Essays in International Finance

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To my parents and to my brother

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Gonçalo Pina, December 2012.

Abstract

This thesis investigates two economic policy dimensions in contemporary world economy. The first chapter focuses on the recent accumulation of international reserves by central banks in developing economies. I present a simple model of reserve management where a central bank accumulates reserves in order to avoid spikes in inflation during financial crises. This monetary perspective helps to account for the massive accumulation of reserves observed in the data. The second chapter turns to financial reform, with an emphasis on the role played by savings. I show how imperfect competition in the financial sector can internalize externalities and yield larger investment when domestic savings are low. Taking this view allows for a better understanding of the empirical relationship between financial reforms and economic growth.

Resúmen

Aquesta tesi investiga dues dimensions de la poltica económica en l'economia mundial contemporània. El primer capítol es centra en la recent acumulació de reserves internacionals per part dels bancs centrals en les economies en desenvolupament. Exposo un model senzill de gestió de reserves per part d'un banc central que acumula reserves amb l'objectiu d'evitar els augments pronunciats d'inflació durant les crisis financeres. Aquesta perspectiva monetària ajuda a explicar l'acumulació massiva de reserves que s'observa en les dades. El segon capítol es focalitza en la reforma financera, emfasitzant el paper de l'estalvi. Demostro com la competència imperfecta en el sector financer pot internalitzar les externalitats i així generar més inversió, concretament quan l'estalvi és baix. L'adopció d'aquest punt de vista permet entendre millor la relació empírica entre les reformes financeres i el creixement econòmic.

Foreword

This dissertation consists of two essays in international finance. Each chapter focuses on a different policy dimension that is of particular relevance for developing economies.

The first chapter studies the recent increase in international reserves holdings in developing economies, a phenomenon that has been puzzling academics and policy makers in the last decades (Jeanne 2007). This paper explores the view that international reserves are the outcome of optimal policy from a central bank that wishes to smooth inflation. Inflation is distortionary, but the central bank needs to raise inflation-related revenues. These revenue needs are exceptionally large during financial crises. As a result, the central bank optimally accumulates international reserves in order to spread the distortions associated with inflation over time. A quantitative exercise for an average developing economy using data between 1970 and 2007 predicts long-run levels of reserves that coincide with average holdings in developing economies. Furthermore, the model delivers predictions for exchange rates that mirror the data: (i) exchange rates depreciate while the central bank accumulates reserves; (ii) if a country has accumulated a large amount of reserves, exchange rates do not drastically depreciate during a financial crisis. Finally, the monetary perspective studied in this paper sheds light on the determinants of cross-sectional variation in reserve holdings.

The second chapter investigates the optimal portfolio of financial reforms. This chapter shows that between 1973 and 2005, many countries decided to implement macro reforms (defined as the liberalization of prices and quantities in financial markets), but not micro reforms (reforms targeting the participants and competition in financial markets). Interestingly, countries performing macro reforms grew less when compared to countries that implemented both reforms simultaneously. I explore a second best view of financial liberalization and show theoretically under which conditions performing macro financial reforms without micro financial reforms increases investment. The first best is sometimes not attainable due to the interaction between strategic enforcement breakdown and an over-borrowing external-

ity. In particular, this is the case when domestic savings are low relative to financial intermediation. In the empirical analysis, I show that accounting for differences in savings rates contributes to our understanding of the effect of different portfolios of financial reforms on growth.

Taken together, these chapters highlight the role of second best policies in a world of imperfect financial markets. In the first chapter, reserve accumulation is a costly response to insufficient international insurance for financial risks. In the second chapter, restricting competition in the financial sector is a costly alternative to a world of volatile capital flows and contract enforcement crises. The recent financial crisis has spurred a growing literature on financial policy in open economies. This dissertation adds to this exciting field of research.

Contents

Chapter 1

The Recent Growth of International Reserves in Developing Economies: A Monetary Perspective

1.1 Introduction

The last 20 years have witnessed a large increase in international reserve holdings by central banks in developing economies. Figure 1.1 plots the evolution of reserves for developed and developing economies as a share of their *GDP* between 1970 and 2007.[1] The most striking feature of this graph is the divergence between the two groups of countries between 1987 and 2007. Following a relatively stable period of reserves to *GDP* ratios close to 10%, since 1987 developed economies have been reducing their reserves relative to *GDP*. At the same time, developing economies have steadily increased their international reserves relative to *GDP* to a level that exceeded 25% in 2007.

Why have central banks in developing countries increased their reserve holdings, in contrast to their developed-country counterparts? This accumulation has important implications. From the perspective of a developing economy, it represents foregone consumption and investment in countries with good growth prospects. From the perspective of the global economy, reserves have played a role in the emergence of upstream capital flows - from poor

[1] International reserves are defined as liquid external assets under the control of the central bank.

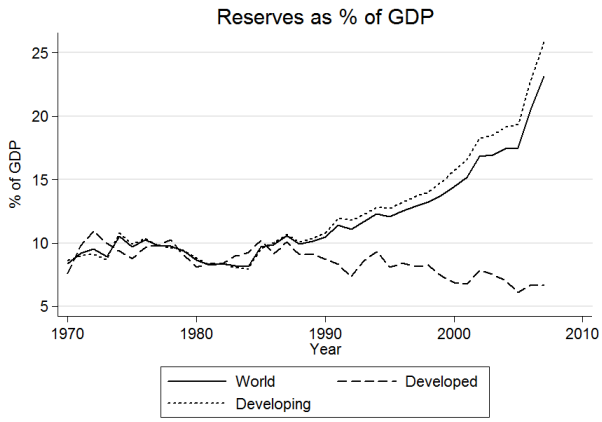

Figure 1.1: Unweighted cross-country averages of International Reserves as a share of GDP for 24 developed economies and 154 developing economies between 1970-2007. Source: author's calculations based on the updated and extended version of the dataset constructed by Lane and Milesi-Ferretti (2007).

to rich countries - and contributed to global imbalances. This paper takes a monetary view on this phenomenon and argues that the desire of central banks to smooth inflation together with their financial responsibilities during banking crises can explain observed reserve holdings.

I set up the problem of a central bank that has to finance exogenous and stochastic spending shocks with inflation. Inflation is distortionary and the central bank wishes to spread distortions over time. To do so, it accumulates reserves in order to smooth inflation against these shocks. Central bank spending shocks are particularly large during banking crises. Using data between $1970-2007$, I find that the long-run level of reserves for an average developing economy predicted by the model amounts to 21% of *GDP*.

Figure 1.2 plots the incidence of banking crises in the last 40 years. The gray bars plot the frequency of banking crises in the world economy during 5-year windows. These crises were particularly frequent in the last 20 years.[2] Banking crises were also very costly. The numbers on top of the

[2]Reinhart and Rogoff (2008) show that banking crises are not exclusive to the last two decades. Between the late 1890 and the early 1930s there was a similar incidence of banking

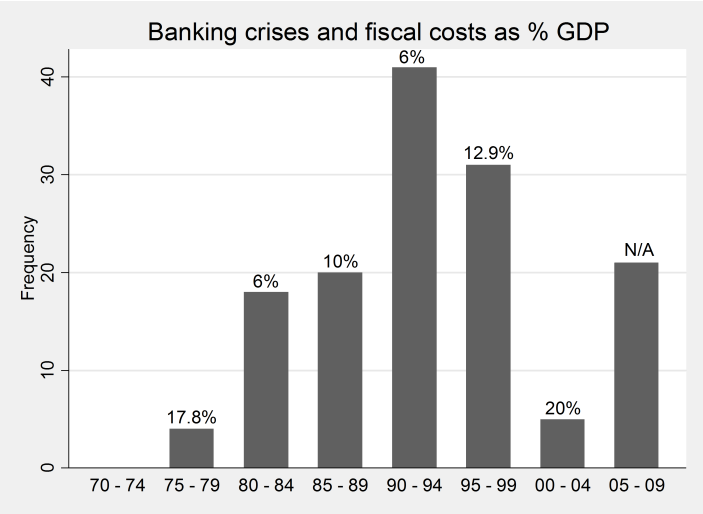

Figure 1.2: Frequency of crises and median fiscal cost (gross, as % of *GDP*; N/A: not available) between 1970-2010. Measure for fiscal cost is only available for selected crises. Source: Laeven and Valencia (2008, 2010).

gray bars represent the median fiscal cost of banking crises in percentage of *GDP* for each 5-year window. Furthermore, a substantial fraction of these fiscal shocks are financed by the central bank with inflation related revenues. Available estimates amount to 10% of *GDP*, in episodes where the total fiscal cost ranges between 15 and 65% of *GDP*.[3]

Ultimately, what matters for the central bank are prospective crises, not realized crises. Figure 1.3 plots reserves against a measure of size of the financial sector between $1987-2007$ for developed and developing economies. There is a clear positive relationship between reserves and size of the financial sector. In this paper I argue that, starting in the late 1980s, the need to provide banking sector support in periods of crisis required a new as-

crises across the world economy. They associate these events to increases in capital mobility (see Figure 3 in their paper).

[3] See Burnside et al (2001, 2006) for estimation of inflation related revenues. Looking at a larger sample between $1970-2006$, Laeven and Valencia (2010) find that for developing economies the median banking crisis had a direct fiscal cost of 11.5% of *GDP*, an increase in public debt of 12.7% of *GDP*, and output losses of 29.4% of *GDP*. Developed economies face smaller direct fiscal costs, larger increases in public debt and similar output losses. These values are 3.7%, 36.2% and 32.9%, respectively. Section 1.4 discusses the available data.

sessment of international reserves adequacy by central banks in developing economies.[4,5]

It is instructive to look at one of these developing economies. Figure 1.4 plots at the evolution of Reserves, $M2$ (as a measure of size of the financial sector) and inflation in Korea between 1987 and 2010, together with the timing of the Korean 1997 banking crisis and the Global 2007-09 crisis. Section 1.5 goes into more detail into these two episodes but it is noteworthy to see that even for the annual data presented in Figure 1.4, in both crises reserves decreased relative to output. This reduction was stronger in the 2007 crisis, although this episode was not classified as a banking crisis in Korea (Laeven & Valencia (2010)). One important difference in 2007-08, was that the Korean central bank had now amassed a large stock of reserves. This picture also shows the upward trend in the size of the financial sector as measured by $M2/GDP$, and a downward trend in inflation. These two come associated with a large increase in reserves as a share of GDP. In both crises, inflation increases as reserves decrease.[6]

The model also predicts exchange rate behavior that is consistent with the evidence. Large stocks of international reserves have been associated with undervalued exchange rates. In the model, the central bank accumulates in-

[4]Empirical research has noted the correlation between the size of the financial sector and reserves. Burke and Lane (2001) are the first to document the correlation between M2/GDP and reserves in a purely cross sectional analysis. Obstfeld et al (2010) perform a panel analysis and argue that in developing economies M2/GDP causes reserves and that managed exchange rate mechanisms are correlated with reserves. They interpret reserves as savings to support the banking sector through bailouts while avoiding currency depreciation.

[5]There are other policies that countries can take to avoid banking crises. For example, prudential regulation. In this paper, I take these as exogenous to the actions of the central bank.

[6]Consider first the 1997 crisis. Burnside et al (2006) estimate the amount financed by depreciation-related revenue to be about 13.5 percent of GDP. This was obtained with a cumulative inflation of about 8 percent and a small reduction of international reserves (reserves also increased due to the $57 billion IMF bailout agreement). The Global 07-09 crisis had two important differences for Korea. First, it hit only indirectly. According to Laeven and Valencia (2010) there was no banking crisis in Korea in this period. Second, the central bank had already accumulated a large amount of reserves. It was still the case that failed and assisted banks amounted to about 27.3% of total banking assets. The central bank spent a total of $26.6 billion in foreign currency liquidity, $10 billion from reserves and $16.4 billion from SWAP agreements with the US Federal Reserve.

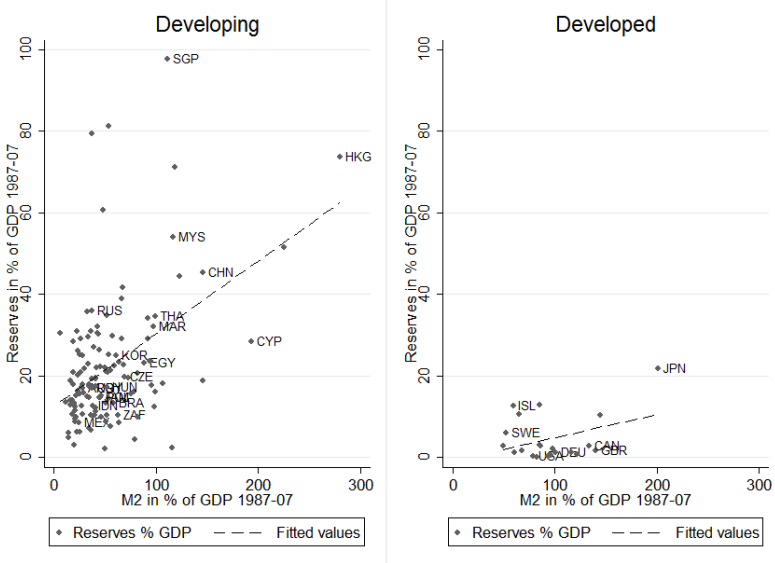

Figure 1.3: International Reserves as a share of GDP and size of the financial sector (measured by $M2/GDP$) for developing and developed economies between 1987-2007. Sources: Lane and Milesi-Ferretti (2007) and WDI.

ternational reserves resorting to inflation.[7] As a consequence, the value of domestic currency decreases relative to foreign currencies. In other words, the nominal exchange rate depreciates during the accumulation process. When a crisis occurs, the central bank deploys its reserves to finance the banking sector support. This sustains the value of domestic currency and keeps the exchange rate from collapsing.[8]

The view explored in this paper can shed light on the divergence between the two groups of economies in Figure 1.1. Developed economies are less dependent on international reserves because (i) they rely less on inflation related revenues, and (ii) their central banks have access to contingent borrowing in times of crisis. There is also substantial heterogeneity within

[7]The model abstracts from the role of sterilization policy, by assuming that domestic debt and foreign debt are perfect substitutes for domestic agents. This implies that printing money is always inflationary. See Brutti (2011) and Gennaioli et al (2010) for open economy models where domestic agents prefer to hold domestic government bonds.

[8]Aizenman and Sun (2009) and Dominguez et al (2011) show that countries drew from their reserves during the 2008 crisis. Obstfeld et al (2009) show that countries with larger international reserve holdings devalued their currencies less during 2008.

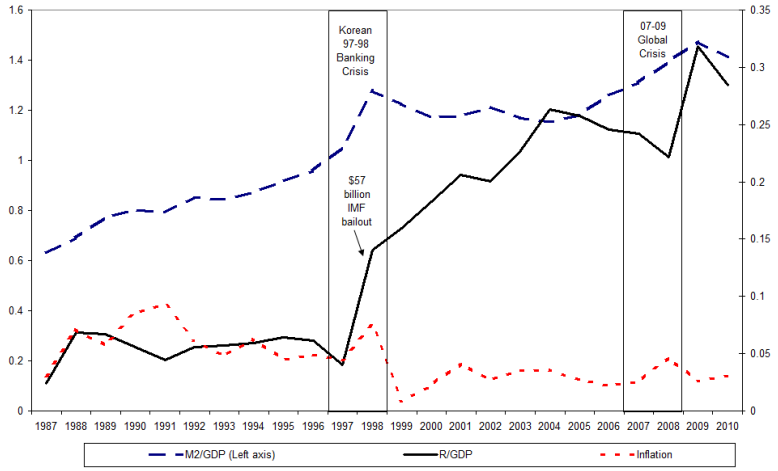

Figure 1.4: Annual data on Reserves and M2 as a share of *GDP*, and inflation for Korea between 1987 - 2010. Data from IFS.

countries that accumulate reserves. Although most developing countries have accumulated international reserves, Figure 1.1 masks substantial cross-sectional variation. Figure 1.3 illustrates this point by plotting the average ratio of reserves to *GDP* between 1987 and 2007 for both groups of countries on the y-axis. This heterogeneity is less present for developed economies.

In the quantitative section of the paper I perform a series of exercises to study the sources of cross-sectional variation in reserve accumulation. I find that the most important determinant of the stock of international reserves is the size of a crisis. The frequency with which crises occur is less important. This indicates that countries with larger banking sectors should have more international reserves. The other crucial determinant of reserves is the relative importance of distortions. I highlight two distortions in this paper: inflation distorts the consumption/savings and the investment decisions of households. The investment distortion is particularly disruptive since in the open economy setting used in this paper, capital is more elastic than consumption. Inflation can not distinguish between capital and consumption. As a consequence, countries where the investment distortion is more prevalent accumulate larger stocks of international reserves. The empirical

analysis confirms that countries with less developed financial markets, and lower access to credit, have larger stocks of reserves. This distinction between size and financial development is important to understand the cross-sectional variation of international reserves within developing economies.

The recognition that reserve holdings are a crucial instrument for policy in open economy models dates back to the literature on balance of payments crises in economies with fixed exchange rates - notably, Krugman (1979), Flood and Garber (1984) and Broner (2009). In these papers, the level of reserves determines the duration of an unsustainable exchange rate peg. Calvo (1987) provides microeconomic foundations and studies the dynamics of balance of payments crises in an economy with maximizing agents that demand money due to a cash-in-advance constraint. Subsequent work by Burnside et al (2001), Kumhof et al (2010), Rebelo and Veigh (2008) and Rigobon (2002) analyzes economic policy in this model.[9] Although these papers study policy, they take the central bank's holdings of reserves at the moment of the crisis as exogenous. In other words, there is no reserve accumulation in place. The main differences in my paper are that I study an economy that is not yet in crisis, and where the central bank takes into account the magnitude of a prospective crisis and the distortions associated with inflation when accumulating international reserves.[10]

A recent literature studies optimal accumulation of international reserves as

[9]Burnside et al (2001) argue that the Asian crisis of 1997 was caused by prospective deficits associated with implicit guarantees to failing banks, to be financed with inflation related revenues. The reserve accumulation model I explore in this paper shares the same perspective on monetary policy. Faced with the possibility of future deficits, but in a situation with strong economic conditions, a central bank accumulates reserves to avoid future large swings in inflation and exchange rates. Kumhof et al (2010) extends the analysis to different ad-hoc inflation and exchange rate mechanisms to explore their quantitative implications. Rebelo and Vegh (2008) study the optimal time to abandon a fixed exchange rate mechanism. Rigobon (2002) studies the problem of a central bank that draws from its reserves to reap benefits from a future fiscal reform.

[10]It is important to mention that the focus on the inflation tax is a simplification. For example, Burnside et al (2006) show that seigniorage is not the only monetary instrument used to finance spending in the wake of a crises. This assumption, done here for convenience, is a shortcut to other inflation-revenue distortionary mechanisms, namely the deflation of nominal non-indexed debt and an implicit fiscal reform, consisting of reducing the foreign currency value of government expenditures.

precautionary savings or insurance in order to smooth aggregate consumption. This perspective, developed by Alfaro and Kanczuk (2009), Durdu et al (2009) and Jeanne and Rancière (2010), considers that developing economies depend on short-term capital inflows. Countries accumulate reserves to sustain consumption when there are negative output shocks and access to international financial markets is interrupted, a view that has been synthesized by the celebrated Guidotti-Greenspan rule.[11] However, quantitative versions of these models cannot account for the observed level of reserves.[12] Furthermore, this literature points to short term debt as a crucial determinant of reserves. But in the data short term debt is not strongly correlated with reserves.[13]

The monetary perspective presented in this paper shares the view that reserves are held due to insurance or precautionary motives. But there are important differences with the consumption smoothing literature. I focus on the problem of one big agent, the central bank, that interacts with the rest of the economy. On the contrary, the literature on consumption smoothing summarizes the whole economy as one single agent. This literature is implicitly assuming that resources can be allocated within the economy in a non-distortionary way.[14] My paper shows that heterogeneity plays a crucial role. The shocks I consider affect disproportionally one part of the economy, the central bank. Also, the mechanism to transfer resources within the economy - inflation - is distortionary. Together, these assumptions provide a different reason for central banks to hold reserves that has been overlooked so far. International reserves are a way to smooth the distortions associated with transferring resources within the economy.[15]

[11] The Guidotti-Greenspan rule states that the ratio of reserves to short term debt should be 1 (Greenspan (1999)).

[12] Jeanne and Rancière (2010) find that reserves should be 9.1% of GDP, Durdu et al (2009) find 9.61%, whereas Alfaro and Kanczuk (2009) find 0%. These are much smaller than the 25.8% shown in Table A.4.1 (Appendix A.4) and Figure 1.1.

[13] See Obstfeld et al (2010) and Section 1.4 of this paper.

[14] To make this point clear, I show that a model of consumption smoothing obtains the same reserves levels as a model of inflation smoothing when inflation is non-distortionary.

[15] Aizenman and Marion (2004) study political-economy considerations in an ad-hoc model without micro foundations where a government decides between reserves and distortionary taxation.

These features are ultimately related to the literature on tax smoothing introduced by Barro (1979). In Barro's economy, the optimal tax policy is for the government to smooth taxes over time. This policy is the consequence of convex costs associated with distortionary taxes. I take this insight and embed it in a monetary model. Importantly, this leads to a dramatic increase in the level of international reserves predicted by the small open economy model.

The paper proceeds as follows: Section 1.2 introduces the monetary model and describes the central bank problem. In Section 1.3 I solve for a deterministic example that allows for a closed form solution, and develop the main intuitions of the model. Section 1.4 studies the quantitative predictions of the model. Section 1.5 looks at some case studies and performs a cross-country empirical analysis on reserve accumulation. Finally, Section 1.6 concludes and points to future research.

1.2 A monetary model of reserve accumulation

The model extends Rigobon (2002) and Calvo (1987) with a focus on reserve accumulation. A representative consumer and a central bank use a non-contingent bond to smooth exogenous stochastic financing needs. I focus on the the problem of a central bank. The central bank dislikes inflation but has financial responsibilities, demanded by the government.[16] To finance them it can use two instruments: (i) it can raise inflation related revenues or (ii) it can withdraw from its international reserves. Because inflation is distortionary, the central bank wishes to spread the burden of inflation across time. As a result, it accumulates reserves in non-crisis periods and when necessary, uses a mix of inflation and reserves.

[16]These financial responsibilities take the form of financial sector support but are demanded by the government. This comprises a situation of fiscal dominance. I assume that the central bank has operational autonomy, but has to comply with demands of funds from the fiscal authority. Alternatively, one could write a model where the government decides the full portfolio of distortionary taxes, including the inflation related revenues.

1.2.1 Setup

Consider a small open economy with one traded good. This good can be used for consumption or investment. Time is continuous. There are two agents: an infinitely lived representative consumer and a central bank. At any moment in time, the economy is either on a crisis state (H), or in a non-crisis state (L). The difference between the two is the amount of funds demanded from the central bank. I now describe the problem of each agent in this economy.

The representative consumer maximizes the expected lifetime utility from the consumption plan $\{c_t\}_0^\infty$. The objective function of the consumer is given by:

$$E_0 \int_0^\infty u(c_t) e^{-\beta t} dt \tag{1.1}$$

where,

$$u(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}$$

and $\beta > 0$ is the discount factor. The consumer can invest in a production technology, in a risk free foreign bond or in money holdings. Production features a Cobb-Douglas technology using capital k_t and labor l_t: $F(k_t, l_t) = A_t k_t^\alpha l_t^{1-\alpha}$. The consumer has one unit of labor $l_t = 1$, α is the share of capital and capital depreciates at rate δ. Then, investing k_t units of capital in domestic production yields $Ak_t^\alpha - \delta k_t$ units of output.

In addition, the consumer has access to two assets. A foreign bond f earns the foreign real interest rate ρ, that is assumed to be constant. The consumer can also invest in money holdings M_t. Money is introduced in this economy through a cash-in-advance constraint on consumption and on the use of capital. This asset is useful for production and consumption purposes, but loses value with inflation. The opportunity cost of holding money is given by the nominal interest rate, which corresponds to the loss of value due to inflation plus the return lost with not being able to use these resources in the

production technology or in the foreign bond.

