t^R) \lambda_t^R = \beta E_t \lambda_{t+1}^R \quad (32)$$

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

$$\mu_t^R \geq 0 \quad (34)$$

and

$$\kappa[y_t^T + \frac{1-a}{a}(\frac{c_t^T}{y_t^N})^{1/\zeta}y_t^N] - d_{t+1} \geq 0 \quad (35)$$

By comparing the first-order conditions of the decentralized economy and the Ramsey planner's economy shown in equations (18) and (31), 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 (31), an additional unit of tradable consumption reduces its marginal utility when the constraint 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 overborrowing³².

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)³³.

A.1.3 Regulated Economy - Optimal Tax

The optimality conditions (25)- (29) are unchanged except for the debt Euler Equation (25), which now takes the form:

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

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³²Schmitt-Grohe and Uribe (2016) make a case for multiple equilibrium in this class of models, where instead of overborrowing, the decentralized 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.

³³This 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.

Definition 6.1. *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:

$$c_t^T + d_t = y_t^T + \frac{d_{t+1}}{1 + r_t} \quad (36)$$

$$d_{t+1} \leq \kappa[y_t^T + p_t y_t^N] \quad (37)$$

$$\lambda_t = U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) \quad (38)$$

$$\left(\frac{1 - \tau_t}{1 + r_t} - \mu_t\right)\lambda_t = \beta E_t \lambda_{t+1} \quad (39)$$

$$p_t = \frac{A_2(c_t^T, y_t^N)}{A_1(c_t^T, y_t^N)} \quad (40)$$

$$\mu_t[\kappa(y_t^T + p_t y_t^N) - d_{t+1}] \quad (41)$$

and

$$\mu_t \geq 0 \quad (42)$$

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 .

The difference between the equilibrium described in definition 3.1 and the one described in 3.2 relies on (39), which is the first-order condition with respect to d_{t+1} and now has τ_t reducing the marginal utility of debt.

A.1.4 Solution

The lack of a closed-form solution in both baseline and extended models requires us to solve the models using global methods in order to conduct a quantitative analysis of them. In the unregulated economy of the baseline model, we use policy function iteration procedures; in the Ramsey planner version, since there is no pecuniary externality, we use standard value function iteration procedures. These methods allow us to derive numerically the policy functions that map states—the two endowment processes and debt—into decision

variables with which we later conduct simulations in the quantitative analysis presented in the next section.

The solution method of the (S, s) model cast in [Equation 10](#) to [Equation 14](#) first requires us to solve for the baseline Ramsey economy to obtain the policy functions of the control variables, including τ^* . Then, given the stochastic process of endowments, we simulate 1 million periods and obtain τ_t^* for each period t (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 of the (1 million) values of τ_t^* obtained in the previous step. By doing this, we obtain all possible combinations of policy functions, given a simulated process for the endowments, for each state of the economy and for each different τ^* and its correspondent indirect utility at each period. This process facilitates the solution of the Ramsey planner problem with (S, s) costs. Once this is done, in the (S, s) model we need to keep track of the state (τ_{t-1}) and assume that the initial value of the tax is 0 ($\tau_0 = 0$). Then for each period in the simulation, given a calibrated value of K , we obtain V_t^A and V_t^{NA} . In case the former is greater than the latter, we set $\tau_t = \tau_t^*$, otherwise $\tau_t = \tau_{t-1}$.

This procedure turns out to be more computationally efficient than value function iteration. When solving by value function iteration, there is no need to calculate τ^* beforehand, since this variable now is endogenously determined within the algorithm. However, because this considerably increases the dimensions of state space, it becomes a computational burden to solve for each country with this method. As a result, we apply the latter method to solve one country, Argentina, and obtain virtually the same results than with our algorithm.