Let P_t be the domestic price level at t, and $\pi_t = \frac{\dot{P}_t}{P_t}$ the domestic inflation rate (and let the international inflation rate be zero). I assume that purchasing power parity holds (PPP) such that the exchange rate is determined by inflation. Assume also that all debt is indexed to domestic inflation.[17] Then, the nominal domestic interest rate is given by: $i_t = \rho + \pi_t$. The flow budget constraint of the consumer can be written as:

$$\dot{f}_t + \frac{\dot{M}_t}{P_t} + \dot{k}_t = \rho f_t + A k_t^{\alpha} - \delta k_t - c_t \tag{1.2}$$

Additionally, the consumer faces a cash-in-advance constraint. To consume c_t units of the consumption good and to operate the capital stock k_t, he must have real money holdings $\frac{M_t}{P_t}$ at least larger than $v_c c_t + v_k k_t$, where (v_c, v_k) measure the constant amount of cash needed for consumption and production services. The cash-in-advance constraint is given by:

$$v_c c_t + v_k k_t \leq \frac{M_t}{P_t} \tag{1.3}$$

Define $a_t = f_t + \frac{M_t}{P_t} + k_t$ as the wealth of the consumer in real terms. Because consumers only care about real balances, define real money balances as $m_t = \frac{M_t}{P_t}$. As a store of value, money is always dominated by foreign assets if $i_t = \pi_t + \rho \geq 0$, which I assume throughout. Thus, the cash-in-advance constraint (1.3) will always hold with equality and money demand is given by $m_t = v_c c_t + v_k k_t$. I can then rewrite the flow budget constraint as

$$\dot{a}_t = \rho a_t + A k_t^{\alpha} - (1 + v_c i_t) c_t - (\delta + \rho + v_k i_t) k_t \tag{1.4}$$

Finally, the consumer's solvency condition is given by:

[17] This implies that domestic and foreign debt are perfect substitutes for the consumer and limits inflation related revenues to the inflation tax.

$$\lim_{t\to\infty} a_t e^{-\beta t} \geq 0 \tag{1.5}$$

The problem of the consumer is then to choose a sequence of $\{c_t\}_0^\infty, \{k_t\}_0^\infty$, so as to maximize (1.1), subject to the flow budget constraint (1.4) and the solvency condition (1.5), given $\{i_t\}_0^\infty$, f_0, k_0 and m_0. Appendix A.1.1 shows that the solution to the consumer problem is given by the following system of differential equations:

$$k_t = \left(\frac{\alpha A}{\delta+\rho+v_k i_t}\right)^{\frac{1}{1-\alpha}} \tag{1.6}$$

$$\frac{\partial c_t^j}{\partial a_t} \approx \left(1+v_c i_t^j\right)\cdot\left(\frac{c_t^j}{\sigma}\right)\cdot\left(\rho-\beta-q_j\left(1-\frac{\left(1+v_c i_t^j\right)}{\left(1+v_c i_t^{-j}\right)}\frac{\left(c_t^j\right)^\sigma}{\left(c_t^{-j}\right)^\sigma}\right)\right)\cdot\left(\dot{a}_t^j\right)^{-1} \tag{1.7}$$

$$\dot{a}_t^j = \rho a_t + A\cdot\left(k_t^j\right)^\alpha - \left(1+v_c i_t^j\right)c_t^j - \left(\delta+\rho+v_k i_t^j\right)k_t^j \tag{1.8}$$

$$\lim_{a\to\infty} c_t^j = \infty, \qquad j = L,H \tag{1.9}$$

Equation (1.6) shows that capital is determined by the international interest rate ρ, the depreciation rate δ and the domestic nominal interest rate that is relevant for the use of capital, $v_k i_t$. Because there are free movements of capital, at any period t, the capital stock is obtained by equating marginal cost to marginal benefit. It follows from equation (1.6) that at any period t, production is maximized if i_t is the lowest possible. This equation summarizes the production side of the agent's problem, and highlights the distortions in production caused by inflation.

There are two equations governing consumption and savings for each state $j = L,H$, given by equations (1.7) and (1.8). The effect of the domestic nominal interest rate on production is important for this decision, and it is felt through equation (1.8). The solution to the consumer problem is then defined by a family of curves for each pair of interest rates $\left\{i_t^L, i_t^H\right\}_0^\infty$,

depending on the state of the economy. For any given interest rate pair $\left(i_t^L, i_t^H\right)$, if the economy spends enough time in state L, the consumer's assets will tend to a^*, defined as a situation where $\dot{a}_t^L = 0$.

For a given interest rate policy, this model is a traditional small open economy model and can be used to study consumption, investment and capital flows. In this paper, I am interested in optimal interest rate policy and reserve management, and their implications for the aggregates in the economy. We now turn to the problem of the central bank.

1.2.2 The central bank problem

I assume the central bank to be benevolent. It solves a constrained optimization problem: subject to the demands of the government, the consumer's choices and it's own budgetary constraints, the central bank maximizes the representative consumer's utility. The solution is represented by a time-consistent contingent plan for the interest rate $\{i_t\}_0^\infty$ that maximizes (1.1). Because the consumer demands real money balances, the central bank can tax the consumer through inflation. With the resources obtained from seigniorage $\frac{\dot{M}_t}{P_t}$, the central bank can pay for spending g_t or accumulate international reserves r_t that earn interest ρ. Absent any borrowing constraint, the central bank can also borrow from the international bond market at rate ρ. However, since this asset is not contingent on shocks to g_t, the central bank does not have access to perfect insurance.

The external budget constraint of the central bank is given by:

$$\dot{r}_t = \rho r_t + \frac{\dot{M}_t}{P_t} - g_t \tag{1.10}$$

In exchange for the financing g_t the central bank gets domestic debt, either issued by the government or from financial institutions. The balance sheet of the central bank is then given as:

$$b_t + r_t = m_t$$

where, $b_t + r_t$ are the assets, and m_t corresponds to its liabilities. The budget constraint of the central bank can be rewritten as:[18]

$$\dot{b}_t = \rho b_t + g_t - (\pi_t + \rho) m_t \tag{1.11}$$

The central bank may face a constraint on how much debt it can issue abroad. I introduce this through an exogenous borrowing constraint given by $r_t \geq \underline{r} = 0$.

Note that the assumptions of PPP, indexed debt and perfect capital mobility imply that choosing inflation π_t is the same as choosing i_t. Since international inflation is zero, exchange rate depreciation tracks one to one the inflation rate. That is, when inflation increases, the value of the domestic currency loses value and the exchange rate depreciates. When choosing the nominal interest rate, the central bank takes into account the impact of its decisions on the representative consumer. In particular, the set of equations given by (1.6)-(1.9) are constraints in the optimal policy problem of the central bank.

Absent any spending demands g_t, the optimal policy of an unconstrained central bank is given by the Friedman rule, with $i_t = 0$ and $\pi_t = -\rho$. However, g_t will occasionally be quite large and the central bank will have to resort to inflation. To keep the analysis simple, I study the case where g_t takes one of two values $\left\{g^L, g^H\right\}$, and evolves according to the following Poisson process:

[18] Further details can be found in Appendix A.1.2.

$$g_{t+dt} = \begin{cases} g^L & w.p. \quad 1 - q_L dt & \text{if } g_t = g^L \\ g^H & w.p. \quad q_L dt & \text{if } g_t = g^L \\ g^H & w.p. \quad 1 - q_H dt & \text{if } g_t = g^H \\ g^L & w.p. \quad q_H dt & \text{if } g_t = g^H \end{cases} \tag{1.12}$$

This economy will be in one of two states of nature, defined by $g_H >> g_L$. At any non-crisis period, a crisis arrives with probability q_L and leaves with probability q_H. Because crises are relatively less frequent than safe periods, $q_H >> q_L$. This framework captures in a parsimonious way the type of shocks that I am studying: infrequent but severe crisis. We are now ready to study the optimal policy problem. At any t, the central bank takes as given a_0 and b_0 and solves:[19]

$$\begin{aligned} &\max_{\{i_t\}} E_0 \int_0^\infty u(c_t) e^{-\beta t} dt \\ &s.t. \\ \dot{b}_t &= \rho b_t + g_t - i_t m_t \\ \dot{a}_t &= \rho a_t + A k_t^\alpha - (1 + v_c i_t) c_t - (\delta + \rho + v_k i_t) k_t \\ r_t &= m_t - b_t \\ m_t &= v_c c_t + v_k k_t \\ \lim_{T \to \infty} b_T e^{-\beta T} &= 0, \ a_0, b_0, \\ &g_t \text{ given by } (1.12) \\ i_t &\geq 0, r_t \geq \underline{r} \\ \text{and equations } &(1.6) - (1.8) \end{aligned}$$

Suppose the economy starts in a period with low g_t, but the central bank knows it might face a crisis soon, and an increase in g_t. In this simple setting, the central bank can either print money or draw from its reserves.

[19] This model approximates a version of the model of consumption smoothing considered in the literature if lump-sum taxation is available and if we assume that $v_c, v_k = 0$.

Printing money causes inflation which decreases consumption and distorts savings and investment. It follows that the optimal policy of the central bank is to smooth inflation.

The extent to which it can smooth inflation depends on the existence of constraints on how much the central bank can borrow abroad.[20] If the central bank is unconstrained, the crisis will be financed mostly with future revenues and the central bank need not accumulate many reserves. On the other hand, if there is a constraint, this limits the amount of future revenues a central bank can transfer to the crisis period thus increasing precautionary savings ex-ante.

The optimal policy problem can be described with two value functions, one for each state $j = L, H$, subject to the relevant constraints. Given state j, the relevant state variable of the economy is summarized by a pair of domestic credit and assets of the representative agent (a_t, b_t). There are four constraints in the central bank problem. First, his budget constraint which is summarized by equation (1.11). Second, the borrowing constraint on reserves $r_t \geq \underline{r}$. There are two constraints coming from the consumer problem represented by equations $(1.6) - (1.8)$: the consumer budget constraint and an equation that combines (1.6) and (1.7), which summarizes the optimal consumption and investment decisions given the policy of the central bank. I represent the problem using the following value functions, where I omit the subscripts t and the state variables to simplify notation:

$$\begin{aligned}\beta V^L = \max_{i^L} & u\left(c^L\right) + V_b^L \cdot \left(\rho b + g^L - i^L \cdot \left(v_c c^L + v_k k^L\right)\right) \\ & + V_a^L \cdot \left(\rho a + A \cdot \left(k^L\right)^\alpha - c^L \cdot \left(1 + v_c i^L\right) - \left(\delta + \rho + v_k i^L\right) k^L\right) \\ & + q_L \cdot \left(V^H - V^L\right) \end{aligned} \tag{1.13}$$

subject to:

[20] In the model, foreign reserves are net of foreign debt of the central bank. There are some cases of central banks issuing debt and accumulating reserves - for example, the Monetary Stabilization Bonds issued by the Bank of Korea in 2004, and the establishment of emergency swap lines between central banks during the 2008 crisis.

$$\frac{\partial c^L}{\partial a} \approx \left(1+v_c i^L\right) \cdot \left(\frac{c^L}{\sigma}\right) \cdot \left(\rho - \beta - q_L \left(1 - \frac{\left(1+v_c i^L\right)}{\left(1+v_c i^H\right)} \left(\frac{c^L}{c^H}\right)^{\sigma}\right)\right) \cdot \left(\dot{a}^L\right)^{-1}$$

for the low expenditure state, and

$$\begin{aligned} \beta V^H = & \max_{i^H} u\left(c^H\right) + V_b^H \cdot \left(\rho b + g^H - i^H \cdot \left(v_c c^H + v_k k^H\right)\right) \\ & + V_a^H \cdot \left(\rho a + A \cdot \left(k^H\right)^{\alpha} - c^H \cdot \left(1+v_c i^H\right) - \left(\delta + \rho + v_k i^H\right) k^H\right) \\ & + q_H \cdot \left(V^L - V^H\right) \end{aligned} \tag{1.14}$$

subject to:

$$\frac{\partial c^H}{\partial a} \approx \left(1+v_c i^H\right) \cdot \left(\frac{c^H}{\sigma}\right) \cdot \left(\rho - \beta - q_H \left(1 - \frac{\left(1+v_c i^H\right)}{\left(1+v_c i^L\right)} \left(\frac{c^H}{c^L}\right)^{\sigma}\right)\right) \cdot \left(\dot{a}^H\right)^{-1}$$

for the high expenditure state, where V^j is the value function of the central bank for states $j = \{L, H\}$ and:

$$\dot{a^j} = \rho a + A \cdot \left(k^j\right)^{\alpha} - c \cdot \left(1+v_c i^j\right) - \left(\delta + \rho + v_k i^j\right) k^j,\ j = L, H$$

$$k_t = \left(\frac{\alpha A}{\delta + \rho + v_k i}\right)^{\frac{1}{1-\alpha}}$$

with boundary conditions:

$$\lim_{a \to \infty} c^j = \infty,\ \lim_{b \to -\infty} i^j = \infty$$

Appendix A.1.3 describes the details of the numeric solution to this problem. If $\underline{r} \neq -\infty$ there is an additional boundary condition in the problem. When reserves hit the constraint, the central bank is forced to float and to finance all g_t with current inflation revenues. In the setting considered in this paper this will only happen in the high state. The problem given by

equation (1.14) is then augmented with the constraint:

$$i_t^H \geq \overline{i^H}$$

where $\left(\overline{i^H}, \overline{b}\right)$ is the solution to:

$$\left(v_c c_t^H\left(a_t, \overline{i^H}\right) + v_k k_t\left(\overline{i^H}\right)\right)\overline{i^H} = g^H + \rho\overline{b}$$
$$v_c c_t^H\left(a_t, \overline{i^H}\right) + v_k k_t\left(\overline{i^H}\right) = \overline{b} + \underline{r}$$
$$\text{and equations } (1.6) - (1.9)$$

This problem does not admit a closed form solution. In Section 1.4, I explore the quantitative implications of the model. Before, the next section develops intuitions resorting to a deterministic example.

1.3 Building intuitions

To make the trade-offs associated with reserve management clear, I focus on a deterministic example that admits a closed form solution. In particular, consider that the expenditure process can be summarized by the following expression:

$$g_{t+dt} = \begin{cases} 0 & \text{if} \quad t < t_1 \\ g & \text{if} \quad t_1 \leq t \leq t_2 \\ 0 & \text{if} \quad t > t_2 \end{cases} \tag{1.15}$$

that is, at $t = 0$, the central bank learns that an increase in spending will occur between t_1 and t_2. Faced with this new information, the central bank must reexamine the adequacy of its current reserve stocks.

1.3.1 The benefits of reserve management

To simplify the analysis, assume that $u = \ln(c)$, $\beta = \rho$, and that the economy is an endowment economy with $y_t = w$ and $v_c = 1$. Under these assumptions, the solution to the consumer's problem is given by:

$$c_t = \frac{w + \rho a_0}{1 + i_t} \tag{1.16}$$

The intuition behind equation (1.16) is the following. Under log-utility the intertemporal elasticity of substitution is 1. If $\beta = \rho$ the consumer is just as patient as the international market. Therefore, the consumer spends the same amount of resources $w + \rho a_0$ in every period to finance his consumption expenditures $(1 + i_t) c_t$, independently of the cost of consumption at t. In this simple setting, the elasticity of savings to the interest rate is zero.

Define a balanced budget inflation rate as the policy from a naive central bank that contemporaneously finances g_t with inflation. That is, where $\dot{b}_t = 0$. In this policy reserve holdings will not be optimal and there will be fluctuations in crucial variables such as consumption and money holdings. Because it implies flexible exchange rates, thus I also refer to it as the "flexible benchmark" or the "non-smoothing benchmark". Replacing the optimal decision of the consumer on the central bank budget constraint:

$$\dot{b}_t = \rho b_t + g_t - \frac{w + \rho a_0}{1 + i_t} i_t, \forall_t \tag{1.17}$$

which can be rewritten as:

$$\frac{1}{1 + i_f^L} = 1 - \frac{\rho b_0}{y + \rho a_0} > \frac{1}{1 + i_f^H} = 1 - \frac{g + \rho b_0}{y + \rho a_0}, \tag{1.18}$$

while inflation is given by $\pi_t = i_t - \rho$. If the policy of the central bank is to finance government spending only through contemporaneous inflation, then consumption and reserves fluctuate with government spending. For each $j = L, H$:

$$c_t^j = y + \rho a_0 - \left(g_t^j + \rho b_0\right) \tag{1.19}$$

$$r_t^j = y + \rho a_0 - \left(g_t^j + \rho b_0\right) - b_0 \tag{1.20}$$

Equation (1.18) shows that the domestic interest rate is larger in periods when g_t is large, which translates into larger inflation. Equation (1.19) shows that consumption is lower in these periods. The path of these variables is plotted in Figure 1.5. In this economy, the central bank increases inflation in periods with high expenditure, and decrease inflation in periods with low expenditure. Inflation is very volatile and reserves are completely determined by initial conditions and the state of the economy. Because inflation is distortionary and distortions have convex costs, the higher the volatility of inflation, the higher are the welfare costs associated with the naive non-smoothing policy. A central bank behaving optimally steers away from large and volatile inflation. It chooses reserves in order to stabilize inflation, and minimize distortions and welfare costs.

To show this, I first assume that there is no constraint on borrowing by the central bank ($\underline{r} = -\infty$) and then that reserves can never be negative ($\underline{r} = 0$).[21] Since the crisis is expected and there is no constraint on reserves, the optimal solution is to have a constant interest rate. This yields an optimal c_t that is constant:

$$c^* = w + \rho a_0 - \rho\left(G + b_0\right) \tag{1.21}$$

$$i^* = \frac{\rho\left(G + b_0\right)}{w + \rho a_0 - \rho\left(G + b_0\right)} \tag{1.22}$$

where G is the present value of expenditure, $G = \rho^{-1}\left(e^{-\rho t_1} - e^{-\rho t_2}\right) g$.

The (constant) inflation tax will depend on the amount of resources that need to be financed and on the initial wealth of the central bank. Furthermore, it

[21] The detailed solution for the case without a borrowing constraint can be found in Appendix A.2.

will depend on how wealthy the representative consumer is. Figure 1.5 plots the solution of the model.[22] It is possible to see that the optimal solution to an expected crisis when there is no borrowing constraint is to smooth inflation perfectly. Inspecting the lower panels shows that this is achieved with a constant and positive inflation rate. The upper right panel shows the behavior of reserves (r). Initially, the central bank accumulates some reserves to face the crisis, but around $t = 7$, starts borrowing from abroad. Once the crisis is over, the central bank keeps reserves constant.

Adding a constraint on reserves creates an additional incentive to accumulate reserves before the crisis. The solution is depicted in Figure 1.6.[23] The constraint puts a limit on the amount of future revenues that can be transferred to the crisis period. This justifies the jump in consumption, interest rate and inflation when g_t reverts back to 0. Now that the crisis is over the central bank does not need inflation revenues anymore. In fact, the central bank would rather have raised some revenue in these periods, and transferred it to the crisis period. But it can not do this because of the borrowing constraint.

Reserve accumulation is represented in the upper right panel, and is plotted against the case without a borrowing constraint. The central bank still wishes to smooth inflation. Because it can not transfer future revenues to the crisis period, it must transfer more present revenues. For this reason, reserves in the constrained case are larger. As a consequence, in the constrained case inflation (and exchange rate depreciation) is larger in the moments preceding the crisis, but smaller when the crisis is over.

Figure 1.7 solves for a costlier crisis. As expected the central bank must accumulate more reserves. In this simple deterministic setting, a larger crisis is similar to having larger distortions in the general model. This is the case because in the general model, the expected cost of a crisis depends on the size of the crisis but also on the distortions caused by inflation. If distortions

[22] These figures are computed with the following parametrization: $\rho = \beta = 0.05$, $\omega = \frac{2}{3}$, $a_0 = -0.55$, $g_L = 0$, $g_H = 0.1$ (10% *GDP*), $b_0 = 0.5$, $b_1^f = 0.5135$, $r_0 = 0.1$ (10% *GDP*). The timing of the crisis is the following: $g_t = g_H$ between $t_1 = 10$ and $t_2 = 15$, and $g_t = g_L = 0$ elsewhere.

[23] The constrained case is solved in Appendix A.2.2.

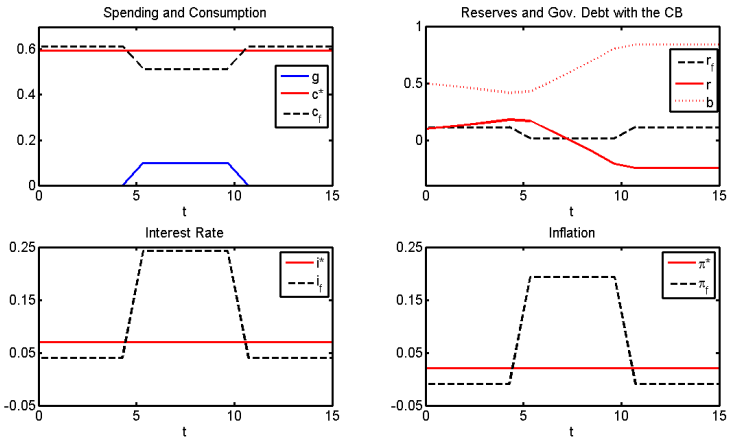

Figure 1.5: The Benefits of Reserve Management: the unconstrained economy under balanced budget (f) and optimal inflation rates ($*$) faced with a predictable increase in expenditure.

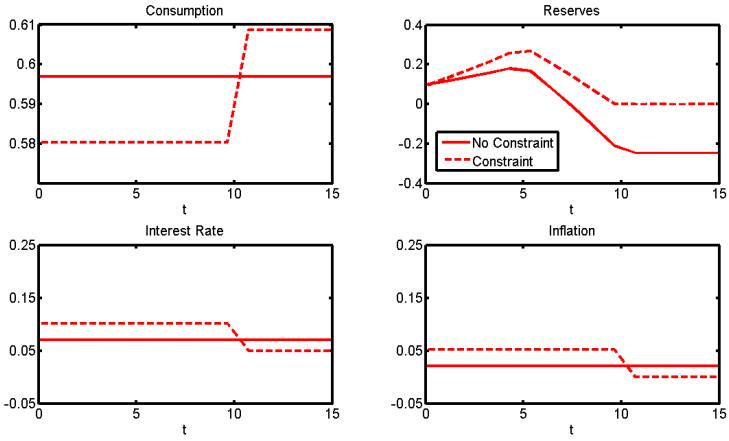

Figure 1.6: Comparison between the constrained and the unconstrained economies.

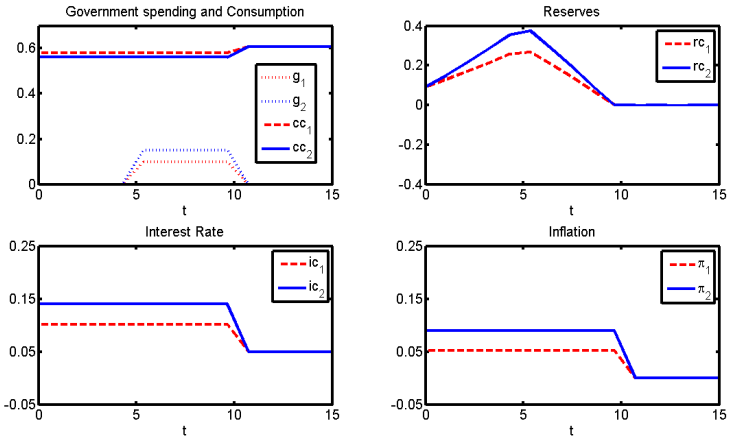

Figure 1.7: Effect of a larger crisis in the constrained case.

are large, the central bank will have a larger desired level of international reserves.

1.3.2 Uncertainty, risk aversion and production distortions

This subsection discusses some crucial features of the model presented in Section 1.2 that were not considered in the previous example. International reserves management is done in an uncertain world. The challenges faced by central banks are not likely to be represented by the deterministic process given by (1.15). Furthermore, preferences may not be well summarized with the log-utility, and inflation can also have negative effects on production.

Introducing uncertainty does not qualitatively change the previous analysis. Given the process for expenditure, the central bank will have a *desired* level of international reserves, and it will accumulate reserves until this level is obtained. If the central bank is uncertain about when the crisis hits the economy, this slows down the accumulation process. In fact, the central bank might find itself in a situation where the crisis hits and international reserves are insufficient. This crisis is then associated with extreme fluctuations in inflation. Once the crisis hits, uncertainty about it's solution translates into a more prudent spending of international reserves. The central bank will be

weary about spending too much too soon, as in some states of the world the crisis can be long.

Closely related to uncertainty is the degree of risk aversion of the agents in this economy. Keeping everything else equal, larger risk aversion makes a crisis more costly if a crisis is associated with fluctuations in consumption. This increases the desired level of international reserves. As with uncertainty, the qualitative analysis is not substantially different.

Finally, I highlight the role of investment. Suppose that utility is given by

$$u(c) = \begin{cases} -\infty & \text{if } c < \underline{c} \\ c & \text{if } c \geq \underline{c} \end{cases},$$

$v_c = 1$ and $0 < v_k < 1$. Everything else is like in Section (1.3.1). Assume that there is no borrowing constraint. Note that production will now fluctuate with interest rate policy. In particular, the consumer will choose capital at any period as:

$$k_t = \left(\frac{\alpha A}{\delta + \rho + v_k i_t} \right)^{\frac{1}{1-\alpha}}$$

while output will be given by:

$$y_t = A k_t^{\alpha}$$

In this setting simple deterministic setting, the total amount of reserves is unchanged. The central bank will not accumulate more than what he needs to finance the crisis. But this case still provides us with some insights on the reserve accumulation process that takes place in the general model. Note that the consumer is willing to postpone consumption above $\underline{c}$ until $i_t = 0$ and capital equals the optimal level. Then, $c = \underline{c}$, and the central bank wishes to spread the capital distortion over time, so as to maximize production. The demand for money from the consumer is given by:

$$m_t = v_c \underline{c} + v_k \left(\frac{\alpha A}{\delta + \rho + v_k i_t} \right)^{\frac{1}{1-\alpha}}$$

Under these assumptions, inflation is very distortionary. As a consequence, a larger inflation rate is needed to finance the same amount of resources.[24] This is the result of the elasticity of capital in this open economy framework. Furthermore, consumption is completely elastic if it is above $\underline{c}$, which amplifies the capital distortion.[25] Note that consumption is completely rigid at $\underline{c}$. In fact, the optimal policy would be to tax only consumption. In the general model consumption is much less elastic than capital. When performing interest rate policy, and deciding on the desired level of international reserves to hold, the central bank will have to take into account this important constraint: inflation can not discriminate between consumption and capital. This constraint makes the effects of inflation worse because inflation falls on a very elastic base. In other words, it makes distortions more convex. In order to avoid these distortions once the economy is faced with a crisis, the desired level of reserves by the central bank is larger.

1.3.3 Summary

Introducing a cash-in-advance constraint in the small open economy model creates a role for money. The need to raise revenues with distortionary inflation creates a motive for inflation smoothing. If the central bank can access international markets, the optimal inflation smoothing prescription is to accumulate some reserves before the crisis, but essentially to borrow when the crisis hits the economy. If there is a constraint on how much the central bank can get indebted, this limits the amount of future revenues that can be transferred to the crisis period. If crises come with larger costs, larger reserves

[24] I set $A = 0.69105$ to normalize *GDP* given by $(1-\alpha)Ak^{\alpha} = 1$, when $i_t = 0$. I set $\underline{c} = 50\%$ of *GDP*, and $v_k = 0.1$. The shock in g is the same as in Section 1.3.1, $g = 0.1$. This yields an interest rate for the unconstrained case of 7.72%, and a corresponding inflation rate of 2.72%. Inspection of Figure 1.5 reveals that these are larger than when the cash-in-advance constraint falls only on consumption. In that case, the interest rate was 7.12%, with an associated inflation rate of 2.12%.

[25] Introducing adjustment costs to capital explicitly would not change the qualitative results of the model.

must be accumulated. Furthermore, if inflation is distortionary, and distortions are convex, approximating the non-smoothing benchmark comes at an ever larger cost. In order to avoid large increases in inflation, the central bank accumulates more reserves.

The behavior of exchange rates is also worth noting. The model predicts that nominal exchange rates should depreciate before a crisis, and depreciate less following a crisis (relative to their flexible benchmarks). Recent research has argued that international reserve accumulation is the side effect of a trade policy that keeps the exchange rate undervalued. In this model, exchange rate depreciation is the outcome of a precautionary motive. As also noted by Levy-Yeyati & Sturzenegger in the Handbook of Development Economics (2010), the precautionary view and the trade policy view have similar implications for the behavior of exchange rates.

The previous points were made using a monetary model. This approach comes with the benefit that it connects with the experiences of countries that are accumulating reserves. Of course, the monetary model is not necessary for the main theoretical insight of the paper. The same fundamental point could have been done with a real model. The crucial element driving reserve accumulation is the existence of heterogeneity and distortionary redistribution during a crisis. In a crisis episode parts of the economy need emergency financing. But there are distortions associated with transferring resources from other parts of the economy. A central authority can avoid part of these costs by keeping some resources as reserves. In order words, it can transfer some resources that were financed outside of the crisis episode. Nevertheless the monetary perspective presented in this paper is important. We observe central banks accumulating reserves, not governments or other big agents. Furthermore, large distortions are necessary to match the recent increase on international reserves. Inflation is a very distortionary way of transferring resources within the economy. It is also something that central banks particularly care about.

These insights are the core of the monetary perspective presented in this paper. Qualitatively, this perspective already delivers a theory for why central banks accumulate international reserves, and highlights the crucial determi-

nants behind this accumulation. Larger crises, larger distortions and more stringent central bank borrowing constraints are all associated with larger reserves. The next section shows that these mechanisms are important quantitatively for the general model.

1.4 Quantitative analysis

In this section I compare the predictions of the model with the data on international reserves. I perform two quantitative exercises using data from the period $1987-2007$. First, I study an average developing economy. I perform the following experiment: a central bank learns at $T = 1987$ that the costs of a banking crisis that have to be financed with inflation related revenues have increased. This happened after many years where costs were low. Prior to 1987, I assume the central bank had accumulated the desired long-run level of reserves predicted by the model. The value of reserves in 1987 is taken from the data, and is around 10% of *GDP*. I assume that no other parameter of the economy changed. Faced with the emergence of costlier crises, the central bank needs to reevaluate the adequacy of its reserves stock.

I will refer to the level of reserves obtained after a long-period without a crisis as the *desired long-run level of reserves*. The desired long-run level of reserves for my benchmark calibration of an average developing economy is 21%. In a simulation, I show that the adjustment to this level of reserves is relatively fast - 20 years without a crisis will suffice. Furthermore, inflation and exchange rate depreciation are the mirror image of international reserves. As the stock of international reserves increases, inflation is ever smaller and exchange rate depreciation decreases. If a crisis hits, the central banks uses a mix of inflation and reserves to finance the deficit. The larger the reserve holdings at the moment of the crisis, the smaller is the increase in inflation.

Second, I perform some experiments that highlight the sources of variation behind 1.3. I show that the capital distortion is particularly important for

reserves accumulation in my model. The more elastic is capital relative to consumption, the larger is the buffer stock of international reserves. Furthermore, I investigate the effect of the frequency of crises and constraints on borrowing by the central bank. The frequency of crises is not a crucial determinant of the buffer stock. This is intuitive. If a crisis hit every period, then crises were already smooth and there is no role for reserve policy. Reserves are most useful when crises are rare and large. Borrowing constraints, however, play an important role. A central bank that is able to borrow 10% of *GDP*, instead of the 0% I use as a baseline, sees a reduction in its buffer stock of international reserves of almost one half.

1.4.1 An average developing economy

Parameter values

In Table 1.2 I report values for the parameters used in the baseline case.[26] The parameters for the real interest rate ρ and the probability of a crisis q_1 come from Jeanne and Rancière (2010). The parameter governing the probabilistic end of the crisis q_2 is taken from Alfaro and Kanczuk (2009). Together, they mean that a crisis happens on average once every 10 years and lasts on average 2 years.[27] To calibrate the production function I use traditional values for the share of capital $\alpha = \frac{1}{3}$ and for the depreciation rate $\delta = 0.06$. I set $A = 1$.

Two crucial parameters are the financing needs in the low and in the high spending states. I normalize $g_L = 0$, and do the analysis for values of g_H between 5 and 15% of *GDP*. Table 1.2 presents available evidence of the fiscal costs of bailing out the banking system in developing economies. The relevant cost for this exercise is the amount accruing to the central bank,

[26] Throughout, crises are computed as a share of potential output. This means that crises are measured in absolute terms. Reserves are measured with respect to current output, are measured in relative terms.

[27] Although these parameters capture the incidence of sudden stops, banking crises and sudden stops frequently happen at the same time. This allows for a cleaner comparison with previous work. For example, Laeven and Valencia (2010) find that the median banking crises in their sample had a duration of 2 years.

that needs to be financed with inflation related revenues. Burnside et al (2006) perform 3 case studies: Korea 1997-2002, Mexico 1994-2002 and Turkey 2001-2002. They find that in these three episodes total inflation-related financing up to 2002 was in present value around 20% of pre-crisis *GDP*.[28]

	Value	Description	Source
$\triangle g$	$0-15$	% of *GDP* increase in spending	Benchmark: 10%
a_0	-55% *GDP*	*NFA*-Reserves as % of *GDP*	Sample average
A	1	Total factor productivity	-
α	$1/3$	Capital share	-
δ	0.06	Capital depreciation rate	-
ρ	0.05	Real interest rate	Jeanne and Rancière (2010)
σ	2	Elasticity of substitution	RBC literature
β	0.0534	Subjective discount factor	Match R/GDP=10% in 1987
q_1	0.1	Probability of a crisis	Jeanne and Rancière (2010)
q_2	0.5	Probability of crisis solution	Alfaro and Kanczuk (2009)
v_c	1	Velocity for consumption	-
v_k	0.1	Velocity for capital	-

Table 1.2: Benchmark Parameters

How do these costs compare to previous work on international reserves? Previous literature has focused on output shocks and sudden stops of capital inflows. Jeanne and Rancière (2010) assume that a representative agent loses access to foreign debt of 10% of *GDP* and suffers an output loss of 6.5% of trend *GDP*. Alfaro and Kanczuk (2009) assume an output loss of

[28]It is important to note that Burnside et al (2006) argue that, at least for the cases of Korea, Mexico and Turkey, only a limited part of the bailouts were financed through seigniorage. They highlight the role of other inflation related revenues that I abstract from in this paper: deflating nominal debt and an implicit devaluation; but also fiscal reforms. The omission of important distortions associated with inflation means that the model can not match the money demand in the data. All the revenues from the model come from seigniorage, so the implied money demand is too large. I can still use this approach to compute the level of reserves in the long-run, if the relative importance of distortions did not change in the last 40 years, which I assume throughout.

10% during a default crisis. In my setup, g can be directly interpreted as an output shock that hits part of the economy (the central bank).

Some parameters are not taken from previous work. I normalize $v_c = 1$ and choose $v_k = 0.1$. These parameters will guide the relative importance of distortions. They capture unobserved features of the economy that determine how distortionary is inflation. For example, adjustment costs to capital can be captured by this parameter v_k. I perform a sensitivity analysis on these parameters in Section 4.2. The borrowing constraint is assumed to be $\underline{r} = 0\%$ of GDP. That is, I assume that the central bank can not access swap lines with other central banks or any type of debt financing.

Country	Date of Estimate	Fiscal cost of banking crises	Increase in Public debt	Inflation financed
Indonesia	Nov. 99	65	-	-
Korea	Dec. 99	24	-	22.3
Malaysia	Dec. 99	22	-	-
Mexico	Nov. 94	15	-	24
Thailand	Jun. 99	35	-	-
Turkey	Jan. 01	18	-	19.2
Developing*	1970-2006	11.5	12.7	-
Developed*	1970-2006	3.7	36.2	-

Table 1.3: Burnside et al (2001), (2006),present value, % of pre-crisis GDP.
* Laeven and Valencia (2010), cumulative, % of current GDP.

Finally, I choose a free parameter in the model, the discount rate β to match the buffer stock of $\frac{RES}{GDP} = 10\%$ in 1987 as the long-run buffer stock in a world where a crisis is given by $g_{H,0} = 6\%$ of GDP. This number is obtained by comparing the size of the financial sector in the developing world, as measured by $M2/GDP$, with its 2007 counterpart: $M2/GDP_{1987} \approx \frac{3}{5} M2/GDP_{2007}$.

Baseline Results

Table 1.4 collects the results of the benchmark calibration. As argued above, I consider as a baseline an increase in spending given by $\triangle g_t = 10\%$. The level of international reserves in the long-run predicted by the model is 20.66% of *GDP*. Remember that this value corresponds to the level of international reserves obtained as the outcome of optimal policy following a long period without a crisis.

$\triangle g_t$	Long run reserves
0.05	8.50%
0.1	20.66%
0.15	33.11%

Table 1.4: *RES*/*GDP* $(\underline{r} = 0\%)$

Figures 1.8 and 1.9 show the path of reserves and exchange rate depreciation before and after a crisis. In Figure 1.8 it is possible to see that in the absence of a crisis, 20 years suffices to approach the long-run buffer stock of reserves. The way accumulation is done is through a decreasing inflation rate, which translates into a depreciating exchange rate. Figure 1.9 shows the effect of a crisis on reserves and exchange rates. Note how when reserves are larger, in the first crisis, exchange rate depreciation is smaller. Obstfeld et al (2009) shows that countries with larger international reserve holdings devalued (and in some cases even appreciated) their currencies less. Dominguez et al (2011) shows that countries drew from international reserves and allowed for some currency depreciation following the 2008 financial crisis. What kept exchange rates from depreciating further was the use of reserves. These authors argue that precautionary motives were behind this decision, as a mercantilist policy would rather see the currency depreciate even more.

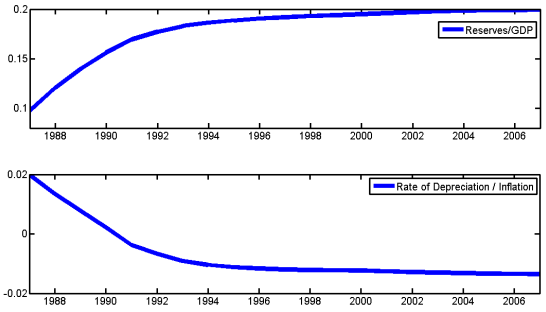

Figure 1.8: Reserves and exchange rate depreciation on the reserve accumulation path.

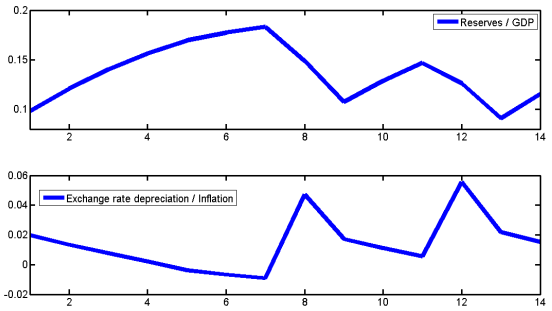

Figure 1.9: Reserves and exchange rates during two crises.

Before investigating the sources of variation behind the long-run level of reserves, I perform a sensitivity analysis on the risk-aversion parameter. As will be clear in Section 1.4.3, this is useful to compare with the consumption smoothing perspective. Table 1.5 collects the results. As expected, larger risk aversion increases the long run level of reserves.

σ	Long run reserves
1	17.71%
2	20.66%
3	24.50%

Table 1.5: *RES/GDP* $(\underline{r} = 0\%)$, $\frac{\triangle g_t}{GDP} = 0.1$

1.4.2 Sources of variation

This section explores the determinants of the stock of international reserves suggested by the model. I highlight the role of distortions, the relative importance of the frequency and magnitude of a crisis, and the effect of borrowing constraints. To study the impact of distortions on reserves, I perform an analysis varying the two velocity parameters v_c and v_k. These parameters measure the relative importance of the different distortions in the economy, that is, they determine how large the elasticity of savings and capital is relative to the interest rate. If $v_c = 0$, the only distortion is on the capital stock. In this open economy setting with free capital movements, the capital stock can be adjusted without any cost and is therefore very elastic to changes in the domestic interest rate. Distortions are large. As a consequence, the buffer stock of reserves is also large. If $v_k = 0$, inflation does not have an impact on output and distortions are relatively small. This is because consumption is less elastic than production. Table 1.6 shows the result of changing these two parameters.

v_k $(v_c = 1)$	Long run reserves	v_c $(v_k = 0.1)$	Long run reserves
0	14.99%	0.25	36.05%
0.05	15.96%	0.5	26.82%
0.1	20.66%	0.75	22.40%
0.15	25.89%	1	20.66%

Table 1.6: *RES/GDP* $(\underline{r} = 0\%), \frac{\triangle g_t}{GDP} = 0.1$

This analysis shows that what is important is the relative size of the two velocity parameters. If one of the velocities is zero, different values of v just have an impact on the level of inflation but not on the distortions. We can see that reserves increase the most when production distortions are more important. This suggests that consumption/savings distortions should be less associated with reserves than production distortions. Figure 1.10 and 1.11 plot a simple correlation between average reserves to *GDP* ratios and the

standard deviation of capital and consumption growth rates over the period 1987-2007. Reserves are inversely related with the standard deviation of the growth rate of the capital stock, but are not related to consumption growth. That is, larger average international reserves between this period are associated with lower volatile growth rates in capital, but not in consumption. This showcases the importance of the capital distortion in the international reserves accumulation process.[29]

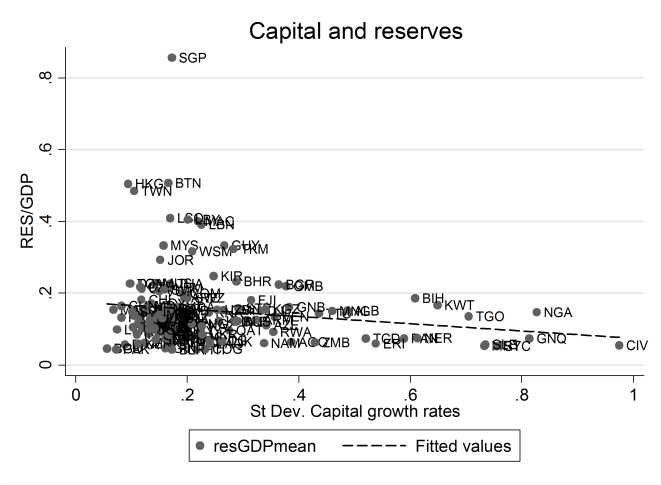

Figure 1.10: Average reserves to GDP ratio and standard deviation of capital growth rates over 1987-2007 for developing economies. Source: Own calculations from the PWT - Heston et al (2011) and Lane & Milesi-Ferretti (2010). The slope is negative and significant at the 5% level.

The analysis so far has considered large and infrequent crisis. How do these compare with costlier but less frequent crises? The first panel of Table 1.7 collects the level of reserves in that case. Consider instead that a country faces an undisciplined fiscal authority, constantly demanding financing with the central bank, and spending crises are small but frequent. The second panel of Table 1.7 collects the buffer stock of reserves in that case. Comparing the numbers, it is possible to see that the crucial dimension to explain the growth of reserves is the existence of large and infrequent crises.

[29]Figures 1.10 and 1.11 plots all the data. Removing the outliers in both figures, only makes the correlation for capital more negative, without changing the correlation for consumption.

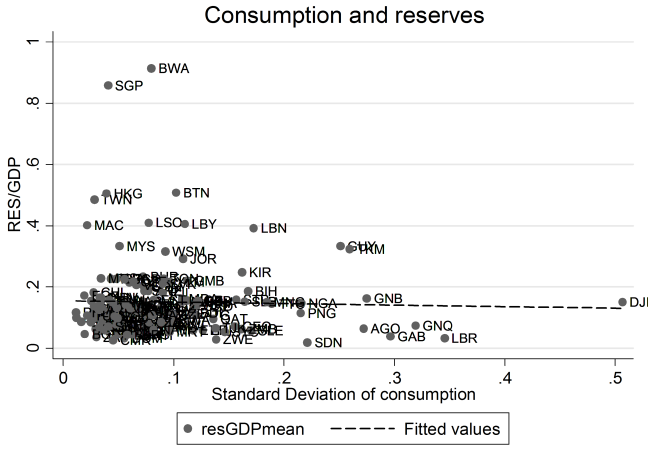

Figure 1.11: Average reserves to GDP ratio and standard deviation of consumption growth rates over 1987-2007 for developing economies. Source: Own calculations from the PWT - Heston et al (2011) and Lane & Milesi-Ferretti (2010).

$q_1\left(\frac{\triangle g_t}{GDP}=0.15\right)$	Buffer Stock	$q_1\left(\frac{\triangle g_t}{GDP}=0.05\right)$	Buffer Stock
0.025	25.27%	0.15	8.75%
0.05	32.34%	0.2	8.93%
0.075	32.81%	0.3	9.00%

Table 1.7: *RES/GDP* $(\underline{r}=0\%)$

I now investigate the effect of the borrowing constraint faced by the central bank. This was a crucial determinant of reserves in the deterministic example. The ability to borrow in the event of a crisis is also an important difference between developed and developing economies. In the 2008 crisis, some central banks established swap lines between them, to ensure liquidity of foreign currency in a period of distress. Central banks in developing economies could not access these credit lines (Obstfeld et al 2009). As expected, increased international borrowing has the potential to reduce the level of international reserves to a large extent, as shown in table 1.8.

$\underline{r}$ as % of GDP	Buffer Stock
$+15\%$	38.62%
$+10\%$	28.51%
0%	20.66%
-10%	11.50%
-15%	4.10%

Table 1.8: RES/GDP , $\frac{\triangle g_t}{GDP} = 0.1$

To sum up, the quantitative analysis of the model shows that reserves adequacy should be measured with respect to the magnitude of the financing needs, the distortions caused by inflation and the ability to access contingent financing following a crisis. In particular, the capital distortion seems to play a crucial role in the determination of reserve stocks.

1.4.3 Comparison with consumption smoothing

To make the role of distortionary inflation smoothing clear I solve for a model where distortions are not important. It is possible to show that the consumption smoothing view is a particular case of the inflation smoothing perspective even if inflation is the only tax possible. This is the case if inflation does not distort output and if the elasticity of savings to the interest rate is zero. These are precisely the two sources of distortions described in section 3. Intuitively, if the consumer always allocates the same share of wealth to consumption services every period, and this wealth is unaffected by monetary policy, inflation is non-distortionary. For the purposes of reserve accumulation, the economy is sufficiently well described by a single agent performing consumption smoothing. As an implication, it follows that these two features - that inflation affects output and savings - are crucial for the quantitative predictions of the model.[30]

I perform the same quantitative experiment for the consumption smoothing model in the baseline parametrization with $g_H = 10\%$ of GDP. The long

[30] Appendix A.3 shows that if $\dot{a} = 0$ and $v_k = 0$, inflation smoothing amounts to consumption smoothing. In particular, this holds in the general model if $u(c) = \log(c)$ and $v_k = 0$.

run level of reserves in this case amounts to 14.65% of *GDP*. Since this comparison is only true for the case with log-utility, the reference value for the monetary model - where $v_k = 0.1$, is 17.71%.

This comparison is particularly conservative. Note that in the monetary model with log-utility the elasticity of savings is different from zero but it is still very small. Furthermore, I disciplined the shocks in my economy to the shocks studied in the consumption smoothing perspective. Banking crises are much larger than those shocks, and financial sector continue growing throughout the developing world.

1.5 Inspecting the mechanism

In this section, I investigate whether the insights of the model help in interpreting the increase of reserves in the last 20 years. I have proposed the emergence of prospective costly banking crises as the trigger behind the recent reserve accumulation in developing economies. There are two crucial elements informing the monetary perspective presented in this paper: (i) central banks use large stocks of reserves to support the banking sector; and (ii) the size of these stocks is determined by spending needs and distortions.

1.5.1 Case studies

I present three case studies of interesting emerging economies before moving on to a cross-country analysis. Figure 1.12 plots data on international reserves for Brazil, Korea and Russia between 1990 and 2010. Figures 1.13 and 1.14 show the percentage variation in international reserves for these countries during two time periods: the period leading to the emerging markets crisis of the late 1990s (1997-2001) and the period leading to the recent world crisis (2005-2009). The most striking feature of Figure 12 is the accumulation of international reserves that took place during the 2000s. Figures 13 and 14 show that these countries used their reserves during both crises. Their experiences allows us to examine how these countries use their re-

serves in the wake of crises. One has to bear in mind, however, that the interventions during the 1990s took place without having yet accumulated a large stock of international reserves.[31] I now describe them one by one.

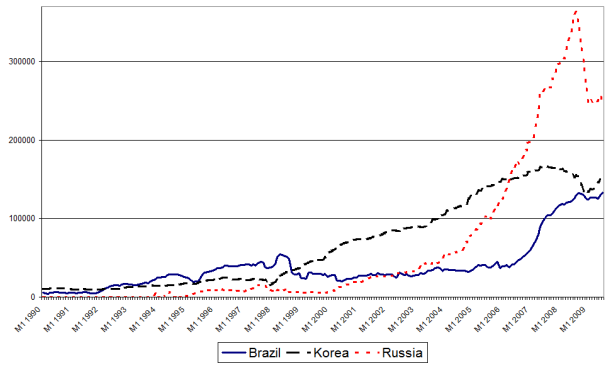

Figure 1.12: Monthly data on international reserves. Millions of SDRs. Source: IFS

In the 1990s, Brazil pegged its exchange rate. Due to fiscal pressures this regime came under pressure at the end of the 1990s, which saw a large drop in reserves (Edwards, 2003). In 1998, Brazil received a $41.5 billion loan from the IMF to help defend its currency. This did not avoid the devaluation of the real at the beginning of 1999, which resulted in the abandonment of the pegged exchange rate regime. What followed was a period of slow international reserve accumulation until May 2006, that subsequently accelerated until 2008. Faced with a crisis, but with a flexible exchange rate regime, Brazil was able to use its international reserves differently. The 2008 Management Report of the Brazilian central bank states that "the Central Bank decided to inject foreign currency liquidity into the domestic economy". In particular, "through net sales of US$ 7.6 billion on the domestic spot market". However, it is also stated that "the monetary authority offered a net total of US$ 8.3 billion in credit lines with repurchase commitments as of September 2008". In other words, the central bank sold foreign currency in the domestic market but also injected liquidity directly into domestic banks

[31] Some authors point to the Asian crisis as the event that led countries to accumulate reserves (see Wolf (2008) and Aizenman and Lee (2007)). Inspection of Figure 1.1 shows that reserve accumulation was already in place. It is still true, however, that there is an acceleration in the accumulation process.

by establishing emergency credit lines. In the context of the model, the Brazilian central bank used previously accumulated international reserves to increase liquidity of domestic banks both through market and non-market instruments. Even though this is not a formal bailout of the banking sector, practically these interventions gave banks direct support in the form of foreign currency.

The Russian example is even more dramatic. In the end of 1997, the stock of international reserves in Russia was substantially depleted, following an economic slowdown, an artificially high fixed exchange rate and a chronic fiscal deficit, which was aggravated by the economic cost of the first war in Chechnya.[32] An IMF bailout was approved in 1998, and a floating peg was adopted. The Central Bank of the Russian Federation ended up spending an even larger amount than the bailout to preserve the currency from depreciating even further (about 27$ billion). As in Brazil, once the crisis was resolved, Russia built up a much larger international reserves stock, which was put to use in the recent crisis. During the 2008 crisis, Russia suffered from the collapse of oil prices and a reversal of capital flows, in the form of outflows into foreign assets. As a response, the Central Bank of the Russian Federation actively used international reserves to provide liquidity to the banking sector and to intervene in the foreign exchange markets. In its 2008 annual report, the central bank states that "funds provided by the Bank of Russia to maintain banking sector stability in September—December exceeded 9% of GDP", and justifies the decrease of international reserves with operations in the domestic foreign exchange market, as well as with direct support to the banking system: "the decrease in value resulting from placements of the Bank of Russia's funds with certain Russian banks, including Vnesheconombank".

Finally, we turn to South Korea. South Korea was at the center of the Asian crisis of 1997. Following depreciation in other countries, the Korean Won heavily depreciated in October 1997, draining the countries reserves, which led to an IMF bailout by the end of the year. The cost of bailing out the bank-

[32] Edwards (2003) notes that the nominal deficit averaged 7.4% of GDP during the three years preceding the crisis.

ing sector was estimated to be 24% of *GDP* by December 1999, 13.5% of *GDP* were eventually financed with inflation-related revenues (see Burnside et al, 2006). During the 2008 crisis, international reserves decreased substantially in Korea, "affected by the foreign exchange authorities' expanded supply of foreign currency liquidity (...) to ease unrest in the domestic foreign currency fund market" (Annual Report 2008). Complementary to this policy, the Korean Central Bank resorted also to foreign currency swap arrangements with the Federal Reserve, which amounted to a total of $30 billion, adding to the $260 billion reserves it already owned.

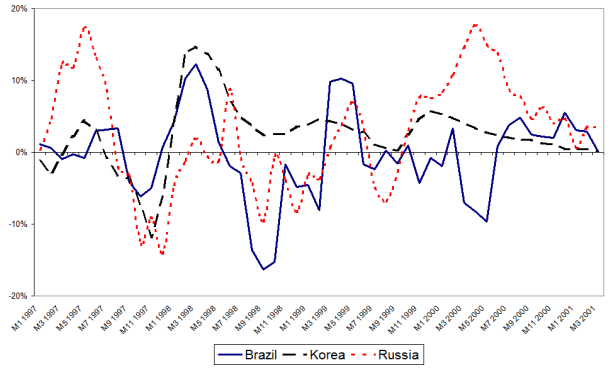

Figure 1.13: 3-month moving average % change between 1997-2001. Source: IFS.