A.1.5 Alternative Costs of Policy Making - First-Order Conditions

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

$$\begin{aligned}
[c_t^T] : & U'(A(c_t^T, y_t^N))A_1(c_t^T, y_t^N) - \\
& \theta_t^R \left(\frac{1 - \tau_t}{1 + r} \right) \left\{ (c_t^T)^{-1/\zeta} \left(\frac{-\sigma + 1/\zeta}{1 - 1/\zeta} \right) [a(c_t^T)^{1/(1-1/\zeta)} + (1-a)(y_t^N)^{1/(1-1/\zeta)}] \frac{-\sigma+1/\zeta}{1-1/\zeta} - 1 \left(\frac{a}{1 - 1/\zeta} \right) (c_t^T)^{\frac{1/\zeta}{1-1/\zeta}} \right. \\
& \quad \left. - \frac{1}{\zeta} (c_t^T)^{-1/\zeta-1} [a(c_t^T)^{1/(1-1/\zeta)} + (1-a)(y_t^N)^{1/(1-1/\zeta)}] \frac{-\sigma+1/\zeta}{1-1/\zeta} \right\} \\
& \quad + \lambda_t^R \mu_t^R \kappa \frac{1-a}{a} \frac{1}{\zeta} \left(\frac{c_t^T}{y_t^N} \right)^{1/\zeta-1} = \lambda_t^R \quad (43)
\end{aligned}$$

$$[d_{t+1}] : \frac{\lambda_1^R}{1+r} = \beta \lambda_{t+1}^R + \lambda_t^R \mu_t^R \quad (44)$$

$$[\tau_t] : -\lambda_t^R C'(\tau_t) + \frac{\theta_1^R}{1+r} [(c_t^T)^{-1/\zeta} [a(c_t^T)^{\frac{1}{1-1/\zeta}} + (1-a)(y_t^N)^{\frac{1}{1-1/\zeta}}] \frac{-\sigma+1/\zeta}{1-1/\zeta}] = 0 \quad (45)$$

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

$$\mu_t^R \geq 0 \quad (47)$$

and

$$\kappa [y_t^T + \frac{1-a}{a} \left(\frac{c_t^T}{y_t^N} \right)^{1/\zeta} y_t^N] - d_{t+1} \geq 0 \quad (48)$$

A.2 Additional Figures

Figure 15: Use of Capital Controls: All Instruments

Notes: In Panel A, the bars depict the share of countries that have used (i.e., value of the 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 2015q4, the maximum total of quarters is 80 (100%). Here we include capital controls (URRs, Taxes on Inflows, and Taxes on Outflows), and macroprudential instruments (Reserve Requirements and FX Reserve Requirements).

Figure 16: Episodes of Activation in Capital Controls: Country by Country

Notes: The beginning of an episode was defined as when, for a given policy instrument at period 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 first row shows episodes of activation in the controls at a quarterly frequency, and the second row shows such episodes at a yearly frequency. Here we show for each capital control instrument—URRs (first row), Taxes on Inflows (second row), and Taxes on Outflows (third row)—the episodes of activation in each country.

Figure 17: Serial Correlation of Capital Controls: Country by Country

Notes: The figure shows for each capital control instrument—URRs (first row), Taxes on Inflows (second row), and Taxes on Outflows (third row)—the t -order serial autocorrelation for each country.

Figure 18: Episodes of Capital Controls & the Macroeconomy: All Capital Controls

Notes: The figure shows the episodes described in Figure 4 along with the cross-country mean deviation from the average GDP growth. The plots shown the following number of episodes: URRs (7), Taxes on Inflows (6) and Taxes on Outflows (11). We also include the URRs Tax Equivalent (7 episodes).

Figure 19: Episodes of Activation in Capital Controls & Macroprudential Instruments

Notes: The beginning of an episode (episodes are depicted by red lines) 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 $t+10$. Here we included the macroprudential instruments from our data base: Reserve Requirements (and the Marginal Reserve Requirements) and Reserve Requirements on Foreign Exchange (and the Marginal FX Reserve Requirements).

Figure 20: Capital Controls, Macroprudential Instruments, and the Business Cycle

Notes: 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 graph) and countries that have (right column). The episodes of boom and bust correspond to the period from 2000q1 to 2015q4 given the availability of data from macroprudential instruments.

Figure 21: Price-Based and Non-Price-Based Capital Controls

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

Figure 22: Serial Correlation of Capital Controls: The Extensive Margin

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

Figure 23: Capital Controls with Alternative Cost Functions

Notes: The top row of the figure shows in a three-period framework a recursive simulation of the capital control's tax with convex costs of adjustment in period 1 (left panel) and period 2 (right panel). The horizontal axis displays different values for the endowment of the tradable good in period 2. Periods 1 and 3 are assumed to have a fixed endowment of 1. The bottom row shows in a three-period framework a recursive simulation of the capital control's tax with concave costs of adjustment in period 1 (left panel) and period 2 (right panel). The horizontal axis displays different values for the endowment of the tradable good in period 2. Periods 1 and 3 are assumed to have a fixed endowment of 1. This simulation is constraint to real and non-negative values of the tax.

A.7. Additional Tables

Table 4: Share of Each Capital Control Instrument over the Total Amount of Instruments per Country

Country	Price-Based				Non-Price-Based	
	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, Rep.	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%

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Notes: The table corresponds to Stylized Fact 6. It shows for each country the share of each instrument over the total. Thus, for each country, the sum of each row is equal to 1. The first four instruments correspond to price-based capital controls, and the last two to non-price-based controls.

Table 5: Baseline Calibration: Country Results

Country Name	Number of Currency Crises 1995-2010	TARGETED MOMENTS		CALIBRATED PARAMETERS		SIMULATED MOMENTS		SIMULATED K=0		CALIBRATED PARAMETERS WITH K=0		SIMULATED MOMENTS CALIBRATED $\kappa=0$ AND K=0	
		Number of crisis every 100-Y Sovereign+External Debt Crisis	Frequency of changes in tau (avg Inf-Out) = Number of Changes in 20 Years	κ	K	Simulated Crisis	Simulated Changes	K=0 simulated crisis	K=0 simulated changes	κ	K	Simulated Crisis	Simulated Changes
Argentina	1	6.3	5.0	0.3250	0.012000	2.88	4.02	1.87	13.16	0.3200	0.0000	1.90	13.14
Brazil	5	31.3	7.0	0.3050	0.016930	32.92	4.09	18.92	16.30	0.2950	0.0000	30.29	17.12
Chile	1	6.3	0.5	0.3300	0.000400	2.38	0.62	2.38	12.93	0.3100	0.0000	2.48	12.98
China	0	0.0	0.0	0.3500	0.000100	0.00	0.00	0.00	11.77	0.3300	0.0000	0.00	11.77
Colombia	6	37.5	2.0	0.3250	0.009500	28.08	2.38	28.04	16.10	0.3250	0.0000	28.04	16.10
Czech Republic	0	0.0	0.5	0.3400	0.000001	0.00	0.00	0.00	10.27	0.3400	0.0000	0.00	10.27
Ecuador	6	37.5	2.5	0.3200	0.015530	59.52	7.34	32.60	10.59	0.3200	0.0000	32.60	10.59
Hungary	4	25.0	0.0	0.3270	0.019000	1.99	0.00	1.57	10.73	0.3220	0.0000	18.62	14.65
India	4	25.0	0.0	0.3200	0.018000	48.55	0.00	1.59	13.70	0.2950	0.0000	28.89	17.94
Indonesia	1	6.3	1.0	0.3290	0.000001	1.66	2.00E-05	1.66	13.63	0.3270	0.0000	1.97	13.72
Israel	0	0.0	0.0	0.3400	0.000001	0.00	0.00	0.00	9.60	0.3300	0.0000	0.00	9.79
Korea, Rep.	2	12.5	2.5	0.3240	0.015600	3.43	3.21	1.63	12.08	0.2915	0.0000	15.68	12.05
Malaysia	3	18.8	2.5	0.3152	0.015600	48.37	2.64	25.39	12.42	0.3152	0.0000	25.39	12.42
Mexico	1	6.3	0.0	0.3290	0.000005	1.60	0.00	1.60	12.03	0.3281	0.0000	2.70	12.08
Peru	1	6.3	0.5	0.3250	0.014000	25.75	0.71	1.28	11.62	0.3150	0.0000	11.50	14.21
Philippines	2	12.5	0.0	0.3260	0.004000	1.75	0.00	0.09	10.97	0.2950	0.0000	27.80	16.80
Poland	5	31.3	0.0	0.3240	0.015000	21.44	0.00	12.67	13.71	0.3220	0.0000	29.40	16.41
Russia	6	37.5	1.5	0.3200	0.018900	17.39	1.58	16.97	13.39	0.3100	0.0000	29.59	15.41
South Africa	2	12.5	2.0	0.3263	0.005100	47.68	4.67	1.54	13.41	0.3200	0.0000	17.79	16.42
Thailand	8	50.0	0.0	0.3200	0.017000	39.22	0.00	38.78	13.13	0.2500	0.0000	50.09	11.05
Turkey	5	31.3	1.5	0.3200	0.016600	27.35	3.16	27.35	16.50	0.3150	0.0000	30.92	16.49
Mean	3.0	18.8	1.4	0.3257	0.0102	19.62	1.64	10.28	12.76	0.3131	0.0000	18.36	13.88