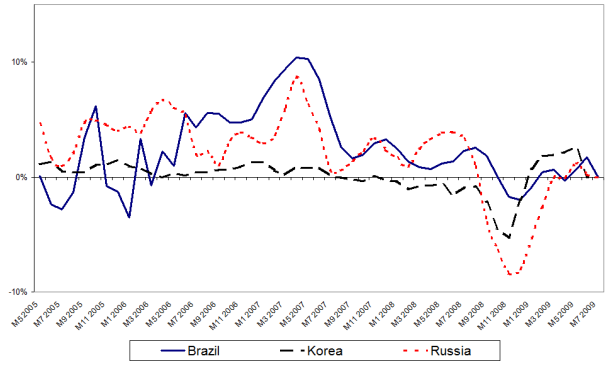

Figure 1.14: 3-month moving average % change between 2005-2009. Source: IFS.

The fact that international reserves were used in the crisis of 1998 as well as in the crisis of 2008 raises the question why countries accumulated such

vast amounts of reserves between these two events. Table 1.9 reports key variables for international reserve accumulation for the three countries previously discussed. It presents summarized data on international reserves, exchange rate regimes, size of the financial sector (as measured by $M2/GDP$) and short term debt for the period 1990-2009, as well as for the two periods preceding the Asian crisis of the late 90s and the world financial crisis of 2008. We have already seen in Figure 1.12 that reserves were much larger before the recent crisis, and the table shows that this also holds when measured relative to *GDP*. Something else must have changed.

Mean 1990-09	R/GDP	ER Regime	$M2/GDP$	STD/GDP
Brazil	6.4	MFloat except CPeg: 95-98	38.5	4.39
Russia	11.9	Float: 92-99; CPeg: 00-09	22.28	3.74
Korea	14.5	CPeg: 92-98	50.73	–
Mean 1996-98				
Brazil	5.94	Crawling Peg (CPeg)	34.72	3.85
Russia	2.9	Float	18	2.23
Korea	8.36	Crawling Peg	41.21	–
Mean 2005-07				
Brazil	9.1	Managed Floating (Mfloat)	53.74	2.49
Russia	29.62	Crawling Peg	32.89	4.45
Korea	24.99	Managed Floating	63.03	-

Table 1.9: Exchange rate regime data from Ilzetzki, et al (2011)
Other variables are taken from the WDI.

Short term debt do not seem capable of accounting for the recent increase in reserves. Exchange rates are still important, but at least Brazil and Korea moved towards more flexible exchange rate regimes. The crucial variable seems to be $M2/GDP$. This suggests that supporting the banking system has taken on a crucial role in the use of international reserves. Dominguez et al (2011) highlight the role of international reserves as a facility for a lender of last resort. Obstfeld et al (2010) interpret their finding that $M2/GDP$ is

correlated with international reserves as evidence for reserves being held to support the financial sector.

1.5.2 Some regressions

I explore the full cross-country evidence by performing a regression in the spirit of Obstfeld et al (2010) and Dominguez (2010). I add to the literature by including variables that account for the key aspects of the monetary perspective.

The model predicts that the desired level of reserves is positively related to prospective government deficits. In the context of this paper, prospective deficits can be measured relative to the size of potential bailouts in the banking sector. At the same time, the desire to avoid large movements in exchange rates is reflected in the presence of important distortions associated with inflation and exchange rate depreciation. In concordance with the literature I include M2/GDP as a measure of the size of the financial sector and the de-facto exchange rate classification of Ilzetzki et al (2008) to capture the size of distortions.[33]

As an alternative to measure the pervasiveness of distortions, I introduce the measure of financial development $findev$ used in Dominguez (2010), defined as the sum of foreign portfolio equity and debt liabilities divided by GDP. I further include controls for trade openness and short-term debt. Unlike previous literature on reserve accumulation, I explore the relationship between inflation and reserves in my empirical study. The model predicts that if the economy spends longer spells in non-crisis periods, reserves and inflation should be inversely related. As reserves increase, inflation is less and less used.[34] To control for the effects of crises, I add a year-dummy variable that takes the value of 1 in the presence of a currency (dCC) or sys-

[33] Larger levels of this index reflect more flexible exchange rates. I assume a linear effect of the exchange rate classification on reserves. More details on the exchange rate data used in this paper can be found in Appendix A.4.3.

[34] I omit from my sample the periods of explosive inflation in South America and ex-USSR of the late 1980s and early 1990s. By limiting inflation to be at most 500% in a year, I lose 24 observations.

temic banking crises (*dSBC*). I run the following regression with country fixed effects and time fixed effects on my panel of developing economies between 1980 and 2007:

$$\ln\left(\frac{RES}{GDP}_{i,t}\right) = \beta_0 + t + \beta_1 \ln\left(\frac{GDP}{POP}_{i,t}\right) + \beta_2 \ln\left(\frac{M2}{GDP}_{i,t}\right) + \beta_3 \ln\left(\frac{TRADE}{GDP}_{i,t}\right) + \beta_4 Exch_{i,t} + \beta_5 \text{inflation}_{i,t} + \beta_6 \ln\left(\frac{STDEBT}{GDP}_{i,t}\right) + \beta_7 dCC + \beta_8 dSBC + \beta_9 \ln\left(\frac{FINDEV}{GDP}_{i,t}\right) + \varepsilon_{i,t}$$

The results are presented in Table 1.10 in Appendix A.4. The coefficients for $\ln\left(\frac{M2}{GDP}\right)$, $\ln\left(\frac{TRADE}{GDP}\right)$ and $\ln\left(\frac{STDEBT}{GDP}\right)$ should be interpreted as the log-point increase in the reserves over GDP ratio from a standard deviation increase of each variable. For example, when the size of the financial sector $\ln\left(\frac{M2}{GDP}\right)$ increases by one standard deviation (+ .705 in this sample), the model predicts that the reserve over GDP ratio rises by 0.25 log points. I find that size of the financial sector and openness are positively associated with reserve holdings, whereas I find a negative association for the amount of flexibility in the exchange regime.[35] Inflation is negatively related to reserves, as well as the occurrence of a systemic banking crises.[36] Financial development has a negative coefficient, suggesting that more developed financial systems can support larger sizes of the financial sector without requiring the central bank from holding more reserves.

The empirical analysis presented in this paper stops short of being a full test of the theory, but together with the model, provides us with some insights for the reasons behind international reserve accumulation. Previous findings of the literature are mainly confirmed. Trade and size of the financial sector (as measured by $M2$) are associated with larger reserve holdings, while fi-

[35] This regression has a number of problems, including explanatory variables that are likely to be correlated. I reran the specifications in (7) in Table 1.10 dropping one variable at a time and confirm the results. Table 1.11 in Appendix A.4.4 presents correlations between all the variables used.

[36] A specification with all the controls including currency crises but omitting systemic banking crises finds that currency crises is still insignificant.

nancial development and more flexible exchange rates are inversely related to international reserves.[37] Based on the model, I propose a new explanation for the results on financial development and exchange rates. I argue that these reflect the existence of distortions associated with inflation. Adding inflation to the empirical model of reserve accumulation unveils an inverse relationship between inflation and international reserves. Furthermore, systemic banking crises are associated with a drop in international reserves. These two features of the data concur with the model outlined in this paper, but important work remains to be done in the empirical analysis of international reserves.

1.6 Conclusion and future research

In the last 20 years, central banks in developing economies have accumulated an unprecedented level of international reserves. The level of reserves in these countries now exceeds 25% of *GDP*. This has been puzzling for academics and policy makers. In this paper, I have explored a view where international reserve accumulation is the consequence of long-run central bank policy. This monetary perspective contributes to our understanding of this phenomenon in many dimensions.

First, it justifies why reserve accumulation is done by central banks. I have argued that reserve adequacy should be measured with respect to things that central banks do in developing economies: inflation management and financial sector support during crises. Reserve accumulation is the outcome of constrained optimal policy. Central banks weight the costs of reserves against the benefits associated with avoiding massive disruptions in their economies during crises. That is not to say that this situation is desirable. Ultimately, international reserve accumulation reflects the existence of large shocks, and the absence or imperfection of international insurance markets. Two immediate policy objectives follow from this analysis: reducing the

[37] The relationship between reserves and exchange rate mechanisms is even stronger - and significantly different from zero in all regressions, if one runs the regression on ratios instead of logs of ratios (Dominguez (2010) takes that approach). The same is true for inflation and the other results do not change.

magnitude of shocks, and improving international insurance markets. Neither of these is trivial. But the recent accumulation of international reserves should be understood with these in the backdrop.

Second, this view has predictions for the behavior of exchange rates that are consistent with the data. Reserve accumulation in this paper is associated with a depreciating currency. Also, during a crisis, the central bank uses reserves to fight depreciation. We observe the two in the data. The first of these facts has been used to argue that reserve accumulation is the unintended consequence of trade policy that tries to promote exporting. It is unclear how this literature could account for the second fact. The relative importance of trade and monetary policies remains an unresolved debate, as discussed in Yeyati & Sturzenegger (2010). But it is still noteworthy that the monetary perspective can rationalize the two facts, which can guide future empirical work on this important question.

Third, I have highlighted important factors behind the accumulation of international reserves in different countries. The model predicts that distortions associated with inflation, the magnitude of crisis and how stringent are central bank borrowing constraints, all determine the level of international reserves in developing economies. This list is by no means exhaustive. Future work could enrich the model to fully explore the heterogeneity of reserve accumulation experiences across countries. It should also introduce short-run considerations. Introducing nominal rigidities and breaking down the purchasing power parity assumption would create short-run predictions for exchange rates and reserves that could be tested.

Fourth, I have argued that important variables in the model can account for different reserve accumulation experiences between developed and developing economies, but also for variation within developing economies. I have done this using the traditional regression analysis done in the literature on international reserves. Future work should assess the empirical relevance of the perspective presented in this paper. In particular, a careful estimation of the relevant distortions in the monetary perspective is of paramount importance.

Finally, this paper has focused on a world where exogenous banking crises require the central bank to support the government and the financial sector. Both assumptions can be endogeneized. Central bank policies may affect directly the magnitude or likelihood of banking crises, for example, through their effect on capital flows and the fueling of asset bubbles. Introducing disagreement between the central bank and other agents in the economy would highlight the co-movement of reserves, government and private debt. There is an important trade-off behind the decision of giving more independence to the central bank. The benefits in terms of price stability may come with important challenges for policy during crisis. A thorough analysis of these factors is essential to our understanding of modern financial architecture, and remains an exciting field of research.

Chapter 2

Financial Reforms, Savings and Growth

2.1 Introduction

The last forty years have seen a wave of financial reform unprecedented in its intensity and scope. Figure 2.1 plots the unweighted cross-country average of a financial liberalization index for different dimensions of financial policy. The solid black line measures overall financial liberalization. According to this index in the late 1980s and early 1990s the World Economy substantially liberalized financial policy. These reforms represent some of the most important economic policy changes in recent times. Understanding their impact on economic growth is of paramount importance.

In this paper, I investigate macro and micro financial reforms. I argue that this simple distinction contributes to our understanding of the effect of financial reforms on growth. Using data for 90 countries between 1973 and 2005, I first document substantial variation in the implementation of different financial reforms. Most reform events focus on macro dimensions. A smaller but substantial share include both dimensions, and only a negligible share focus solely on micro dimensions (see Table 2.1 and Figure 2.1).

I divide macro and micro reforms with respect to the instrument of policy. Macro financial reforms target aggregate prices and quantities in financial markets. Examples include lifting capital account restrictions, and abolishing interest rate and credit controls. On the contrary, micro financial reforms

target the structure and organization of financial markets. Examples include allowing free entry in the financial sector, the privatization of financial institutions, the promotion of equity markets and the establishment of regulation and supervision of the banking sector.[1]

Studying different reform strategies is important because they come associated with different outcomes in terms of growth. Although most financial reforms are correlated with larger growth, countries reforming both dimensions simultaneously tend to grow more (see Figure 2.2).

These growth differentials are consistent with the empirical literature on financial reform and growth, in particular with papers arguing that equity market liberalizations lead to growth.[2] I extend on this work by unveiling a crucial variable to understand these growth differences in the data: the savings rate. I document that countries with higher savings rates grow more following simultaneous reforms, while countries with lower savings rates grow more following macro reforms. These effects are present even after controlling for the direct effect of savings on growth. In the model, I provide an explication for these observations grounded on non-discriminatory contract enforcement problems.

According to the neoclassical growth model, an increase in the savings rate is associated with a temporary effect on growth. Henry (2007) makes the point that financial reforms have the same quantitative effects as a permanent increase in the savings rate: opening to capital flows, allowing competition in the banking sector, introducing equity markets; all increase the pool of resources available to finance domestic investments and lead to a temporary increase in growth. If savings rates are independent of financial reforms, a country with lower savings rate should benefit more from these reforms. Looking at the data, I find that this only holds when reforms focus on macro dimensions. On the contrary, when reforms simultaneously

[1] The division follows Bandiera et al (2000). These authors study the effect of different reforms on domestic savings for a small group of countries. In this paper, I use a larger dataset and investigate the effect of reforms on growth.

[2] Bekaert et al (2005) and Henry (2007) study equity market liberalizations and capital flows liberalization. In my work I use a larger sample, and investigate a larger set of reforms. More importantly, I explicitly study the growth effect of different reform strategies.

affect macro and micro dimensions, growth is larger when the savings rate is large.[3]

I argue that these patterns are consistent with a second best view of financial reform. I write a simple model of financial trade and focus on two policy dimensions: capital flows (as macro reforms) and domestic financial competition (as micro reforms). I assume that this economy would like to import capital from abroad and that there are no natural reasons to have a monopolist intermediating financial trades. In the model, the first best can only be obtained by lifting all restrictions to capital flows and competition. But in this economy the enforcement of financial contracts is strategic and non-discriminatory, and the interaction between the enforcement decision together with the presence of externalities can some times make the first best unattainable. A planner does not care for foreigners and would like to avoid payments abroad. Because enforcement breakdown is non-discriminatory, he might have to measure the benefits of forfeiting payments to foreigners against the cost borne by savers, when savers deposit domestically. An important result from the non-discrimination literature is that the first best is not always attainable when domestic savings are small relative to financial intermediation.[4]

In this paper I propose that a less competitive financial sector has its incentives aligned with enforcement and corrects the externalities: profits are only made under contract enforcement. I show that a simple second best argument justifies the growth effects of different reform strategies that I document in the data. In particular, it can explain why countries with large savings rate benefit the most with simultaneous reforms, and why countries with low savings rate are better off doing only macro financial reforms, relative to doing simultaneous reforms. Reforming both dimensions with low

[3]Bandiera et al (2000) argue that savings rates are essentially unaffected following financial reforms. Of course, it could be that my results are driven by another variable correlated with savings. But note that this variable would have to affect reforms asymmetrically.

[4]The assumption of non-discrimination between domestic and foreigners has been recently used by Kremer and Mehta (2000), Brutti (2010), Guembel and Sussman (2009), Broner and Ventura (2011), Broner and Ventura (2010), Gennaioli, et al (2010), and Rappoport (2010). Broner et al (2010) argue that this assumption can be rationalized with sufficiently deep secondary markets.

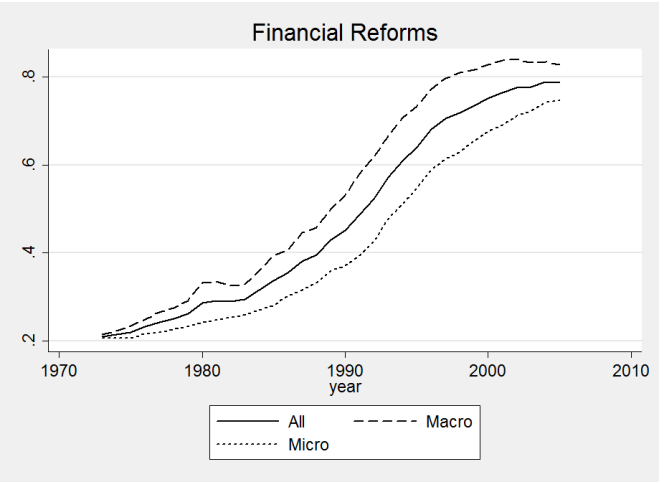

Figure 2.1: All refers to the sample mean of all the entries of the financial reform index constructed by Abiad et al (2010). Macro reforms include capital account restrictions, interest rate controls and credit controls. Micro reforms include entry and regulation in the banking sector, privatization and the establishment of equity markets. All sub-indices take larger values if there is more liberalization except for regulation where the opposite is true.

Ordering of Reform			
% of episodes in which following dimension (partially) reformed first			
Regions	Macro Reforms	Micro Reforms	Simultaneous
All	47.3	15.3	37.3
Advanced	43.3	16.7	40.0
Developing	48.3	15	36.7

Table 2.1: I normalize macro and micro indices between 0 and 1. Table 2.1 defines a macro (micro) reform as a change in these indices such that the macro (micro) index is above 0.5, while the other component is below 0.5. A reform is considered simultaneously macro and micro if it is such that both indices are above 0.5. I employ a 3 year window around each event and give priority to earlier events in case of overlap.

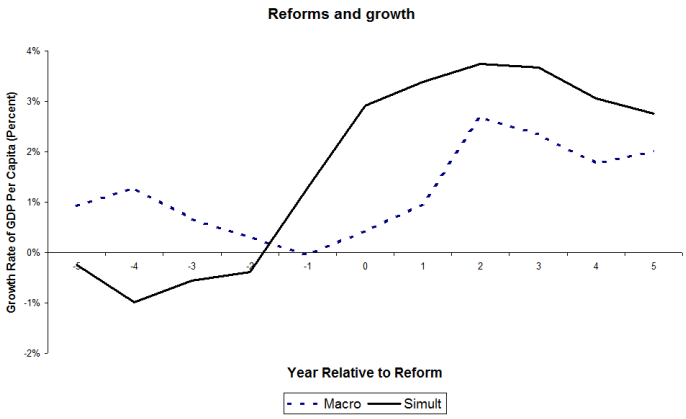

Figure 2.2: The average growth rate of GDP per capita rises less when countries perform macro reforms first. The x axis denotes time in years relative to each type of liberalization. Table 2.9 in Appendix B.1 shows the reform dates used in this figure.

savings can lead to an enforcement crisis which translates into a negative effect on growth.[5]

The monopolist financial sector does not necessarily replicate the planner's preferred outcome. It cares only about maximizing profits. In fact, an optimal credit policy by a government could always lead to the first best, but the objective of this paper is to study situations where the government can not implement the first best, and has to resort to second best policies.[6]

The theoretical view proposed in this paper is closely related to the work by Broner & Ventura (2010). Their paper is the first to study the effects of macro financial reforms under strategic enforcement with non-discrimination. They do this for a given level of competition in the financial market. In my paper, I explicitly study two dimensions of reform, and I draw implications

[5]In the neoclassical model considered for example in Henry (2007) the relationship between savings and growth following liberalization should be monotonic. In this paper, I model the presence of thresholds in the savings rate, that determine the success of different financial reforms.

[6]The reasons why the government can not implement the first best are two fold. First, it can not discriminate between savers and entrepreneurs, just as it can not discriminate between domestic and foreign agents. Second, even if it could, it can not commit to credit policies.

regarding the empirical relationship between reforms, savings and growth.

The empirical work in this paper is related to the literature on growth and financial liberalization. I use methods described in Bekaert et al (2005) and Henry (2000, 2007) to assess the impact of different reform strategies on growth. These two approaches differ mostly with respect to the horizon during which reforms should affect growth. Bekaert et al (2005) tests for permanent effects of reforms on growth. Henry (2005, 2007) studies temporary effects. In this paper I take an agnostic view on this issue, and highlight that results appear to be robust to both approaches. Growth following financial reforms of both macro and micro policy dimensions is two times as large as reforms that focus only on macro dimensions.

Other theories have been to proposed to explain some of the facts presented in this paper. Gertler & Rogoff (1990) argue that severe domestic financial frictions can lead to capital flight following macro financial reform. I emphasize enforcement problems and the effect of different levels of competition in domestic financial markets. Ragan & Zingales (2003) suggest there are political economy factors behind the implementation of different financial reforms. With respect to this literature, this paper presents a rational alternative that is complementary to the political economy of reform. In my paper it is the market failure that induces the lack of reform, and not the political capture. Other political economy explanations of reforms associated with ideology find mixed results (see Alesina & Roubini (1992) and Bartolini & Drazen (1997)). Fernandez & Rodrik (1991) present a learning story where successful initial reforms promote further reforms. It does not explain which reforms should be implemented. The theory presented in this paper suggests that countries with low savings rates should reform price and quantities in financial markets but not necessarily domestic financial competition.

The rest of the paper proceeds as follows. Section 2.2 develops the model and discusses the main results. Section 2.4 studies the determinants of financial reform, and tests whether the view presented in this paper can account for the negative growth effect described above. Section 2.4 concludes and points to future research.

2.2 A simple model of financial reforms

I study financial reforms in a simple model of asset trade and investment. There are three types of agents in this economy: savers, entrepreneurs and financial intermediaries. Savers and entrepreneurs take as given policies from a benevolent planner. I will focus on two aspects of policy. First the planner decides on the rules governing financial trade. Secondly, it decides whether to enforce previously written financial contracts. There is an important asymmetry in the ability of the planner to commit to these two different types of policy. I assume that the planner can commit to rules governing financial trade but can not commit to enforce financial contracts.

The planner can choose macro and micro rules for financial trade. I will focus on competition in the financial sector as a micro reform and on opening to international capital flows as a macro dimension. Later I discuss other financial reforms.

I begin by studying an economy that is in financial autarky, where only domestic trades are allowed. This allows me to illustrate the trade-off behind enforcement but also the role played by financial intermediaries with different levels of competition. If the country is in financial autarky, failing to enforce contracts has no effect on average consumption but can have important distributional effects. When the autarky solution rewards any type of agents too much relative to other types, a planner that cares about average utility might be willing to break down contracts as a redistribution tool. In anticipation, savers will not engage in financial trade, and investment and output will be low.

Ultimately, these enforcement problems are the consequence of externalities that interact with the lack of commitment from the planner. Entrepreneurs and savers are atomistic which can lead to over borrowing by entrepreneurs and coordination problems between savers. Reducing competition in financial markets allows the financial intermediary to not take as given the actions of the planner, and to internalize the externalities and induce enforcement.

I then open up this economy to international capital markets. If the econ-

omy is importing capital, enforcement breakdown can now increase average consumption. The temptation to break down contracts is larger the smaller are savings. I will show how the optimal choice between macro and micro reforms crucially depends on savings.

I finalize this section by discussing the sequencing of financial reforms, relating to different types of macro and micro financial reforms and drawing empirical implications from the model, that I test in the next section.

2.2.1 Preliminaries and assumptions

There are three maximizing private agents in this economy: savers, entrepreneurs and financial intermediaries. Savers (s) and entrepreneurs (e) are atomistic and have masses $1-\varepsilon$ and ε, respectively. Savers have funds but do not have good investment opportunities. Entrepreneurs lack funds but have good investment opportunities. I assume that only domestic financial intermediaries can lend to entrepreneurs. Furthermore, these are the only domestic agents that can borrow in the foreign market for capital when capital flows are liberalized.[7] The number of intermediaries operating in the market depends on policy set by the planner. If the planner chooses perfect competition there is an infinite number of intermediaries; if it decides to restrict competition there is only one.

There is one good that can be used for consumption, storage or investment. There are two periods $T=0$ and $T=1$. In period $T=0$, the planner first decides on the institutional arrangement: perfect competition vs. no competition in the financial sector, financial autarky vs. capital flow liberalization. Then, agents choose investment decisions. In period $T=1$, the enforcement of financial contracts is decided strategically by the planner, and agents consume.

There are two technologies in this economy, storage (l) and investment (k). Storage is less productive than investment - it simply transfers resources

[7] There are different ways to justify this assumption. Financial intermediaries may have collateral that is valuable abroad, or they may have assets abroad that are seized in case of non-repayment, or can simply be foreign and have branches in the domestic economy.

across time without a return. Investing 1 unit of the good in storage today yields 1 unit of the good tomorrow. On the contrary, investment has a return. Investing k units today, yields k^{α} units tomorrow, where $\alpha \in (0,1)$. These different technologies are the source of gains from trade in this economy. Domestic savers can not operate the investment technology and would like to access its returns. Foreign savers would like to benefit from the larger returns relative to their alternative investments.

Intermediaries maximize period by period profits and distribute these profits proportionally between domestic agents. There is an asymmetry between saving and borrowing. Contrary to borrowers, domestic savers can save with domestic intermediaries or with the foreign market when capital flows are liberalized.[8]

Institutional arrangements are determined by a forward looking calculation of average welfare in the economy. They can not be overturned. On the contrary, contracts are subject to an enforcement decision at $T = 1$ that is strategic. In particular, I assume that the enforcement of these contracts maximizes the utility of the average domestic agent at $T = 1$. A crucial assumption in this paper is that the enforcement decision can not discriminate between domestic and foreign agents. This implies that canceling contracts with foreigners implies also destroying domestic asset trade. That is the only cost associated with enforcement breakdown.