Notes: The table shows in the fifth and sixth columns the country-by-country calibrated values of κ and K . The targeted moments, which are the frequency of crisis every 100 years, and the frequency of changes in capital controls every 20 years, are shown in the third and fourth columns respectively. The simulated moments that correspond to each of the two targeted moments are in the seventh and eighth rows, respectively. Columns nine and ten show the same two simulated moments that result by keeping the calibrated κ , but setting $K = 0$. The last four columns columns show the calibration of κ when $K = 0$, and the simulated crisis and changes in capital controls for this scenario.

Table 6: Welfare Analysis: Country results

Country	Welfare Des	Welfare Ramsey	Consumption Eq UR to Rams	Welfare (S, s)	Welfare Ramsey	Consumption Eq (S, s) to Rams
Argentina	-1.92	-1.71	1.53%	-1.88	-1.74	1.01%
Brazil	-1.73	-1.57	1.24%	-1.81	-1.62	1.45%
Chile	-1.84	-1.65	1.50%	-1.77	-1.76	0.06%
China	-1.76	-1.75	0.00%	-1.76	-1.75	0.04%
Colombia	-1.83	-1.73	0.78%	-1.83	-1.72	0.82%
Czech Republic	-1.76	-1.76	0.00%	-1.76	-1.75	0.05%
Ecuador	-1.88	-1.71	1.22%	-1.88	-1.71	1.23%
Hungary	-1.92	-1.73	1.48%	-1.76	-1.74	0.12%
India	-1.71	-1.58	0.97%	-1.88	-1.71	1.34%
Indonesia	-1.76	-1.74	0.11%	-1.76	-1.75	0.03%
Israel	-1.76	-1.76	0.00%	-1.76	-1.75	0.05%
Korea, Rep.	-1.69	-1.55	1.08%	-1.90	-1.72	1.42%
Malaysia	-1.85	-1.68	1.24%	-1.85	-1.69	1.21%
Mexico	-1.75	-1.75	0.00%	-1.75	-1.74	0.02%
Peru	-1.86	-1.66	1.53%	-1.85	-1.71	1.03%
Philippines	-1.71	-1.58	0.98%	-1.78	-1.74	0.30%
Poland	-1.91	-1.72	1.44%	-1.89	-1.73	1.24%
Russia	-1.83	-1.6797	1.21%	-1.93	-1.72	1.53%
South Africa	-1.90	-1.70	1.49%	-1.80	-1.73	0.47%
Thailand	-1.43	-1.35	0.64%	-1.88	-1.72	1.23%
Turkey	-1.85	-1.67	1.33%	-1.87	-1.70	1.27%
Mean	-1.79	-1.67	0.94%	-1.83	-1.73	0.76%

Notes: The table shows in the fourth column the country-by-country consumption equivalence of households in the unregulated economy to be as well as of those in the frictionless Ramsey economy. The last column shows the consumption equivalence of households in the ($S; s$) economy to be as well as of those in the frictionless Ramsey economy.