To summarize this discussion, at $T = 0$ the planner chooses between four possible institutional arrangements:

$$X \times Y = \{(x,y) \,|x \in X = (PC, MP) \text{ and } y \in Y = (AUT, CF)\}$$

where PC stands for perfect competition, MP for monopoly, AUT for autarky and CF for liberalized capital flows. Institutional arrangements (x,y) are chosen to maximize:

[8]This asymmetry between the financial trades of savers and entrepreneurs can be justified by monitoring asymmetries. Deposits do not need monitoring, but loans need to be monitored by a domestic financial intermediary who is subject to domestic law and therefore to strategic domestic enforcement. It is not crucial for the results in this paper.

$$U_0 = E_0 \left[(1-\varepsilon) \ln \left(c_1^s \left(E_1 \right) \right) + \varepsilon \ln \left(c_1^e \left(E_1 \right) \right) \right] \tag{2.1}$$

where E_0 stands for the expectations operator, E_1 summarizes the enforcement decision at $T = 1$. To simplify the analysis, I will assume throughout that the parameter space is such that the planner prefers liberalizing both dimensions to liberalizing only macro dimensions. If the first option is not attainable he prefers to liberalize macro dimensions only relative to the other options.[9]

The first best may not be attainable due to strategic enforcement breakdown. Enforcement E_1 can take two values. If $E_1 = 1$ there is enforcement of financial contracts. If $E_1 = 0$ there is enforcement breakdown of financial contracts and the economy is in a situation of widespread default. Enforcement is chosen in period $T = 1$ to maximize average utility of that period, which is given by:

$$U_1 = (1-\varepsilon) \ln \left(c_1^s \left(E_1 \right) \right) + \varepsilon \ln \left(c_1^e \left(E_1 \right) \right) \tag{2.2}$$

2.2.2 Financial autarky

Savers

Savers wish to maximize utility at $T = 1$. A saver receives an endowment in period 0 and 1 of w_0^s and w_1^s, respectively. He has access to two investment options: (i) the storage technology (l_0) transforms one unit of the good at time 0 into one unit at time 1; and (ii) financial trades with domestic intermediaries (b_0^s), for a gross return of R^s in period 1. Formally, a saver solves the following problem:

$$\max_{c_1^s, b_0^s, l_0} E_0 \left[\ln \left(c_1^s \right) \right]$$

[9] This assumption is not necessary for any of the results to be presented in this paper but it substantially simplifies the presentation of these results by omitting the discussion of empirically irrelevant cases. I will further assume that parameters are such that in autarky it is better to have a single intermediary over perfect competition.

$$s.t.$$

$$b_0^s = w_0^s - l_0$$

$$c_1^s = \begin{cases} w_1^s + R^s b_0^s + l_0 + \pi & \text{if } E_1 = 1 \\ w_1^s + l_0 + \pi & \text{if } E_1 = 0 \end{cases}$$

Where π are profits generated by financial intermediaries. Savers decisions are taken after the institutional choice. They use backward induction to solve for the enforcement decision and therefore face no uncertainty.

The decision to invest in the domestic financial market relative to storage depends crucially on the enforcement decision. If enforcement holds, savers will deposit their funds with financial intermediaries when the return on deposits exceeds the return on storage. On the other hand, if enforcement does not hold, or the return on deposits does not exceed 1, savers store their funds at $T = 0$. Formally:[10]

$$b_0^s = \begin{cases} w_0^s & \text{if } R^s > 1 \text{ and } E_1 = 1 \\ [0, w_0^s] & \text{if } R^s = 1 \text{ and } E_1 = 1 \\ 0 & \text{if } R^s < 1 \text{ or } E_1 = 0 \end{cases}$$

In a symmetric equilibrium the total supply of funds is perfectly rigid if $R^s > 1$, and given by:

$$S = (1 - \varepsilon) b_0^s \tag{2.3}$$

Entrepreneurs

Entrepreneurs wish to maximize utility at $T = 1$. An entrepreneur receives endowments in period 0 and 1 of $w_0^e = 0$ and $w_1^e > 0$, respectively. He has access to two investment options: (i) investment (k_0) that yields k_0^α in

[10] Savings and consumption follow: $l_0 = w_0^s - b_0^s$ and $c_1^s(E = 1) = w_1^s + R b_0^s + l_0 + \pi$ and $c_1^s(E = 0) = w_1^s + l_0 + \pi$.

period 1; and (ii) financial trades with domestic intermediaries (b_0^e), for a gross return of R^e in period 1. Formally, an entrepreneur faces the following problem:

$$\max_{c_1^e, k_0, b_0^e} E_0 \left[\ln \left(c_1^e \right) \right]$$

$$s.t.$$

$$b_0^e = -k_0$$

$$c_1^e (E) = \begin{cases} w_1^e + k_0^\alpha + R^e b_0^e + \pi & \text{if } E = 1 \\ w_1^e + k_0^\alpha + \pi & \text{if } E = 0 \end{cases}$$

The entrepreneurs would like to borrow to equate the marginal return of investment to its marginal cost. The solution to their problem is given by:[11]

$$k_0^e = \left(\frac{\alpha}{R^e} \right)^{\frac{1}{1-\alpha}}, b_0^e = -k_0^e \tag{2.4}$$

In a symmetric equilibrium, the aggregate demand of funds is given by:

$$D = \varepsilon \cdot \left(\frac{\alpha}{R^e} \right)^{\frac{1}{1-\alpha}} \tag{2.5}$$

And it is possible to see that $\frac{\partial D}{\partial R^e} < 0$. The demand of funds is elastic and depends negatively on the interest rate.

Financial intermediaries

Financial intermediaries maximize profits. To simplify I will consider only extreme cases of competition. Therefore, it is irrelevant if competition is a

[11] Consumption levels are given by $c_1^e (E = 1) = w_1^e + (1 - \alpha) \cdot \left(\frac{\alpha}{R} \right)^{\frac{\alpha}{1-\alpha}} + \pi$ and $c_1^e (E = 0) = w_1^e + \left(\frac{\alpha}{R} \right)^{\frac{\alpha}{1-\alpha}} + \pi$.

la Cournot or Bertrand. Domestic intermediaries are the only agents that can lend to entrepreneurs, and the only domestic agents that can borrow abroad. Whatever profits they obtain from intermediation, they transfer to domestic savers and entrepreneurs in a proportional fashion.

Equilibrium

In this simple economy there are two possible equilibria that I label Pessimistic (P) and Optimistic (O). Before analyzing the effect of market structure on financial trade and investment it is useful to study these equilibria resorting to two results. The first result highlights the importance of expectations in this simple model: there is always a pessimistic equilibrium where savers just store their funds and no financial trades occur. The second result states that an equilibrium with financial trade and investment does not always exist, and that it depends on the interest rates charged to savers and entrepreneurs. Replacing the consumptions derived in the previous section in equation (2.2), it is possible to see that $E_1 = 1$ is sustainable if and only if:

$$(1-\varepsilon)\ln\left(\frac{w_1^s + R^s w_0^s + l_0 + \pi}{w_1^s + l_0}\right) + \varepsilon \ln\left(\frac{w_1^e + (1-\alpha)\cdot\left(\frac{\alpha}{R^e}\right)^{\frac{\alpha}{1-\alpha}} + \pi}{w_1^e + \left(\frac{\alpha}{R^e}\right)^{\frac{\alpha}{1-\alpha}}}\right) \geq 0 \tag{2.6}$$

In financial autarky, the enforcement decision has no effect on average consumption. But enforcement can still break down because the planner wishes to redistribute away from savers and towards entrepreneurs. The following two lemmas summarize this discussion.

Lemma 1 *There is always a pessimistic equilibrium where enforcement breaks down and* $k_0 = 0$.

Proof: If all savers expect that enforcement will break down at $T = 0$ there are no financial contracts to be enforced under autarky, and the enforcement decision is irrelevant. □

Lemma 2 *The optimistic equilibrium exists if and only if inequality* (2.6) *is satisfied.*

Proof: This condition can be obtained using the consumptions in footnotes (10) and (11) in equation (2.2) and rearranging. □

To simplify the analysis I assume for now that if the optimistic equilibrium exists, it is played. If the optimistic equilibrium does not exist, then the pessimistic equilibrium is played. We are now ready to analyze the effects on investment and output of different levels of financial competition under autarky.[12]

Equilibrium under perfect competition

Under perfect competition with enforcement intermediaries make zero profits. There is a single interest that clears the market, $R : \int b^i(R)\,di = 0$. This interest rate is given by $R^e = R^s = R^{PC,AUT} = \alpha\left(\frac{\varepsilon}{(1-\varepsilon)w_0^s}\right)^{1-\alpha}$. It depends negatively on w_0^s and $(1-\varepsilon)$ and positively on ε and α. I assume that $R^{PC,AUT} \geq 1$, such that storage is dominated by deposits. The solution is represented in Figure 2.3.

For this equilibrium to exist enforcement must occur. Replacing these interest rates in (2.6), together with $l_0 = 0$ and $\pi = 0$, it is possible to rewrite this condition as:

[12]More generally, the equilibrium that is played depends on the realization of a sunspot variable at $T = 0$ given by $\chi = (O,P)$, with probabilities $\Pr(\chi = O) = 1-\rho$ and $\Pr(\chi = P) = \rho$. If O realizes, the optimistic equilibrium is played. If P realizes, the pessimistic equilibrium is played. I assume that the sunspot is revealed and perfectly observable as of $T = 0$, but only after the institutional arrangement is in place. This assumption implies that only the institutional decision at $T = 0$ is taken under uncertainty. This sunspot does not depend on the level of competition in the domestic financial market.

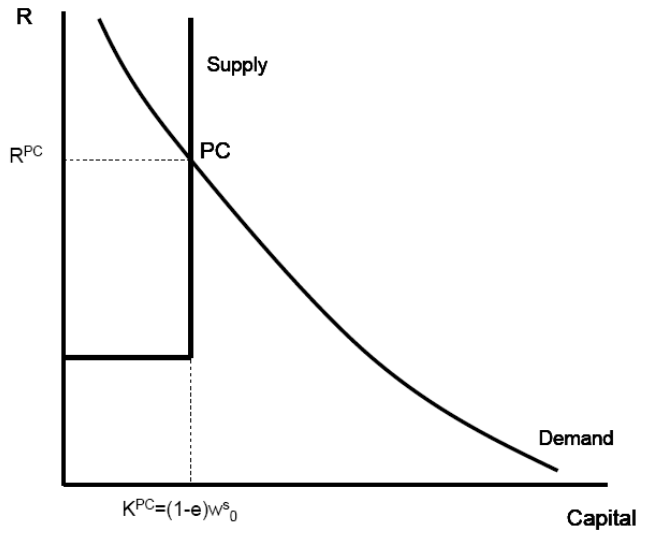

Figure 2.3: Perfect Competition. The interest rate that clears the market is given by R^{PC}.

$$(1-\varepsilon)\ln\left(\frac{w_1^s+\alpha\left(\frac{\varepsilon}{1-\varepsilon}\right)^{1-\alpha}(w_0^s)^{\alpha}}{w_1^s}\right)+\varepsilon\ln\left(\frac{w_1^e+(1-\alpha)\cdot\left(\frac{1-\varepsilon}{\varepsilon}w_0^s\right)^{\alpha}}{w_1^e+\left(\frac{1-\varepsilon}{\varepsilon}w_0^s\right)^{\alpha}}\right)\geq 0$$

Equilibrium under one financial intermediary

Suppose that there is only one financial intermediary. Under autarky this financial intermediary will have both monopolist and monopsonistic powers. Therefore the interest rates for savers and entrepreneurs will not be the same. Savers get R^s, which will also be the marginal cost of funds for the monopolist. The monopsonist can push down the returns of savers to the point they are indifferent between storing and depositing. On the other side of the market, the monopolist charges R^e to entrepreneurs and will constrain the amount of funds available to entrepreneurs. This agent makes profits when $R^e > R^s$. I assume that the intermediary is owned by the private agents in this economy. The problem of the financial intermediary in the absence of competition is given by:

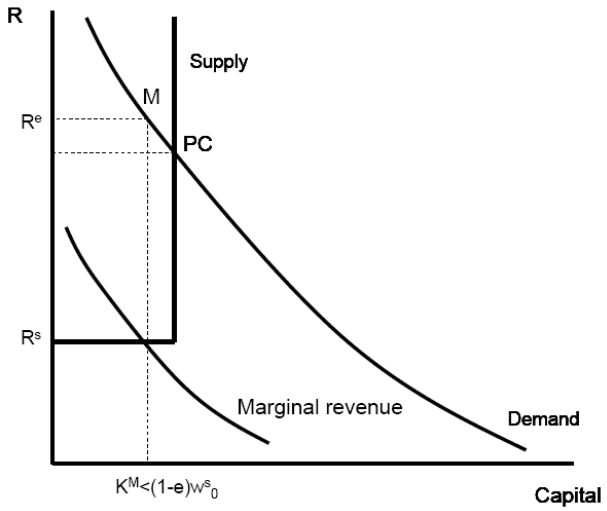

Figure 2.4: Unconstrained financial intermediary. The interest rates are R^e for entrepreneurs and R^s for savers.

$$(R^s, R^e) = \arg\max E_0 \left[E_1 \cdot (R^e - R^s) \cdot \varepsilon \left(\frac{\alpha}{R^e} \right)^{\frac{1}{1-\alpha}} \right]$$

$$s.t.$$

$$(M1)\, \varepsilon \cdot \left(\frac{\alpha}{R^e} \right)^{\frac{1}{1-\alpha}} \leq (1-\varepsilon) \cdot w_0^s \text{ and } R^s \geq 1$$

$$(M2) : R^e \cdot \varepsilon \cdot \left(\frac{\alpha}{R^e} \right)^{\frac{1}{1-\alpha}} \leq \varepsilon \cdot \left(\frac{\alpha}{R^e} \right)^{\frac{\alpha}{1-\alpha}}$$

$$(M3) : E_1 = \arg \max_{E_1 = \{0,1\}} (1-\varepsilon) \cdot \ln\left(c_1^s(E_1)\right) + \varepsilon \cdot \ln\left(c_1^e(E_1)\right)$$

$$c_1^s(E_1), c_1^e(E_1) \text{ solve agents' problems}$$

The first constraint $(M1)$ states that the intermediary can raise the funds it wishes to supply. In this simple model under autarky, the supply of funds is fixed if $R^s \geq 1$. Note that savers have no better outside option other than storage. I assume that if they are indifferent between storing or depositing, they deposit their funds. The second constraint $(M2)$ states that total repayment is constrained by the total amount of resources produced by entrepreneurs. The third constraint $(M3)$ summarizes the enforcement decision at $T = 1$.

Because the intermediary only makes profits when enforcement is guaranteed, we can replace $(M3)$ with an analogous constraint where $E_1 = 1$:

$$(1-\varepsilon)\cdot \ln\left(\frac{c_1^s(E_1=1)}{c_1^s(E_1=0)}\right) + \varepsilon \cdot \ln\left(\frac{c_1^e(E_1=1)}{c_1^e(E_1=0)}\right) \geq 0 \quad (M3')$$

If no constraint binds, then the solution to this problem is given by the traditional condition that equals marginal revenue to marginal cost: $k^e = \left(\alpha^2\right)^{\frac{1}{1-\alpha}}$ and $R^e = 1/\alpha$. Figure 2.4 plots the solution to the unconstrained problem.

Let us now discuss the solution when constraints do bind. The first constraint $(M1)$ is a constraint on the quantity of funds supplied by the monopolist, and translates into a constraint on the interest rate: it can not be too low, $R^e \geq \alpha\left(\frac{\varepsilon}{(1-\varepsilon)w_0^s}\right)^{1-\alpha}$. The second constraint $(M2)$ puts an upper bound on how many resources the monopolist can extract from entrepreneurs. Put differently, the interest rate charged to these agents can not be too large: $R^e \leq \alpha^{\frac{\alpha}{1+\alpha}}$. Finally, $(M3\prime)$ summarizes the strategic decision at $T = 1$ of whether to enforce contracts. The monopolist only makes profits if this condition is satisfied. It will therefore choose R^s, R^e in order to guarantee that enforcement happens.

Figure 2.5 plots the solution to this problem when a financial intermediary is constrained by the amount of savings he has access to under autarky, that is when M1 binds. I will assume that the economy is in such a situation[13] In this situation, competition has no negative impact on investment and output. It simply redistributes surplus from savers to entrepreneurs. Savers get $R^s = 1$, the value of their outside option, while entrepreneurs are charged $R^e = R^{MP,AUT} = R^{PC,AUT} = \alpha\left(\frac{\varepsilon}{(1-\varepsilon)w_0^s}\right)^{1-\alpha}$. Profits are equally divided between savers and entrepreneurs. This creates some redistribution but is not crucial. If instead savers owned the intermediary, this agent would still find a way to induce enforcement. In other words, if at these interest rates $(M3')$ would not be satisfied, the financial intermediary chooses a different combination to satisfy this constraint.[14]

[13] This assumption is not necessary if the supply of funds is upward slopping. This is the case if the utility of savers is not of the log type. The monopolist is always constrained then.

[14] Replacing this interest rate in $(M2)$, it is possible to see that this is always feasible if

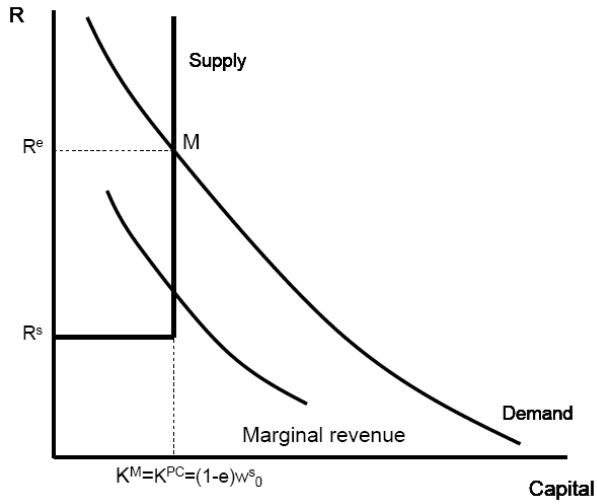

Figure 2.5: Constrained monopolist. Monopolist only redistributes surplus from savers to entrepreneurs.

Policy and Investment under Autarky

Under autarky, enforcement breakdown has no effect on average consumption but still has distributional effects. Having one financial intermediary eases the temptation to break financial contracts by the planner and can in some cases generate higher utility and investment. This result is summarized in the following proposition:

Proposition 1 *Under financial autarky with* $(M1)$ *binding, investment is larger under a monopolist/monosponist if and only if:*

- $(1-\varepsilon)\ln\left(\frac{w_1^s+\alpha\left(\frac{\varepsilon}{1-\varepsilon}\right)^{1-\alpha}\left(w_0^s\right)^{\alpha}}{w_1^s}\right)+\varepsilon\ln\left(\frac{w_1^e+(1-\alpha)\cdot\left(\frac{1-\varepsilon}{\varepsilon}w_0^s\right)^{\alpha}}{w_1^e+\left(\frac{1-\varepsilon}{\varepsilon}w_0^s\right)^{\alpha}}\right)<0$

$w_0^s \geq (\alpha)^{\frac{1}{1-\alpha^2}}\frac{\varepsilon}{1-\varepsilon}$. As savers have no outside option and the elasticity of deposits to the interest rate is zero, $R^s=1$. Monopolist profits are given by $\Pi=(R^e-R^s)\cdot k^M$. It is still necessary to confirm that under these prices, there is enforcement. Replacing in equation $(M3')$:

$$(1-\varepsilon)\cdot\ln\left(\frac{w_1^s+w_0^s+\pi}{w_1^s}\right)+\varepsilon\cdot\ln\left(\frac{w_1^e+(1-\alpha)\cdot\left(\frac{1-\varepsilon}{\varepsilon}w_0^s\right)^{\alpha}+\pi}{w_1^e+\left(\frac{1-\varepsilon}{\varepsilon}w_0^s\right)^{\alpha}}\right)\geq 0$$

where $\pi=\left(\alpha\left(\frac{\varepsilon}{(1-\varepsilon)w_0^s}\right)^{1-\alpha}-1\right)(1-\varepsilon)w_0^s$. If w_0^s is sufficiently large, this is the case.

- $(1-\varepsilon)\cdot\ln\left(\frac{w_1^s+w_0^s+\pi}{w_1^s}\right)+\varepsilon\cdot\ln\left(\frac{w_1^e+(1-\alpha)\cdot\left(\frac{(1-\varepsilon)w_0^s}{\varepsilon}\right)^{\alpha}+\pi}{w_1^e+\left(\frac{(1-\varepsilon)w_0^s}{\varepsilon}\right)^{\alpha}}\right)\geq 0$

where $\pi=\left(\alpha\left(\frac{\varepsilon}{(1-\varepsilon)w_0^s}\right)^{1-\alpha}-1\right)(1-\varepsilon)\,w_0^s$.

Proof: The proof follows from the analysis above. □

This result highlights an important feature of this economy with strategic enforcement. It states that under some conditions having one single financial intermediary in autarky is the optimal institutional arrangement. The reason for this is that a large intermediary can internalize the planner's enforcement decision at $T=1$. The planner can not commit to enforce financial contracts. But the single financial intermediary provides him with a powerful commitment technology: profit maximization by a private agent.

Let us now discuss why the planner has to resort to this second best institution in light of its commitment problem. Instead, it could develop credit policies or operate a state-owned bank that would induce enforcement of contracts. Unfortunately, this requires commitment and if these policies are also subject to the commitment problem, the planner can not do better than the intermediary. In particular, the planner can not commit to any policy where $c_1^s\neq c_1^e$. It then faces a similar problem as with enforcement. Ex-ante it would like to promise that enforcement does not leave any agent worse off compared to no trade in domestic financial markets. But ex-post the planner will break enforcement and redistribute. If the consumption at $T=1$ is smaller than what savers would get on their own, that is, if $\left((1-\varepsilon)\,w_0^s\right)^{1-\alpha}+w_1^s\,(1-\varepsilon)+w_1^e\varepsilon<w_1^s+w_0^s$, then savers are better off not participating in the financial market with the planner policy. In these cases, the planner is better off resorting to the single financial intermediary as a commitment technology.

2.2.3 Capital flows liberalization

Assume now that there is a deep international market with no enforcement problems willing to supply or demand funds in period 0 in exchange for a gross interest rate of $R^* = 1 + r$ in period 1. Defaulting on contracts with the international market comes with no externally imposed costs, but it can have internal costs. This is the consequence of the assumption that it is not possible to discriminate between domestic and foreign asset trades. Under this assumption, enforcement breakdown means also that all the planned domestic trades are canceled.

Following capital flow liberalization, savers can deposit abroad or at home, but entrepreneurs have to borrow from domestic intermediaries, who in turn access foreign markets or domestic savers. Agents in this economy face different interest rates on their financial trades with the international market due to enforcement problems. If an agent is borrowing from abroad $R^{B,*}(E) = \frac{1+r}{\Pr(E=1)}$, but if an agent is lending abroad $R^{L,*} = 1 + r$.[15]

Once again there are two possible equilibria that I label Pessimistic (P) and Optimistic (O). In the pessimistic equilibrium, savers invest abroad and enforcement always breaks down, independently of the level of competition. Savers are better off compared to autarky, as they can now benefit from the international interest rate and avoid storing. In the optimistic equilibrium, savers save domestically and enforcement can happen, but it may depend on the level of competition in financial markets.

In order to have enforcement it is necessary that the deposits made by savers are subject to the enforcement decision. But it is not sufficient. In case of enforcement breakdown entrepreneurs do not repay what they borrowed. Strategic enforcement will trade-off the costs of enforcement breakdown borne by savers, with the benefits accruing to entrepreneurs. It follows that for an optimistic equilibrium to exist, entrepreneurs must not promise too many payments abroad through financial intermediaries.

[15] Throughout, I will assume a symmetric equilibrium for all agents in the economy and that gross positions are minimized.

Like before, assume that if the optimistic equilibrium exists it is played. If the optimistic equilibrium does not exist, then the pessimistic equilibrium is played instead. In order to distinguish between domestic and foreign trades, let b^i stand for domestic financial of agents trades, with $B^s = (1-\varepsilon)\, b^s$, $B^e = \varepsilon b^e$ and $F = B^e + B^s$ for foreign trades. Under autarky, $F = 0$. I will focus on economies that following opening to capital flows, import capital from abroad.

Equilibrium under perfect competition

As discussed under autarky, under perfect competition the existence of the optimistic equilibrium is not always guaranteed. Under capital flow liberalization, besides redistributional concerns, enforcement breakdown comes with the benefit that payments abroad are canceled at $T = 1$.[16]

In an optimistic equilibrium savers deposit domestically, and intermediaries complement these funds with foreign borrowing to supply entrepreneurs. I can construct the optimistic equilibrium by finding conditions under which enforcement breakdown would destroy so much domestic asset trade that this does not compensate avoiding payments abroad. If that is the case:

$$R^{S,*} = R^{B,*}(E = 1) = 1 + r \tag{2.7}$$

and domestic deposits are again given by:

$$B_0^s = (1-\varepsilon)\, w_0^s \tag{2.8}$$

while borrowing by entrepreneurs and intermediaries is given by

[16]To see that the pessimistic equilibrium with $k_0 = 0$ and $F = \omega_0^s(1-\varepsilon)$ always exists, suppose all savers deposit abroad and all intermediaries catering entrepreneurs borrow from abroad. Then, enforcement only implies a transfer of resources abroad, and there is enforcement breakdown. Since contracts are never enforced, the interest rate $R^B(P) = \infty$, and investment is zero. In this economy, there is no capital flowing to the country, only capital flight. Entrepreneurs do not invest at all, and savers move their capital abroad to earn the international interest rate.

$$B_0^e = -\varepsilon \left(\frac{\alpha}{1+r} \right)^{\frac{1}{1-\alpha}} \tag{2.9}$$

$$F_0^e = B_0^s + B_0^e$$

The condition determining the existence of this equilibrium when the domestic economy is a net capital importer is given by:

$$(1-\varepsilon) \ln \left(\frac{w_1^s + (1+r) w_0^s}{w_1^s} \right) + \varepsilon \ln \left(\frac{w_1^e + (1-\alpha) \cdot \left(\frac{\alpha}{1+r} \right)^{\frac{\alpha}{1-\alpha}}}{w_1^e + \left(\frac{\alpha}{1+r} \right)^{\frac{\alpha}{1-\alpha}}} \right) \geq 0 \tag{2.10}$$

Enforcement breakdown hurts savers and benefits entrepreneurs. If $E_1 = 0$, savers lose $(1+r) w_0^s$ and entrepreneurs win $\alpha \left(\frac{\alpha}{1+r} \right)^{\frac{\alpha}{1-\alpha}}$. Note that if $1+r$ is smaller than $R^{AUT,PC}$ savers are worse off following liberalization. In the optimistic equilibrium the incentives to redistribute towards entrepreneurs are less prevalent compared to autarky. Observing equation (2.10) it is possible to see that if savings are sufficiently large this equilibrium always exists. Finally, the need of intermediation also plays a role, in particular if $\alpha/(1+r)$ is too large, this inequality will not hold and the optimistic equilibrium does not exist.

Equilibrium under one financial intermediary

Under capital flow liberalization the single financial intermediary is still a monopolist, but no longer a monopsonist as savers can now deposit abroad. Besides redistribution, there is a new way a monopolist can induce enforcement. The monopolist can constrain lending to make sure that the optimistic

equilibrium exists in situations where foreign borrowing would otherwise be too large.

The problem of the monopolist looks very similar to the one under autarky, except that now there are no constraints on the amount of funds he has access to. Furthermore, because now savers can also deposit their funds abroad, the marginal cost of funds is larger. The problem can be summarized as:

$$(R^s, R^e) = \arg\max E_0 \left[E_1 \cdot (R^e - R^s) \cdot \varepsilon \cdot \left(\frac{\alpha}{R^e}\right)^{\frac{1}{1-\alpha}} \right]$$

s.t.

$$R^e \varepsilon \cdot \left(\frac{\alpha}{R^e}\right)^{\frac{1}{1-\alpha}} \leq \varepsilon \cdot \left(\frac{\alpha}{R^e}\right)^{\frac{\alpha}{1-\alpha}} \qquad (M2)$$

$$(1-\varepsilon) \cdot \ln\left(\frac{c_1^s(E_1=1)}{c_1^s(E_1=0)}\right) + \varepsilon \cdot \ln\left(\frac{c_1^e(E_1=1)}{c_1^e(E_1=0)}\right) \geq 0 \qquad (M3')$$

$$R^s \geq 1 + r$$

$$c_1^s(E_1) = \begin{cases} w_1^s + R^s b_0^s + (1+r)(w_0^s - b_0^s) + \pi & \text{if } E_1 = 1 \\ w_1^s + (1+r)(w_0^s - b_0^s) & \text{if } E_1 = 0 \end{cases}$$

$$c_1^e(E_1) = \begin{cases} w_1^e + (1-\alpha)\left(\frac{\alpha}{R^e}\right)^{\frac{\alpha}{1-\alpha}} + \pi & \text{if } E_1 = 1 \\ w_1^e + \left(\frac{\alpha}{R^e}\right)^{\frac{\alpha}{1-\alpha}} & \text{if } E_1 = 0 \end{cases}$$

Suppose that $(M2)$ does not bind and that $E_1 = 1$. The solution is represented in Figure 2.6, and is such that: $R^s = 1 + r$ and $R^e = (1+r)/\alpha$.

If at this interest rate $R^e = (1+r)/\alpha$ there is no enforcement and $E_1 = 0$, the monopolist will increase it further to ensure that enforcement occurs.[17]

This section has argued that the monopolist can solve the overborrowing externality that makes the optimistic equilibrium unattainable under the perfect competition. The monopolist can always reduce entrepreneurial borrowing to satisfy the condition that the optimistic equilibrium exists. There is another potential role for the monopolist. To the extent that the monopolist can engage in ex-ante discrimination between domestic and foreign depositors, it can attract domestic savings by paying a larger interest rate on its

[17] If it can ex-ante discriminate between domestic and foreign savers, it will make sure that domestic savings are invested in the domestic economy, and are subject to the enforcement decision, thus avoiding the pessimistic equilibrium.

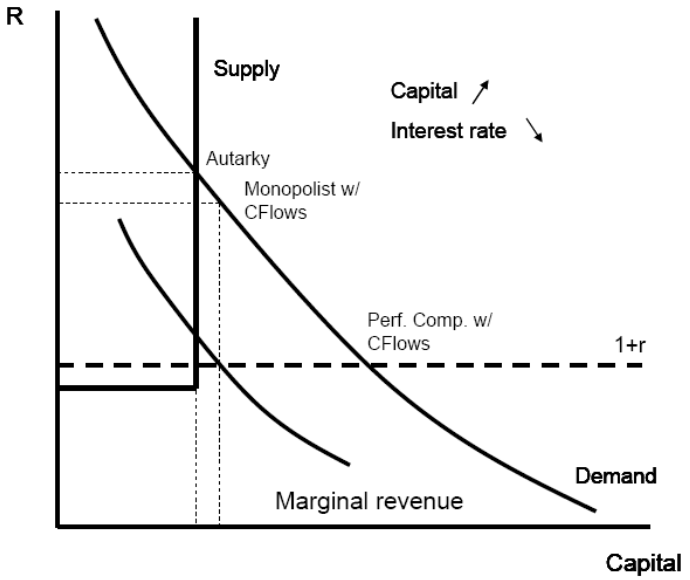

Figure 2.6: Capital Flow Liberalization with Perfect Competition and with Monopoly.

domestic depositors and this way eliminate the pessimistic equilibrium. [18]

The next section studies conditions that determine the optimal institutional arrangement at $T = 0$ under capital flow liberalization.

Policy and investment

I have argued that a monopolist will constrain credit if necessary and make sure that the optimistic equilibrium exists. It is possible to see this beneficial role of the monopolist in Figure 2.7. This figure shows a situation under which the optimistic equilibrium does not exist with perfect competition. For a given level of domestic savings, the horizontal line represents the

[18] For the ex-ante discrimination to be effective the monopolist must also guarantee that these deposits are not tradable abroad. Note that I have assumed that if the optimistic equilibrium exists it is played but this need not be the case. Instead if savers are indifferent regarding where to keep their savings, a sunspot variable would determine the symmetric equilibrium. By making sure that domestic savings are invested domestically, the monopolist coordinates savers towards a situation that is independent of the sunspot variable.

smallest level of R^e such that the optimistic equilibrium exists. Let's define this interest rate as $\underline{R}^e$, given by:

$$(1-\varepsilon)\ln\left(\frac{w_1^s+(1+r)\cdot w_0^s+\pi}{w_1^s}\right)+\varepsilon\ln\left(\frac{w_1^e+(1-\alpha)\cdot\left(\frac{\alpha}{\underline{R}^e}\right)^{\frac{\alpha}{1-\alpha}}+\pi}{w_1^e+\left(\frac{\alpha}{\underline{R}^e}\right)^{\frac{\alpha}{1-\alpha}}}\right)=0 \tag{2.11}$$

where $\pi=(\underline{R}^e-(1+r))\,\varepsilon\left(\frac{\alpha}{\underline{R}^e}\right)^{\frac{1}{1-\alpha}}$. The optimistic equilibrium only exists if the interest rate charged entrepreneurs is large enough, or in another words, if investment and foreign borrowing are small enough. Crucially, the amount of savings relaxes this constraint which in turn determines when it is better to have perfect competition together with capital flows liberalization.

The next proposition summarizes these results.

Proposition 2 *Under capital flows liberalization, it is better to have a monopolist that can at most constrain trade and capital flows if two conditions are guaranteed:*

1. *The optimistic equilibrium with perfect competition must not exist, $\underline{R}^e(w_0^s)>1+r$.*
2. *The optimistic equilibrium with a monopolist must exist.*

These conditions are more likely to be satisfied the lower are savings w_0^s.

Proof: The proof of 1. follows from the analysis above. As argued before, 2. is guaranteed by the monopolist. Finally, the last statement is obtained by noting that $\partial\underline{R}^e/\partial w_0^s<0$ together with part 1 of this proposition. □

2.2.4 Discussion and empirical implications

In this simple framework I have identified a socially valuable role for a monopolist through a classic second best argument. The monopolist is

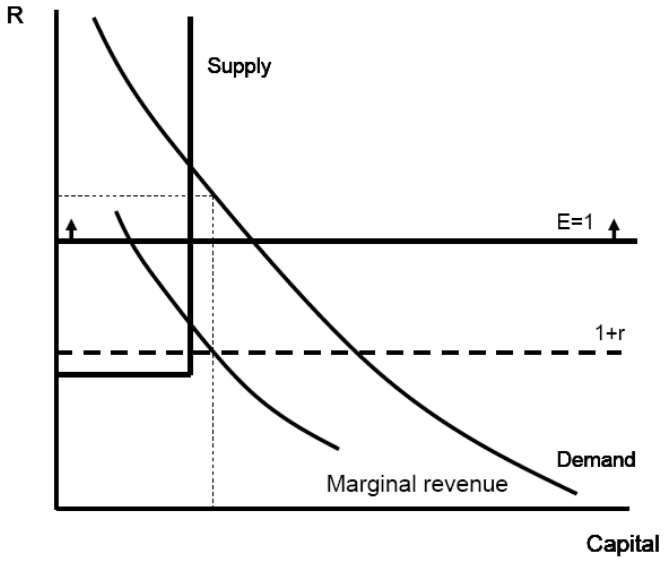

Figure 2.7: Enforcement breakdown under perfect competition, but enforcement under monopoly.

distortionary but has a stake on enforcement. This happens because only through enforcement it can extract rents from the economy. The single financial intermediary can make the optimistic equilibrium possible by constraining the amount of funds supplied to the entrepreneurial sector. In a situation where enforcement would break down under perfect competition due to over-borrowing, a sufficiently large mark-up can correct these imbalances, allow for capital to flow in and spur investment.[19] The main insight of this simple model is to show how reducing competition in financial markets allows intermediaries to internalize externalities and induce enforcement. Profit making intermediaries have a stake on the enforcement of financial contracts, and this in turn substitutes for the lack of commitment by the planner.[20]

[19]This complementarity between capital flows, private agents actions and enforcement is also present in Brutti (2009) and Gennaioli et al (2011), in a different formulation. Furthermore, these two papers focus on the sustainability of public debt.

[20]Remember that if a monopolist could ex-ante discriminate between domestic and foreign savers he will be interested in keeping domestic savings subject to the enforcement decision. This notion of ex-ante discrimination is considered in Broner & Ventura (2011) as a desired policy by a planner. They argue that it goes against the non-discrimination as-

In the model I have focused on capital flows and domestic competition but many other reforms can be thought of as having similar effects. For example, other macro restrictions such as restrictions on the interest rate and on the quantity of credit, can be thought of as limits on the amount of funds that can be traded in the economy. In a perfectly competitive financial market these can reduce the amount of intermediation but will not necessarily correct the externalities I discuss in the model. This is because ultimately, it matters where the credit comes from. Regarding micro restrictions, the establishment of equity markets can be thought of as an increase of competition. Equity markets allow firms to get funds in the stock market, directly from savers. Therefore, this reform is very similar to introducing competition in the financial sector, to the extent that debt and equity are close substitutes.

This model has non-trivial empirical implications. From an ex-ante perspective, the model suggests that opening to capital flows and to competition should depend on the ability to raise domestic savings. If savings are large both macro and micro reforms should be implemented. If savings are small, reforms should focus only on macro dimensions. This yields two sets of predictions regarding financial reform. If the choice of reform is exogenous, we should observe strong growth for countries doing simultaneous reforms only if they have high savings. If they have low savings, growth should be larger if only macro reforms are implemented.[21]

The choice of reform is most likely not exogenous in the data. It is still possible to see if any correlations between different portfolio of reforms and savings are present in the data. To the extent that countries endogenously

sumption that is crucial for their analysis. The same argument applies here. One interesting extension would be to understand if private agents can engage better in ex-ante discrimination, perhaps through targeting activities, and if this way the monopolist could also eliminate the pessimistic equilibrium.

[21]The model presented in this paper is static by nature. It is still possible to gain some intuition as to what would be the optimal sequencing of different financial reforms. We have seen that a country with low savings relative to entrepreneurial borrowing is better off reforming macro dimensions but not micro. But as capital flows into the country, the borrowing needs of entrepreneurs are smaller. This wealth effect can free the economy from the enforcement problems, make the monopolist obsolete, and allow for reforms also of micro dimensions.

select reforms to maximize growth, this should bias the growth coefficients against finding growth differentials in the data due to savings. From an ex-post perspective, the model suggests that opening up to capital flows should increase credit more if there is perfect competition in the domestic financial sector.

The following section turns to the data to see if the insights from the model can help us understand the growth effects of financial liberalization.

2.3 Empirical analysis

In this section I study empirically the growth effect of different financial reforms. In order to minimize data mining biases I use definitions and specifications from previous work on related topics. In particular, I use the definition of macro and micro reforms by Bandiera et al (2000). In the regressions, I follow closely the specifications of Bekaert et al (2005) and Henry (2007). Throughout, I investigate the robustness of my results to using alternative definitions of reforms and empirical specifications. Three main results emerge from this analysis.

First, different reform strategies matter for growth. I find that a financial reform incorporating both macro and micro dimensions leads to larger growth than a reform featuring mostly macro dimensions. I extend on the previous literature by using a larger data sample, detailed information on the types of reforms implemented and studying the intensity of reforms. More importantly, I focus on the growth effect effects of different portfolios of reforms.

Second, I argue that savings play a crucial role in the relationship between different reforms and growth. I find that a high savings rate at the time of the reform contributes to explaining the growth differential between simultaneous and macro reforms. Simultaneous reforms come with larger growth only if the savings rate is large. Countries with low savings rates grow more if they perform first macro reforms.

Finally, I show that the distribution of the savings rate is not consistently

different across different reforms.

2.3.1 Data

The Abiad et al (2010) index of financial reform

The main innovation of this index is the breakdown of reform in different dimensions of financial policy: (1) capital account restrictions, (2) credit controls, (3) interest rate controls, (4) entry barriers, (5) state ownership in the banking sector, (6) equity market policy and (7) supervision of the banking sector. Along each dimension, a country was given a score on a graded scale from zero to three, with zero corresponding to repression and three indicating full liberalization (with the exception of supervision of the banking sector, where the opposite is true). This index is available for a sample of 91 countries over the period 1973-2005, making it the most comprehensive database on financial reforms available.

From this database I extract the dates and intensity of different financial reforms. To do so, first I construct two sub-indices of macro and micro financial reforms. I follow Bandiera et al. (2000) and separate this index between macro (1-3) and micro reforms (4-7). I construct the following two indices:

$$macro_t = \frac{capital\ flows_t + credit\ controls_t + interest\ rate\ controls_t}{9} \tag{2.12}$$

$$micro_t = \frac{entry\ barriers_t + state\ ownership_t + equity\ markets_t + regulation_t}{12} \tag{2.13}$$

The first two rows in Table 2.2 show the summary statistics for the macro and micro sub-indices.

	Obs	Mean	Std. Dev.	Min	Max
Macro	2671	0.5597	0.3424	0	1
Micro	2671	0.4403	0.2974	0	1
GDPgrowth	5807	0.0191	0.0654	-0.5005	1.476
GrossPrivSav/GDP	5308	0.1729	0.1642	-1.426	0.8688
Secondary	4491	60.60	33.71	0.1698	166.17
Life Expectancy	6349	64.19	10.68	26.41	82.51
Gov/GDP	5248	0.1662	0.0720	0.0138	0.8316
POPgrowth	6864	0.0176	0.0167	-0.3586	0.1895
Trade/GDP	5418	0.8053	0.4681	0.0031	4.381
Inflation	5808	41.34	395.18	-53.71	15442.3
CurrentAcc/GDP	4556	-0.0360	0.1057	-2.405	0.567

Table 2.2: Summary statistics.

Other country characteristics

I use data from the World Development Indicators on the following variables: *GDP* per capita, savings rate, secondary education, life expectancy, government spending as a share of *GDP*, population growth, current account in percent of *GDP* and credit in percent of *GDP*. Merging with the financial reform dataset I obtain an unbalanced panel of 90 countries between $1973-2007$. Table 2.2 shows the summary statistics for these variables.

2.3.2 Financial reforms in the data

In this subsection I outline the definition of financial reforms used in this paper. I then document substantial variation in the way reforms are implemented in the data. This evidence highlights two main strategies of reform: macro financial reforms only, and both dimensions simultaneously.

The main definition of financial reform used in this paper is a threshold definition. The first contribution of the literature on financial reforms and growth is to identify the dates when policy changes take place (namely, Bekaert et al, 2005 and Henry, 2007). I obtain comparable dates for different financial reforms using the dataset by Abiad et al (2010) and constructing the macro and micro indices defined by equations (2.12) and (2.13). In

my main specification, I will identify a particular dimension as reformed if the sub-index is above 0.5 (its theoretical mean value). I construct a set of mutually exclusive dummies that take a value of 1 when a dimension is reformed and 0 when it is not. This set of dummies is defined as $\text{Reform}_{i,t} = \{Macro, Micro, Simultaneous\}$. The dummy regarding macro (micro) dimensions is equal to 1 if the macro index is reformed and the micro (macro) index is not reformed. The simultaneous dummy takes on a value of 1 if both dimensions are reformed, and 0 if at least one dimension is not reformed. This approach mirrors the work of Bekaert et al (2005).

An alternative definition of reform is to identify reform events (Henry, 2007). I define an event as a change in policy where the subindices move above or below the 0.5 threshold. Events differ with respect to the dimensions that are reformed following the change in policy. I construct a set of dummies that take on the value of one at the moment of reform and up to 5 years following the reform, and zero otherwise: $\text{Reform}_{i,t} = \{Macro, Micro, Simultaneous\}$. Some of these events overlap. A *Macro* (*Micro*) reform is such that following the policy change, only *Macro* (*Micro*) dimensions are reformed. A *Simultaneous* reform is such that both dimensions are reformed. To isolate events, I employ 3 year bands around the date of the event ($T = 0$), and in case of overlap I give priority to the earlier event. If any overlap remains, I give priority to the event that is closest to the actual reform date, i.e., to $T = 0$). Following these rules eliminates all possible overlap between events. The frequency of reforms shown in Table 2.1 are computed using this approach, and correspond to the dates where $T = 0$. In Table 2.3 I extend Table 2.1 and divide policy events by geographical reasons. The main message of this table is that there are no substantial differences in the pattern of reforms across different geographical regions (Table 2.9 in Appendix B.1 collects these dates).[22]

[22]Note that using this definition I am treating a situation where a *Micro* reform is reversed (but a *Macro* reform is not) as a *Macro* reform. This is done to be consistent with the definition of reform that follows Bekaert et al (2005). As a robustness check I have considered reversals as alternative policy events and found similar results.

Ordering of Reform			
% of episodes in which following dimension (partially) reformed first			
Regions	Macro Reforms	Micro Reforms	Simultaneous
Advanced	43.3	16.7	40
Emerging Asia	56.6	13	30.4
Latin America	51.4	17.1	31.4
Sub-S. Africa	45.8	16.7	37.5
Transition	39.2	14.2	46.4
N. Africa & M. East	50	10	40

Table 2.3: I normalize macro and micro indices between 0 and 1. Table 2.1 defines a macro (micro) reform as a change in these indices such that the (macro) index is above 0.5, while the other component is below 0.5. A reform is considered simultaneously macro and micro if it is such that both dimensions are now above 0.5.

2.3.3 Financial reforms and growth

In this section I present the effect of different reforms on growth for the main definition of financial reform outlined in the previous section. I investigate these effects using two different approaches, that correspond to the two definitions of reforms discussed above. The first approach tests for a permanent effect of financial reform on growth. The second tests for a temporary effect of financial reform on growth.

Permanent effects

In Table 2.4 I describe the results of a standard growth regression that follows Bekaert et al (2005). I regress non overlapping five year average growth rates on traditional growth determinants and on the dummies associated with different types of financial reform. The specification is given by:

$$y_{i,t+k,t} = \alpha_0 + \beta Q_{i,1980} + \gamma' X_{i,t} + \alpha' \text{Reform}_{i,t} + \varepsilon_{i,t+k,k} \tag{2.14}$$

where $y_{i,t+k,t}$ is the average growth over non-consecutive 5 year windows. $Q_{i,1980}$ represents logged *GDP* per capita in 1980, and the other controls $(X_{i,t})$ include government spending as a percentage of *GDP*, proportion of secondary school enrollment, population growth and life expectancy. I perform a pooled OLS regression where I test the impact of different financial reform dummies (Reform$_{i,t} = \{Macro, Micro, Simultaneous\}$). I follow the literature and present coefficients and standard errors corresponding to the averages of three non-overlapping 5 year windows, starting in 1981, 1982 and 1983.

This regression captures the average growth effect over 5 years of having different dimensions of financial policy liberalized, independently of when the change in policy took place. Growth regressions have been criticized because of collinearity of the regressors. In order to address this concern, I introduce controls individually. The OLS estimates are consistent and show that the simultaneous liberalization coefficient is large (0.018 in column (7) when all the controls are introduced) and more than four standard errors away from zero. It is also almost double the size of the coefficient associated with performing only macro reforms (0.010). This suggests that, on average, having both dimensions liberalized is associated with a 1.8 percentage points increase in the average of real per capita growth in *GDP* relative to a situation where no dimension is liberalized, and 0.8 percentage points compared to a situation when only the macro dimension is reformed. This is a huge effect of a simultaneous liberalization.[23]

Temporary effects

Table 2.5 summarizes the results of an alternative approach that follows Henry (2007). I regress yearly growth on a set of country and time effects, and on a set of country specific dummy variables that take on the value of one in the year that country *i* performs a particular reform, and on each of the five subsequent years:

[23]The coefficients associated with the control variables have the expected signs (see Bekaert et al, 2005).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)
Macro	0.014	0.016	0.013	0.015	0.011	0.012	0.010	Mac Low	0.019
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)		(0.006)
Micro	0.000	0.005	0.003	0.000	-0.001	-0.001	0.011	Mac High	0.015
	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)		(0.007)
Simult	0.017	0.023	0.019	0.015	0.012	0.013	0.018	Micro	0.014
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)		(0.009)
$\ln(GDP)_0$		-0.004					-0.017	Sim Low	0.017
		(0.002)					(0.003)		(0.005)
Gov/GDP			-0.068				-0.016	Sim High	0.02
			(0.029)				(0.032)		(0.005)
Second.				0.003			-0.009	Sim Full	0.023
				(0.006)			(0.011)		(0.006)
PopGr					-0.565		-0.957	Privsav_{t-1}	0.017
					(0.133)		(0.170)		(0.019)
Log(life)						0.028	0.099	Controls	Yes
						(0.012)	(0.022)		
Constant	0.009	0.043	0.019	0.008	0.021	-0.105	-0.239		-0.193
	(0.003)	(0.013)	(0.005)	(0.004)	(0.004)	(0.048)	(0.083)		(0.084)
Obs	409	399	404	392	409	409	377		376
Adj. R2	0.052	0.066	0.061	0.048	0.091	0.063	0.213		0.227

Table 2.4: Average coefficients and standard errors for 3 separate OLS regressions: 81-05, 82-06; 83-07. All regressions control for log(initial GDP per capita), log(life expectancy), government expenditure as a share of GDP, % secondary school enrollment, population growth. Column (8) controls also for the one period lagged savings rate.

	(1)	(2)	(3)
Macro Reform	0.00732**	0.00732**	0.000664
	(0.00288)	(0.00360)	(0.00185)
Micro Reform	0.00981	0.00981	0.00347
	(0.00505)	(0.00734)	(0.00331)
Simultaneous	0.0193***	0.0193***	0.00491***
	(0.00246)	(0.00335)	(0.00184)
Observations	2588	2588	2588
Number of cc	90	90	90

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Table 2.5: Country and year fixed effects in both regressions. Column (1) shows Huber robust standard errors. Column (2) clusters standard errors at the year and country level. Column (3) reports the coefficients from a cross-sectional time-series FGLS regression. (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$)

$$y_{i,t} = \alpha_0 + \alpha'_{it}\text{Reform}_{i,t} + \varepsilon_{it} \tag{2.15}$$

where $\text{Reform}_{i,t} = \{Macro, Micro, Simultaneous\}$.

This event-time approach captures the average temporary effect on growth of these different reform strategies using the full time series. Figure 2.2 shows that countries performing macro reforms grow less than countries performing both reforms simultaneously. The omitted dummy corresponds to the average of the status quo, independently of the actual policy in place. Inspecting columns (1) and (2) of Table 2.5 it is possible to see that the coefficient associated with a simultaneous episode for the full sample is large, an average increase in growth of 1.93 percentage points over five years, and highly significant. More importantly, it is two times larger than the coefficient associated with performing Macro reforms first.[24] These results suggest a stronger growth difference between simultaneous and macro reforms in the short run.[25]

[24] Column 3 shows the coefficients associated with a FGLS regressions are lower in magnitude but that the difference between simultaneous and macro reforms subsists.

[25] A potential omitted variable problem is that in a balance of payments crisis, an IMF based reform may not maximize growth opportunities. In particular, it can be tilted towards macro reforms, both for liberalizations and reversals. If that is the case, the dummy variable capturing macro reforms is in fact capturing the recession during a balance of payments crisis. In related research I address this issue by introducing information on balance of

Taken together my results indicate that simultaneous reforms have large effects on growth, and that these effects are captured both when testing permanent and temporary growth effects of reforms. The data mirrors the effects predicted by the model. In the model growth is indeed largest only when both reforms are implemented, but it is also the case that differences in growth should be to some extent due to differences in the savings rate. I turn to these issues next.

2.3.4 Financial reforms, savings and growth

In this section I extend the analysis of the previous section. In particular I am interested in what drives the positive and large effect of simultaneous reforms on growth.

Permanent effects

I perform two median splits. First, I split the simultaneous dummy into three different components according to the level of the savings rate one period before a reform took place. That is, I replace the dummy variable Sim into SimFull, SimLow and SimHigh. SimFull corresponds to cases where both dimensions of reform are fully liberalized throughout the sample. This dummy captures very few developed economies, for which we do not have information on the savings rate before the reform. SimLow and SimHigh correspond to developing economies where the savings rate falls below and above the median of the countries reforming simultaneously.[26]. Then, I perform the same median split for the macro reform only dummy.[27]

payments crisis and on the content of IMF programs. IMF induced reforms are a potential source of exogenous variation in reform, and may be key to uncover the causal effect of reforms on growth.

[26]For this median split to be meaningful I compute the median of the savings rate one year before a simultaneous liberalization, otherwise the median split could be contaminated by growth.

[27]Bekaert et al (2005) perform a similar analysis to investigate the drivers of growth following equity market liberalizations. They focus on financial development, legal environment, quality of institutions and investment conditions; but not on savings.

$$y_{i,t+k,t} = \beta Q_{i,1980} + \gamma' X_{i,t} + \beta_1 MacHigh_{i,t} + \beta_2 MacLow_{i,t} + \beta_3 Mic_{i,t} + \beta_4 SmFull_{i,t} + \beta_5 SmHigh_{i,t} + \beta_6 SmLow_{i,t} + \beta_7 \frac{Sav}{GDP}_{i,t-1} + \varepsilon_{i,t+k,k} \tag{2.16}$$

Column (8) in Table 2.3 shows the results. These results suggest a pecking order in terms of financial reform and growth. Countries with larger than median savings rates that have both dimensions reformed (*SimHigh*) tend to do better in terms of growth. But countries with low savings seem better off having only macro dimensions reformed. Abusing notation slightly, we can see in column 8 that $SimFull > SimHigh > MacroLow > SimLow > MacroHigh$. Although these differences are not very large, they are important. For example, a country with higher than median savings rates that has macro dimensions liberalized would grow 0.5 percentage points more over 5 years if it opted to have both dimensions liberalized. Countries with lower than median savings rates would be better off performing only macro reforms (on average 0.2 percentage points more over 2 years).[28]

Temporary effects

Focus now on the event approach regression. First, I break down Figure 2.2 according to the level of savings. In Figure 2.8 I plot the growth effect of a Simultaneous reform for advanced countries (the full line), and for developing countries with higher and lower than median savings rates one period before the reform (dashed and dotted lines). In Figure 2.9 I perform a similar exercise for Macro reforms. Even in this unconditional analysis it is possible to see that growth is larger for developing countries performing Simultaneous reforms if their savings rate is larger than the median. The picture is less clear for Macro financial reforms.

It is useful to run a regressions where I split reforms into three components:

[28] Note I perform these median splits conditional on the type of reform. I also ran the same regressions doing an overall median split and the effects were similar.

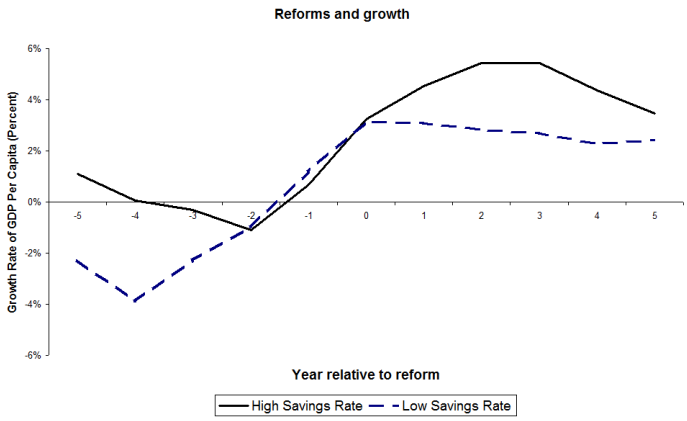

Figure 2.8: The average growth of GDP per capita following a simultaneous reform rises more for countries with larger than median savings rate.

Advanced, Higher than median and Lower than median. Just like in the previous section this median split is done one period before the reform. I then run the following regression in a panel of countries, controlling for country and year fixed effects:

$$y_{i,t} = \alpha_0 + \alpha'_{it}\text{Reform}_{i,t} \times \text{SavDum}_{i,t} + \varepsilon_{it} \tag{2.17}$$

where $\text{Reform}_{i,t} \times \text{SavDum}_{i,t}$ captures whether a particular reform should be treated as higher than median or lower than median. Table 2.6 collects the results. These results suggest that the temporary effects are even larger than the permanent effects. A country with lower than median savings rate performing macro reforms grows substantially more than a country with high savings (1.3 percentage points over 5 years). A country with higher than median savings rate performing simultaneous reforms grows more than a country with lower than median savings rate. The temporary effect of simultaneous reforms is so strong that simultaneous reform now always dominates other reforms.

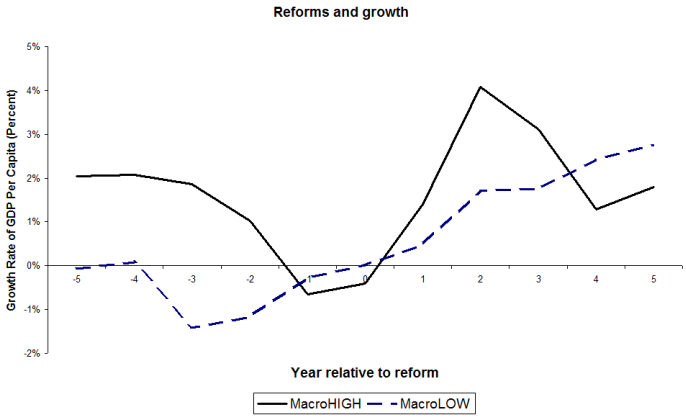

Figure 2.9: The average growth of GDP per capita following a macro reform by savings rate median split.

	(1)	(2)	(3)
Macro Low Sav	0.0134***	0.0134**	0.000274
	(0.00485)	(0.00615)	(0.00299)
Macro High Sav	0.00112	0.00112	-0.001000
	(0.00472)	(0.00558)	(0.00355)
Macro Adv	0.00795**	0.00795	0.00428
	(0.00356)	(0.00615)	(0.00272)
Micro	-0.00301	-0.00301	0.00202
	(0.00528)	(0.00734)	(0.00336)
Simult. Low Sav	0.0236***	0.0236***	0.00689**
	(0.00519)	(0.00757)	(0.00331)
Simult. High Sav	0.0264***	0.0264***	0.0130***
	(0.00581)	(0.00843)	(0.00386)
Simult. Adv	0.00606**	0.00606*	0.00279
	(0.00269)	(0.00306)	(0.00242)
L.privsav	-0.0645**	-0.0645*	0.0488***
	(0.0311)	(0.0386)	(0.00772)
Observations	2486	2486	2486
Number of cc	89	89	89

Table 2.6: Country and year fixed effects in both regressions. Column (1) shows Huber robust standard errors. Column (2) clusters standard errors at the year and country level. Column (3) reports the coefficients from a cross-sectional time-series FGLS regression. (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$)

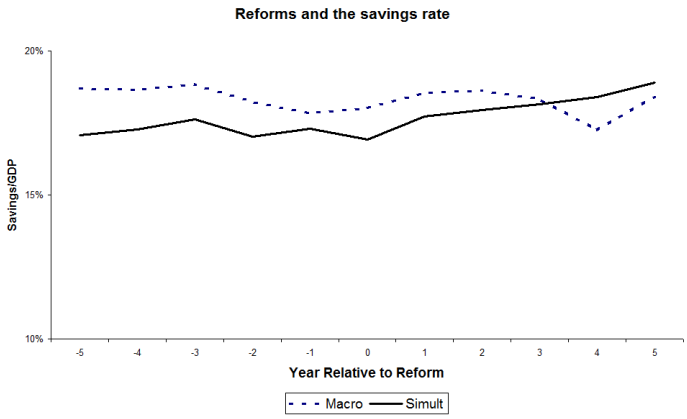

Figure 2.10: The average savings rate is constant following a simultaneous reform and a macro reform.

2.3.5 The savings rate and the implementation of reforms

In the previous sections I have identified a positive growth effect of implementing simultaneous reforms relative to macro reforms. I have also argued that the savings rate is important to understand these growth differentials. For the interpretation of this analysis to be casual, it would be necessary that both the timing of reforms and the choice of reform to be exogenous relative to the savings rate. If this decision is not exogenous, countries would self select into types of reform according to their savings rate. This would bias the analysis, but importantly, it would bias the coefficients against finding growth differentials between reforms. Controlling for the savings rate would be sufficient to account for both the choice of reform and the growth effects that followed.

Unfortunately, it is not possible to test whether the choice of the timing or the choice of financial reform is exogenous. We can still check what were the savings rates before reform and whether there were substantial differences between the two types of reform. If all countries selected reforms according to the optimal plan prescribed by the model, the distributions of savings rates should look very dissimilar. They should have different means and substantial differences in mass, where most countries with large savings rates opt to perform simultaneous reform, and the opposite is true for macro

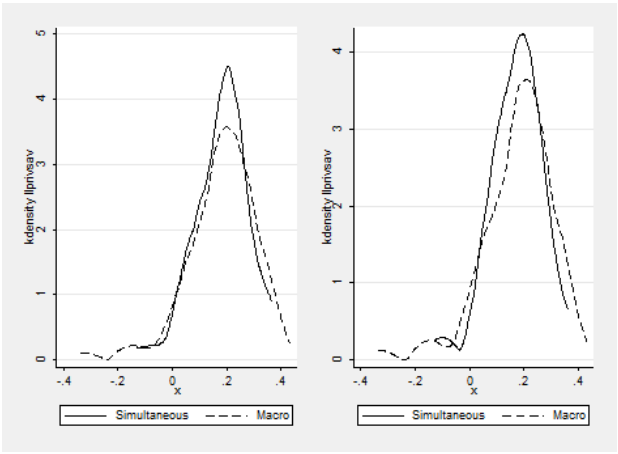

Figure 2.11: The distribution of savings rates used in the median split in the permanent (left panel) and temporary (right panel) approaches.

reforms.

Figure 2.11 plots the one period lagged distribution of savings rates conditional on different types of reform. In the left panel I plot the relevant distribution for the Permanent effect median split. In the right panel I do the same for the Temporary effect median plot. It is possible to see that the distribution of lagged savings rate is not substantially different across reforms.

Another important issue is whether savings rates are themselves affected by financial reform. Previous research has argued that there are no important effects of reforms on savings rates (Bandiera et al, 2000). To address these two issues, first look at Figure 2.10. This figure plots the average saving rate the two different types of liberalization episodes considered in this paper. It is possible to see that this rate is essentially constant for both simultaneous reforms and macro reforms.[29] More importantly, average savings rates are somewhat larger for countries performing simultaneous reform.

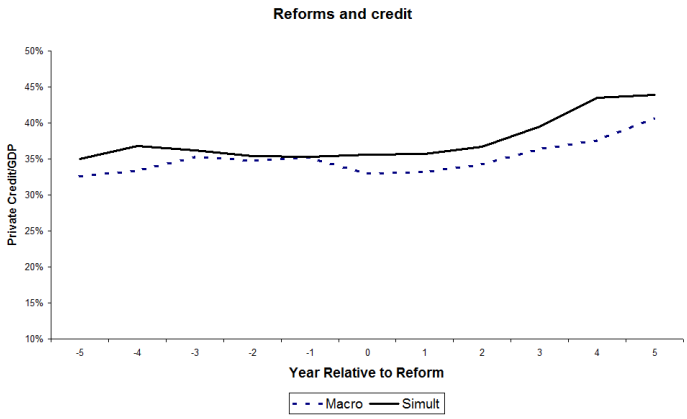

Figure 2.12: Credit as percentage of GDP increases more following a simultaneous reform.

2.3.6 Other predictions of the model

The model predicts that credit should increase more in countries performing both types of reform simultaneously, while savings should not be affected. Figures 2.10 and 2.12 confirm this for the average economy doing a specific reform strategy. Savings are essentially constant for both types of financial reforms. On the other hand, credit increases more for the countries simultaneously reforming macro and micro dimensions.

2.3.7 Robustness

In this subsection I check the robustness of the two most important empirical results in this paper. First, I investigate if the growth differential between macro and simultaneous reform is robust to different definitions of financial reforms and controls. Then, I present evidence that the interaction between reforms and savings is robust. I focus on the permanent effects of growth and investigate two types of robustness checks: on the dummy approach and using alternative specifications. In the dummy approach I control for additional reforms, use an alternative threshold to define reforms and use

[29]This is consistent with the analysis of Bandiera et al (2000) for a smaller sample of countries, and an earlier data sample.

alternative definitions of the macro and micro indices. Regarding alternative specifications, I use the actual value of the indices and also changes in these indices instead of dummies.

Dummy approach

A potential issue with the analysis presented in the previous subsections is that other reforms can take place at the same time as financial reforms. In this subsection I investigate if the growth difference between reforms is still present after controlling for trade and macroeconomic reforms. These policies that could have independent effects on growth. I measure these reforms by including trade as a share of GDP and the inflation rate (both lagged) as additional controls in the regressions described above. The results are presented in column (1) and (4) of Table 2.7. They should be compared with the results in column (7) and (8) of Table 2.4. The first thing to note is that adding additional reforms decreases the magnitude of the reform coefficients. This reflects the interaction between financial reforms and other reforms. The second thing to note is that the difference between macro and simultaneous reforms subsists for column (7), and only simultaneous reforms are more than two standard deviations away from zero. The result that growth is larger for simultaneous reforms with large savings does not seem to be robust to the introduction of these reforms. This could reflect that inflation and trade are more important determinants of growth for countries doing simultaneous reforms with large savings.

In the dummy approach presented in sections 2.3.3 and 2.3.4 I chose a threshold of 0.5 for the subindices. This value is the theoretical mean of the normalized indices. I now investigate if results are robust to using a different threshold definition: the sample mean. For each subindex I compute the sample mean between 1973 and 2005 and use these values as the threshold (see Table 2.2 for the actual values). I present the results in column (2) and (5) of Table 2.8. Comparing them to the results in column (7) and (8) it is possible to see that results are similar or stronger compared to the main specification.

Finally, I define macro and micro reforms using the indices that are closest to the model. In particular, I redefine macro as capital flows reforms, and micro reforms as the average between entry barriers in the banking sector and equity market liberalization:

$$macro_t = \frac{capital\ flows_t}{3} \tag{2.18}$$

$$micro_t = \frac{entry\ barriers_t + equity\ markets_t}{6} \tag{2.19}$$

The results are shown in columns (3) and (6) of Table 2.3.7. It is possible to see that the magnitude of the coefficients is comparable to the previous analysis, but these coefficients are less finely estimated for macro reforms. For simultaneous reforms results go through and are the coefficients are always two standard errors away from zero.

Alternative specifications

In columns (1) and (3) of Table 2.8 I use the information on the actual indices, that now take on values between 0 and 1, which allows me to measure the intensity of reform. The OLS estimates confirm the results of column (1). The coefficient associated with micro dimensions of the financial index is positive (0.022) and larger than the coefficient associated with macro dimensions (0.012). It is also more than two standard deviations away from zero. When I interact these indices with lagged savings, the difference between macro and micro indices is even larger. Looking at column (3) it is possible to see that the coefficient associated with the micro index is now three times larger than the coefficient associated with the macro index. Note that I control independently for the level of lagged savings so this is not the effect of the savings rate on growth.

Columns (2) and (4) perform a similar analysis but defining a reform as a change (over 5 periods) in each index.

	(1)	(2)	(3)		(4)	(5) mean	(6) reduced
Macro	0.008	0.009	-0.003	Mac Low	0.015	0.021	0.013
	(0.005)	(0.005)	(0.009)		(0.006)	(0.006)	(0.011)
Micro	0.006	0.011	0.000	Mac High	0.008	0.008	0.015
	(0.008)	(0.007)	(0.005)		(0.006)	(0.008)	(0.025)
Simult	0.010	0.016	0.011	Micro	0.008	0.013	0.001
	(0.004)	(0.004)	(0.004)		(0.008)	(0.007)	(0.005)
				Sim Low	0.011	0.014	0.011
					(0.005)	(0.005)	(0.005)
				Sim High	0.011	0.020	0.016
					(0.005)	(0.005)	(0.006)
				Sim Full	0.011	0.021	0.011
					(0.006)	(0.006)	(0.006)
				Privsav_{t-1}	0.019	0.017	0.016
					(0.018)	(0.019)	(0.018)
Inflation_{t-1}	0.010			Inflation_{t-1}	-0.015		
	(0.004)				(0.004)		
Trade_{t-1}	0.009			Trade_{t-1}	0.008		
	(0.004)				(0.004)		
Constant	-0.122	-0.238	-0.212	Constant	-0.092	-0.197	-0.166
	(0.080)	(0.083)	(0.084)		(0.081)	(0.084)	(0.087)
Obs	373	377	377	Obs	373	376	376
Adj. R2	0.280	0.210	0.198	Adj. R2	0.288	0.224	0.200

Table 2.7: Average coefficients and standard errors for 3 separate OLS regressions: 81-05, 82-06; 83-07. All regressions control for log(initial GDP per capita), log(life expectancy), government expenditure as a share of GDP, % secondary school enrollment, population growth.

	Indices	Changes		Indices	Changes
Macro	0.012	0.003	Mac×Privsav$_{t-1}$	0.037	-0.007
	0.008	0.07		0.039	0.033
Micro	0.022	0.020	Mic×Privsav$_{t-1}$	0.091	0.107
	0.010	0.010		0.043	0.051
			Privsav$_{t-1}$	-0.042	0.027
				0.022	0.015
Constant	-0.232	-0.09	Constant	-0.240	-0.050
	0.082	0.066		0.084	0.068
Obs	377	358	Obs	376	358
Adj. R2	0.229	0.329	Adj. R2	0.215	0.335

Table 2.8: Average coefficients and standard errors for 3 separate OLS regressions: 81-05, 82-06; 83-07. All regressions control for log(initial GDP per capita), log(life expectancy), government expenditure as a share of GDP, % secondary school enrollment, population growth.

$$y_{i,t+5,t} = \alpha_0 + \beta Q_{i,1980} + \gamma' X_{i,t} + \alpha' \triangle Lib_{i,t,t-5} + \varepsilon_{i,t+5,t} \tag{2.20}$$

The analysis is very similar to the specification with the index values. Note how the difference between macro and micro indices is of one magnitude larger when interacted with savings. Savings interact positively with the micro index, but not with the macro index. Together with the fact that reforms tends to occur more often in macro indices alone, this analysis is consistent with the view that savings and different types of reform interact in non trivial ways.

2.4 Conclusion

This paper presents a simple model that highlights why restricting domestic financial competition when opening up to capital flows might be a desirable policy mix. A first pass at the data suggests that these mechanisms are important empirically, but also unveils a more general view that the different financial reforms matter empirically.

Future research should study the robustness of the mechanism. Theoretically, this simple model can be explored in the context of a dynamic stochastic general equilibrium framework. This would deliver predictions regarding the sequencing of different financial reforms that can be taken to the data. Furthermore, there are other reasons why domestic financial competition might be hurtful when opening up to capital flows. The debate on competition and stability in the banking sector is an alternative explanation (see Beck (2008) for a survey). A general model of competition and capital flow liberalization should add these to the mechanisms considered in this paper, and evaluate the relative contribution of complementary explanations.

The biggest challenge lies with empirical work. This paper has presented some suggestive evidence but if stops short of a full test of the theory. Although the episodes and regressions presented in Section seem to support the view that macro financial liberalization interacts with domestic financial competition in non-trivial ways, the role of competition remains hard to discern empirically. One difficulty with the data is that it is hard to measure competition in the financial sector.

As the world economy exits the most important crisis since the great depression and finds itself struggling with a backlash against market-based financial reforms, the understanding of the optimal policy mix and timing of different reforms is of incalculable value. The last 40 years have been rich in different experiences with reform and reversals which provides economists with a laboratory to study the theory of financial reform. For these reasons, the topics addressed in this paper remain an interesting field for future research.

Appendix A

Appendix to chapter one

A.1 Monetary perspective

A.1.1 Consumer problem

The consumer understands but takes as given the policy of the central bank. In this simple setting, where the only uncertainty is about g_t, this policy is summarized by a pair of interest rates, one for each state $\left\{i_t^L, i_t^H\right\}$. The consumer takes the policy as given by:

$$di_t^j = \mu^j\left(i_t^j\right)dt + \lambda^j\left(i_t^j\right)dq_j$$

Where $\lambda^j\left(i_t^j\right) = i_t^{-j} - i_t^j$. Then, I can write the value function as:

$$\begin{aligned}\beta W^L\left(a_t, i_t^L\right) = \max_{c,k} u\left(c_t^L\right) + W_a^L\left(a_t, i_t^L\right)\cdot\left(\rho a_t + A\cdot\left(k_t^L\right)^\alpha - \left(1+v_c i_t^L\right)c_t^L - \left(\delta+\rho+v_k i_t^L\right)k_t^L\right)\\ + q_L\cdot\left(W^H\left(a_t, i_t^H\right) - W^L\left(a_t, i_t^L\right)\right) + \mu^L\left(i_t^L\right)\cdot W_i^L\left(a_t, i_t^L\right)\end{aligned}$$

Taking first order conditions:

$$u'\left(c_t^L\right) = \left(1 + v_c i_t^L\right) \cdot W_a^L\left(a_t, i_t^L\right) \tag{A.1}$$

$$k_t^L = \left(\frac{\alpha A}{\delta + \rho + v_k i_t^L}\right)^{\frac{1}{1-\alpha}} \tag{A.2}$$

for $j = L, H$, at any t. It is possible to see from equation (A.2) that capital depends on the domestic interest rate through the impact on its marginal cost. These two define the traditional Frisch-type consumption and capital functions. Taking envelope conditions:

$$(\beta - \rho) \cdot W_a^L(a_t, i_t) = W_{aa}^L\left(a_t, i_t^L\right) \cdot \left(\rho a_t + A\left(k_t^L\right)^\alpha - \left(1 + v_c i_t^L\right) c_t^L - \left(\delta + \rho + v_k i_t^L\right) k_t^L\right) + q_L\left(W_a^H\left(a_t, i_t^H\right) - W_a^L\left(a_t, i_t^L\right)\right) + \mu^L\left(i_t^L\right) \cdot W_{ia}\left(a_t, i_t^L\right)$$

Differentiating the first order condition:

$$W_{aa}^L = \frac{\frac{\partial c}{\partial a} u''\left(c_t^j\right)}{\left(1 + v_c i_t^L\right)},$$

where $u'(c) = c^{-\sigma}$, $u''(c) = -\sigma c^{-\sigma-1}$. Replacing in the envelope condition, and omitting the time subscript:

$$(\beta - \rho)\frac{u'\left(c^j\right)}{\left(1 + v_c i^j\right)} = \frac{\frac{\partial c}{\partial a} u''\left(c^j\right)}{\left(1 + v_c i^j\right)} \cdot \left(\rho a + A \cdot \left(k^j\right)^\alpha - \left(1 + v_c i^j\right) c^L - \left(\delta + \rho + v_k i^j\right) k^j\right) + q_j\left(\frac{u'\left(c^{-j}\right)}{\left(1 + v_c i^{-j}\right)} - \frac{u'\left(c^j\right)}{\left(1 + v_c i^j\right)}\right) + \mu^j\left(i^j\right) W_{ia}\left(a, i^j\right)$$

Note that $W_{ia} = W_{ai}$. Then:

$$W_a^j = \frac{u'\left(c^j\right)}{\left(1+v_c i_t^j\right)}$$
$$W_{ai}^j = \frac{\left(1+v_c i_t^j\right) u''\left(c_t^j\right) \frac{\partial c}{\partial i} - v_c u'\left(c_t^j\right)}{\left(1+v_c i_t^j\right)^2}$$

And:

$$(\beta-\rho)\frac{u'\left(c^j\right)}{(1+v_c i^j)} = \frac{\frac{\partial c}{\partial a}u''\left(c^j\right)}{(1+v_c i^j)} \times \left(\rho a + A\cdot\left(k^j\right)^\alpha - \left(1+v_c i^L\right)c^L - \left(\delta+\rho+v_k i^L\right)k^L\right) + q_L\left(\frac{u'\left(c^{-j}\right)}{(1+v_c i^{-j})} - \frac{u'\left(c^j\right)}{(1+v_c i^j)}\right) + \mu^j\left(i^j\right)\frac{\left(1+v_c i^j\right)u''\left(c^j\right)\frac{\partial c}{\partial i} - v_c u'\left(c^j\right)}{(1+v_c i^j)^2}$$

Replacing:

$$(\beta-\rho)\frac{\left(c^j\right)^{-\sigma}}{(1+v_c i^j)} = \frac{-\sigma\left(c^j\right)^{-\sigma-1}\frac{\partial c}{\partial a}}{(1+v_c i^j)} \times \left(\rho a + A\cdot\left(k^j\right)^\alpha - \left(1+v_c i^j\right)c^j - \left(\delta+\rho+v_k i^j\right)k^j\right) + q_L\left(\frac{\left(c^{-j}\right)^{-\sigma}}{(1+v_c i^{-j})} - \frac{\left(c^j\right)^{-\sigma}}{(1+v_c i^j)}\right) + \mu^j\left(i^j\right)\frac{-\sigma\left(c^j\right)^{-\sigma-1}\cdot\left(1+v_c i^j\right)\frac{\partial c}{\partial i} - v_c\left(c^{-j}\right)^{-\sigma}}{(1+v_c i^j)^2}$$

My solution assumes that

$$\mu^j\left(i^j\right)\left(-\sigma\left(c^j\right)^{-\sigma-1}\left(1+v_c i^j\right)\frac{\partial c}{\partial i} - v_c\left(c^{-j}\right)^{-\sigma}\right) \approx 0$$

which obtains:

$$\frac{\partial c^j}{\partial a} \approx \frac{\frac{c^j}{\sigma}\left(\rho-\beta-q_j\left(1-\frac{\left(1+v_c i^j\right)}{\left(1+v_c i^{-j}\right)}\frac{\left(c^{-j}\right)^{-\sigma}}{\left(c^j\right)^{-\sigma}}\right)\right)}{\left(\rho a+A\left(k^j\right)^{\alpha}-c^j\left(1+v_c i^j\right)-\left(\delta+\rho+v_k i^j\right)k^j\right)},\ j=L,H \quad \text{(A.3)}$$

Equation (A.3) is the representative consumer consumption plan. Finally, the budget constraint (1.4), together with the capital demand equation (A.2) and the following boundary condition, concludes the characterization of the consumer problem:

$$\lim_{a\to\infty} c^j = \infty \quad \text{(A.4)}$$

Following Sattinger (2011), it is possible to show that if $\beta \neq \rho$, that is, if the consumer is impatient or patient relative to the international market, the consumer problem has a well defined buffer stock of savings, given the policy from the central bank. It follows that for a given $\left(i^L, i^H\right)$ one single number, the buffer stock of savings, completely summarizes the problem of the consumer. This allows for a numeric, but almost exact solution of the consumer problem.

A.1.2 The consolidated budget constraint

The fiscal authority budget constraint in nominal terms is given by

$$\dot{B}_t = e_t g_t - \Omega_t + i_t B_t \quad \text{(A.5)}$$

where B_t is the government debt with the central bank and Ω_t are profits from the central bank's activities. The balance sheet of the central bank is written as: $M_t = e_t r_t + B_t$, where r_t are reserves in foreign currency, and e_t is the exchange rate. It's profits are written as $\Omega_t = i_t B_t + \rho e_t r_t + \dot{e}_t r_t$. Differentiate the balance sheet of the central bank to obtain:

$$\dot{B}_t = \dot{M}_t - \dot{e}_t r_t - \dot{r}_t e_t \tag{A.6}$$

Solving for Ω_t in $(A.5)$, $\dot{B}_t = e_t g_t - \left(\rho e_t + \dot{e}_t\right) r_t$. Substituting $\dot{B}_t$ out, dividing by e_t and rearranging:

$$\dot{r}_t = \frac{\dot{M}_t}{e_t} - \frac{\dot{e}_t}{e_t} r_t - g_t + \left(\rho + \frac{\dot{e}_t}{e_t}\right) r_t$$

Note that $\frac{\dot{M}_t}{e_t} = \dot{m}_t + \frac{\dot{e}}{e_t} m_t$. This is easy to see from $\dot{m}_t = \left(\frac{\dot{M}}{e}\right) = \frac{\dot{M}e - \dot{e}M}{e^2} = \frac{\dot{M}}{e} - \frac{\dot{e}}{e} m$. Replacing $\frac{\dot{e}}{e_t} = \pi_t$:

$$\dot{r}_t = \rho r_t + \dot{m}_t + \pi_t m_t - g_t \tag{A.7}$$

Alternatively, this can be written as:

$$\dot{r}_t = \rho r_t + \frac{\dot{M}}{P_t} - g_t$$

This is the formulation of the budget constraint of the central bank in Calvo (1987). Note that r_t are net reserves. Net reserves increase with the interest they gain, through changes in the money holdings by domestic agents (who give goods in exchange for money) and with taxes on the money stock (the tax base) from a depreciation in the currency; all this minus the amount spent with the government that period. Finally, it is possible to write this constrain in terms of b_t. By replacing $r_t = m_t - b_t$ into $(A.7)$ and $i_t = (\rho + \pi_t)$:

$$\dot{b}_t = \rho b_t - i_t m_t + g_t \tag{A.8}$$

One way to interpret b_t and g_t is that the government is the first agent that is liable for performing financial sector support, and the amount g_t is how much the central bank is required to hand the government. In exchange, the central bank receives public debt b_t.

A.1.3 Computational appendix

Remember the value function for the low state.

$$\begin{aligned}\beta V^L(a,b) = \max_{i^L} u\left(\psi\left(a,b,i^L\right)\right) + V_b^L \cdot \left(\rho b + g^L - i^L \cdot \left(v_c \psi\left(a,b,i^L\right) + v_k k^L\right)\right) \\ + V_a^L \cdot \left(\rho a + (1-\alpha)\cdot A \cdot \left(\frac{\alpha A}{\delta + \rho + v_k i_t}\right)^{\frac{\alpha}{1-\alpha}} - \psi\left(a,b,i^L\right)\cdot\left(1 + v_c i^L\right)\right) \\ + q_1\left(V^H(b,a) - V^L(b,a)\right) \qquad \text{(A.9)}\end{aligned}$$

Where $\psi\left(a,b,i^L,i^H\right)$ is the consumption function. To get a good guess of the value functions I employ the following method. First, I solve for the case where $V_a^L \dot{a} \approx 0$. I then verify that this approximation does fairly well using finite-difference methods for value function iteration. The reason why this is a good approximation is that the consumer problem quickly approximates a situation in which $\dot{a} \approx 0$.

Then, the first order condition is given by:

$$u'(\psi)\,\psi' = V_b^L \cdot \left(\left(v_c \psi + v_k k^L\right) + i^L \cdot \left(v_c' \psi' + v_k k'\right)\right)$$

Rewriting:

$$V_b^L = \frac{u'(\psi)\,\psi'}{\left(v_c \psi + v_k k^L\right) + i^L \cdot \left(v_c \psi' + v_k k'\right)}$$

Take the envelope condition:

$$\beta V_b^L = V_{bb}^L \cdot \left(\rho b + g^L - i^L \cdot \left(v_c \psi\left(a,b,i^L\right) + v_k k^L\right)\right) + \rho V_b^L + q_1\left(V_b^H(b) - V_b^L(b)\right) \qquad \text{(A.10)}$$

Rewrite:

$$V_{bb}^{L} = \frac{(\beta-\rho)V_b^L - q_1 \cdot \left(V_b^L(b) - V_b^H(b)\right)}{(\rho b + g^L - i^L \cdot (v_c \psi(a,b,i^L) + v_k k^L))}$$

Then, compute $V_{bb}^{L} = \frac{\partial V_b^L}{\partial b}$, and replace in the differential equation to be solved:

$$V_{bb}^{L} = \frac{\partial V_b^L}{\partial b} = \frac{\partial i}{\partial b}\Gamma$$

Where

$$\Gamma^L = \frac{\left(\left(v_c\psi + v_k k^L\right) + i^L \cdot \left(v_c\psi' + v_k k'\right)\right) \cdot \left(u''(\psi)\psi' + \psi'' u'(\psi)\right) - u'(\psi)\cdot\psi' \cdot \left(\left(\left(v_c\psi' + v_k k'\right) + \left(v_c\psi' + v_k k'\right) + i^L \cdot \left(v_c\psi'' + v_k k''\right)\right)\right)}{\left(\left(v_c\psi + v_k k^L\right) + i^L \cdot \left(v_c\psi' + v_k k'\right)\right)^2}$$

Replacing:

$$\frac{\partial i^L}{\partial b} = \frac{\frac{(\beta-\rho)V_b^L - q_1\left(V_b^L(b) - V_b^H(b)\right)}{(\rho b + g^L - i^L(v_c\psi(a,b,i^L) + v_k k^L))}}{\Gamma^L} \tag{A.11}$$

$$\frac{\partial i^H}{\partial b} = \frac{\frac{(\beta-\rho)V_b^H - q_2\left(V_b^H(b) - V_b^L(b)\right)}{(\rho b + g^H - i^H(v_c\psi(a,b,i^H) + v_k k^H))}}{\Gamma^H} \tag{A.12}$$

Finally, the full characterization of the problem requires boundary conditions. To obtain these I iterate on $\overline{b}$, such that the following conditions are satisfied:

$$\left(v_c\psi^H\left(\cdot, \overline{i^H}\right) + v_k k_t\left(\overline{i^H}\right)\right) \cdot \overline{i^H} = g^H + \rho\overline{b}$$
$$v_c\psi^H\left(\cdot, \overline{i^H}\right) + v_k k_t\left(\overline{i^H}\right) = \overline{b} + \underline{r}$$
$$\text{and equations } (1.6) - (1.9)$$

To check that the solution is close to the true solution, note that the state vari-

ables are given by (g,a,b). I use a finite-difference method for continuous-time dynamic programming, as presented in Candler (1998) to discretize the value functions. Remember the value functions of the central bank:

$$\begin{aligned}\beta V^L(a,b) = &\max_{c^L,i^L} u\left(c_t^L\right) + V_b^L \cdot \left(\rho b + g^L - i^L \cdot \left(v_c c^L + v_k k^L\right)\right) \\ &+ V_a^L \cdot \left(\rho a + A\left(k^L\right)^{\alpha} - \left(1 + v_c i^L\right) c^L - \left(\delta + \rho + v_k i^L\right) k^L\right) \\ &+ q_1 \cdot \left(V^H(a,b) - V^L(a,b)\right) \end{aligned} \tag{A.13}$$

for the low expenditure state, and for the high expenditure state:

$$\begin{aligned}\beta V^H(a,b) = &\max_{c^H,i^H} u\left(c_t^H\right) + V_b^H \cdot \left(\rho b + g^H - i^H \cdot \left(v_c c^H + v_k k^H\right)\right) \\ &+ V_a^H \cdot \left(\rho a_t + A \cdot \left(k^H\right)^{\alpha} - \left(1 + v_c i^H\right) c^H - \left(\delta + \rho + v_k i^H\right) k^H\right) \\ &+ q_2 \cdot \left(V^L(a,b) - V^H(a,b)\right) \end{aligned} \tag{A.14}$$

Subject to the consumer solution given by equations (1.6)-(1.9) and the constraint on reserves $r \geq 0$. The solution algorithm is given by:

1. Initialize a grid for (a,b).

2. Initial guess for value functions $V^L(a,b), V^H(a,b)$ given by the procedure described above.

3. Compute implied $k^L, k^H, c^L, c^H, i^L, i^L$: $k^j = \left(\frac{\alpha A}{\rho + \delta + v_k i}\right)^{\frac{1}{1-\alpha}}, c^j$ as the solution to(1.6)-(1.9), i^L : arg max(A.13), i^H : arg max(A.14),

4. Update value functions with the procedure described above, using $V_a^j a$.

5. Verify that solutions satisfy convergence criteria.

A.2 Deterministic example

A.2.1 Deterministic crisis: no reserves constraint

To simplify the analysis, define $\gamma_t = \frac{1}{1+i_t}$:

$$\begin{aligned} \max_{\{\gamma_t\}} E \int_0^\infty \ln(\gamma_t) e^{-\rho t} dt \\ \text{s.t. } \dot{b}_t = g_t - (y+\rho a_0)(1-\gamma_t) + \rho b_t, \\ \lim_{t\to\infty} b_t e^{-\rho t} = 0, r_t \geq -\infty, \gamma_t \leq 1, b_0, a_0 \text{ given} \\ g_{t+dt} = \begin{cases} 0 & \text{if} \quad t < t_1 \\ g & \text{if} \quad t_1 \leq t \leq t_2 \\ 0 & \text{if} \quad t > t_2 \end{cases} \end{aligned} \tag{A.15}$$

I first assume that $\underline{r} = -\infty$. To solve this problem, write the current value Hamiltonian:

$$H = \ln(\gamma_t) + \lambda \left(g_t - (y+\rho a_0)(1-\gamma_t) + \rho b_t\right)$$

First order conditions:

$$\begin{aligned} \frac{\partial H}{\partial \gamma} = 0 \qquad &\Leftrightarrow \frac{1}{\gamma_t} = -\lambda (y+\rho a_0) \\ \frac{\partial H}{\partial \lambda} = \dot{b}_t \qquad &\Leftrightarrow \dot{b}_t = g_t - (y+\rho a_0)(1-\gamma_t) + \rho b_t \\ \frac{\partial H}{\partial b} = \rho\lambda - \dot{\lambda} \;&\Leftrightarrow \rho\lambda = \rho\lambda - \dot{\lambda} \end{aligned}$$

We can see that $\dot{\lambda} = 0$. Then $\gamma_t = -\frac{1}{\lambda(y+\rho a_0)}$, and constant. To find a solution, plug these back in the present value budget constraint $-b_0 = -(y+\rho a_0)(1-\gamma)\frac{1}{\rho} + \frac{1}{\rho}(e^{-\rho t_1} - e^{-\rho t_2})g$ and find

$$\gamma^* = 1 - \frac{\rho b_0 + (e^{-\rho t_1} - e^{-\rho t_2})g}{y+\rho a_0} \tag{A.16}$$

this implies that i is constant: $i = \left(\frac{1}{\gamma} - 1\right) => \pi = \left(\frac{1}{\gamma} - 1\right) - \rho$. Because there is no constraint on how much future revenues can be transferred to the present, the inflation tax is smoothed completely. To solve for b_t at any t, I can use γ^* and initial debt in the budget constraint.

A.2.2 Deterministic crisis: reserves constraint

For simplicity consider that the constraint on reserves is such that $r_t \geq 0$. In the deterministic case, we know that the constraint never hits after t_2. There is no value for reserves after t_2 as the central bank will be floating anyway with low expenditure. Because the crisis is expected, we can write the problem as:

$$\max_{\{\gamma_t\}} \int_0^\infty \ln(\gamma_t) e^{-\rho t} dt$$
$$\text{s.t. } \dot{b}_t = g_t - (y + \rho a_0)(1 - \gamma_t) + \rho b_t,$$
$$\lim_{t\to\infty} b_t e^{-\rho t} = 0, r_t \geq 0, \gamma_t \leq 1$$
$$g_t \text{ given by } (A.15)$$

The solution is by backward induction. We know from the central bank balance sheet that at any point τ when the constraint on r_t is binding, $r_\tau = 0$ and $b_\tau = m_\tau$: $b_\tau = \frac{y+\rho a_0}{1+i^c}$. From this moment onwards $\dot{b}_t = 0$ for $t > \tau$, and $i_t = \rho$. Reserves have no value after t_2, thus $\tau = t_2$. Then the central bank budget constraint implies that

$$\overline{b_g} = \frac{1}{1+\rho}(y + \rho a_0), t > t_2$$

At $t = t_2$:

$$-(y + \rho a_0)(1 - \gamma_2^c) + \rho b_{t_2} = 0$$

which can be solved as:

$$\gamma_2^c = \frac{y + \rho a_0 - \rho b_{t_2}}{y + \rho a_0} \tag{A.17}$$

At any $t \leq t_2$, we can solve for the maximum value γ^c such that at $t = t_2$, debt equals $b_{t_2} = \overline{b_g}$:

$$\int_0^{t_2} \left(\dot{b}_t - \rho b_t \right) e^{-\rho t} dt = \int_0^{t_2} \left(g_t - (y + \rho a_0)(1 - \gamma^c) \right) e^{-\rho t} dt$$

The maximum γ is then given by:

$$\gamma^c = 1 - \frac{\rho (b_0 + G) - \frac{\rho}{1+\rho} (y + \rho a_0) e^{-\rho t_2}}{(1 - e^{-\rho t_2})(y + \rho a_0)} \tag{A.18}$$

And the problem is just the same as before except we add a constraint on $\gamma_t \leq \gamma^c$. Then:

$$\begin{gathered} \max_{\{\gamma_t\}} \int_0^{\infty} \ln(\gamma_t) e^{-\rho t} dt \\ \text{s.t. } \dot{b}_t = g_t - (y + \rho a_0)(1 - \gamma_t) + \rho b_t \\ \lim_{t \to \infty} b_t e^{-\rho t} = 0, \gamma_t \leq 1 \\ \gamma_t \leq \gamma^c \text{ if } t \leq t_2 \\ g_t \text{ given by } (1.15) \end{gathered}$$

We can separate the problem before and after the crisis is over, and replace $(A.17)$ for $t > t_2$. The problem is now:

$$\max_{\{\gamma_t\}} \int_0^{t_2} \ln(\gamma_t)\, e^{-\rho t} dt + e^{-\rho t_2} \int_{t_2}^{\infty} \ln\left(\frac{y+\rho a_0 - \rho b_{t_2}}{y+\rho a_0}\right) e^{-\rho t} dt$$

$$\text{s.t. } \dot{b}_t = g_t - (y+\rho a_0)(1-\gamma_t) + \rho b_t$$

$$\lim_{t\to\infty} b_t e^{-\rho t} = 0, \gamma_t \leq 1, \gamma_t \leq \gamma^c$$

$$b_{t_2} = \frac{1}{1+\rho}(y+\rho a_0)$$

$$g_t \text{ given by } (1.15)$$

Writing the Hamiltonian with the Kuhn Tucker conditions:

$$H = \ln(\gamma_t) + \lambda_t (g_t - (y+\rho a_0)(1-\gamma_t) + \rho b_t) + \mu_t (\gamma_t - \gamma^c)$$

The necessary conditions are then:

$$\begin{aligned}
\tfrac{\partial H}{\partial \gamma} = 0 \qquad &\Leftrightarrow \tfrac{1}{\gamma_t} + \lambda_t (y+\rho a_0) + \mu_t = 0 \\
&\quad \mu_t \geq 0,\ \mu_t (\gamma_t - \gamma^c) = 0 \\
\tfrac{\partial H}{\partial \lambda} = \dot{b}_t \qquad &\Leftrightarrow \dot{b}_t = g_t - (y+\rho a_0)(1-\gamma_t) + \rho b_t \\
\tfrac{\partial H}{\partial b} = \rho\lambda - \dot{\lambda} \ &\Leftrightarrow \dot{\lambda}_t - \rho\lambda_t = -\rho\lambda_t
\end{aligned}$$

Suppose $\gamma_t \leq \gamma^c$ does not bind. Then $\mu_t = 0$ and: $H_\gamma = \frac{1}{\gamma_t} + \lambda_t (y+\rho a_0) = 0$. From here, $\dot{\lambda}_t - \rho\lambda_t = -\rho\lambda_t \Rightarrow \dot{\lambda}_t = 0$, and we get a constant γ_{nc}. This is defined by: $\gamma_{nc} = -\frac{1}{\lambda(y+\rho a_0)}$.[1]. If we hit the constraint, then $\frac{1}{\gamma_t} + \lambda_t (y+\rho a_0) + \mu_t = 0$ and $\gamma = \gamma^c$. The solution is given by:

$$\gamma = \gamma^c \text{ if } t \leq t_2,\ \gamma = 1 - \frac{\frac{\rho}{1+\rho}(y+\rho a_0)}{y+\rho a_0} \text{ if } t > t_2$$

A.2.3 Capital

Remember the budget constraint:

[1] Note I wrote the Hamiltonian with a negative λ.

$$\dot{b}_t = \rho b_t + g_t - m_t i_t$$

Integrating this constraint

$$\int_0^{\infty} \left(\dot{b}_t - \rho b_t \right) e^{-\rho t} dt = \int_0^{\infty} \left(g_t - i_t \left(\underline{c} + v_k \left(\frac{\alpha A}{\delta + \rho + v_k i_t} \right)^{\frac{1}{1-\alpha}} \right) \right) e^{-\rho t} dt$$

Solving for the constant i_t :

$$-b_0 = \rho^{-1} \left(e^{-\rho t_1} - e^{-\rho t_2} \right) g. - \left(i \left(\underline{c} + v_k \left(\frac{\alpha A}{\delta + \rho + i v_k} \right)^{\frac{1}{1-\alpha}} \right) \right) \frac{1}{\rho}$$

The solution can be represented by the following implicit function.

$$i \left(\underline{c} + v_k \left(\frac{\alpha A}{\delta + \rho + i v_k} \right)^{\frac{1}{1-\alpha}} \right) = G + \rho b_0$$

A.3 Consumption smoothing perspective

A.3.1 Equivalence with inflation smoothing

Under these assumptions,

$$y_t = y = A k^{\alpha} - (\delta + \rho) k, \text{ where } k = \left(\frac{\alpha A}{\delta + \rho} \right)^{\frac{1}{1-\alpha}}$$

Furthermore, under log-utility with constant income the consumption function takes the simple form:

$$c_t = \frac{\rho a_0 + y^k}{1 + i_t} \tag{A.19}$$

To see that in this setting inflation smoothing amounts to consumption smoothing note that seigniorage revenues can be written as:

$$S_t = i_t m_t = \left(y^k + \rho a_0\right) \frac{i_t}{1+i_t} = y^k + \rho a_0 - c_t \tag{A.20}$$

Now define lump-sum taxation as $\tau_t = \rho a_0 + y^k - c_t$, and it is possible to see that for any level of revenue $S_t = \tau_t$ it is possible to find an i_t that yields this level of revenue τ_t with the same level of consumption c_t. This happens because in this setting inflation is non-distortionary. Under log-utility, the elasticity of substitution is one and the consumer spends the same share of his income in consumption services, independently of the interest rate.

A.3.2 Solution

Approximate the value functions as:

$$\beta V^L(r_t) = \max_{c_t^L} \left[\ln\left(c_t^L\right) + \left(\rho r_t + A k_t^\alpha - c_t^L - g_L - \delta k_t\right) V_r^L + q_1\left(V^H - V^L\right)\right]$$

for the low deficit state, and:

$$\beta V^H(r_t) = \max_{c_t^H} \left[\ln\left(c_t^H\right) + \left(\rho r_t + A k_t^\alpha - c_t^H - g_H - \delta k_t\right) V_r^H + q_2\left(V^L - V^H\right)\right]$$

for the high deficit state. Taking first order conditions:

$$V_r^L = \frac{1}{c_t^L}, V_r^H = \frac{1}{c_t^H} \tag{A.21}$$

$$k_t = \left(\frac{\alpha A}{\delta + \rho} \right)^{\frac{1}{1-\alpha}} \tag{A.22}$$

By the envelope condition:

$$\rho V_r^L + \left(\rho r_t + A k_t^\alpha - c_t^L - g_L - \delta k_t \right) V_{rr}^L + q_1 \left(V_r^H - V_r^L \right) = \beta V_r^L \tag{A.23}$$

$$\rho V_r^H + \left(\rho r_t + A k_t^\alpha - c_t^H - g_H - \delta k_t \right) V_{rr}^H + q_2 \left(V_r^L - V_r^H \right) = \beta V_r^H \tag{A.24}$$

Differentiating $(A.21)$, obtain:

$$V_{rr}^L = -\frac{1}{\left(c_t^L\right)^2} \frac{\partial c_t^L}{\partial r_t}, V_{rr}^H = -\frac{1}{\left(c_t^H\right)^2} \frac{\partial c_t^H}{\partial r_t}$$

Replacing and rearranging:

$$\frac{\partial c_t^L}{\partial r_t} = c_t^L \left(q_1 \frac{c_t^L}{c_t^H} - (q_1 - \beta + \rho) \right) \left(\rho r_t + A k^\alpha - c_t^L - g_L - \delta k_t \right)^{-1}$$
$$\frac{\partial c_t^H}{\partial r_t} = c_t^H \left(\frac{c_t^H}{c_t^L} - (q_2 - \beta + \rho) \right) \left(\rho r_t + A k^\alpha - c_t^H - g_H - \delta k_t \right)^{-1}$$
$$k = \left(\frac{\alpha A}{\delta + \rho} \right)^{\frac{1}{1-\alpha}}, \lim_{r_t = \infty} c_t^H, c_t^L = \infty$$

When there is a borrowing constraint, there is another boundary condition: $c_t^H(\underline{r}) = A k^\alpha - \delta k - g_H + \rho \underline{r}$. To solve the system, I proceed as in Appendix A.1.1.

A.4 Data appendix

A.4.1 Sample values for reserves

Country Group	1987 (Mean/Median)		2007 (Mean/Median)		Growth (Mean)
Developing	10.7%	5.6%	25.8%	18.1%	142%
Developed	9.7%	6.5%	6.6%	2.3%	-31%
World	10.4%	5.9%	23.2%	16.8%	122%

Table 1.1: Sample (non-weighted) international reserves as a share of *GDP*

A.4.2 Country sample

Developing economies: Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Aruba, Azerbaijan, Bahrain, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Rep., Chad, Chile, China P.R.: Mainland, China P.R.:Macao, Colombia, Comoros, Congo, Dem. Rep. of, Congo, Republic of, Costa Rica, Côte d'Ivoire, Croatia, Cyprus, Czech Republic, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Honduras, Hong Kong, Hungary, India, Indonesia, Iran, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, Korea, Kuwait, Kyrgyz Republic, Lao People's Dem.Rep, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Oman, Pakistan, Panama, Papua New Guinea, , Paraguay, Peru, Philippines, Poland, Qatar, Romania, Russia, Rwanda, Samoa, São Tomé & Príncipe, Saudi Arabia, Senegal, ,Serbia, Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, Solomon Islands, South Africa, Sri Lanka, St. Kitts, St. Lucia, St. Vincent & Grens., Sudan, Swaziland, Syrian Arab Republic, Taiwan, Tajik-

istan, Tanzania, Thailand, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, Uruguay, Uzbekistan, Vanuatu, Venezuela, Rep. Bol., Vietnam, Yemen, Republic of, Zambia, Zimbabwe.

Developed economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

A.4.3 Data used in the paper

- Crisis dummy (Crisis): Laeven and Valencia (2010). A crisis is classified as a systemic banking crisis if there are "1) Significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and bank liquidations); and 2) Significant banking policy intervention measures in response to significant losses in the banking system."

- Exchange rate regime (ExRate): According to Ilzetzki et al (2011), for each country-year observation this variable takes larger values the more flexible is the exchange rate. That is, it takes a value of 1 if there exists a peg, 2 if a crawling peg, 3 if there is managed floating, and 4 if the currency is freely floating.

- Financial market development index (fin_dev1): External portfolio equity liabilities + total debt liabilities over GDP from Lane and Milesi-Ferretti (2007).

- Trade: Share of imports + exports in GDP, World Development Indicators; WDI.

- M2/GDP: Ratio of M2 money supply to GDP; WDI.

- Reserves: Total foreign reserves (including gold) from Lane and Milesi-Ferretti (2007).

- Short Term Debt: Short term debt as a share of GDP; WDI.

- Inflation: consumer prices (annual %); WDI.

A.4.4 Regression tables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year	0.0497***	0.0486***	0.0485***	0.0516***	0.0501***	0.0491***	0.0511***
GDPpc	-0.244	-0.239	-0.258	-0.377	-0.253	-0.264	-0.419
M2/GDP (Size)	0.353**	0.305**	0.329**	0.416***	0.338**	0.362**	0.355**
Trade/GDP	0.655***	0.659***	0.664***	0.702***	0.648***	0.647***	0.685***
Inflation		-0.0016**					-0.0008
Exchange Rate			-0.0629**				-0.0233
FinDev/GDP				-0.284**			-0.301**
STD/GDP					0.0267		0.0668*
dCC						-0.190***	-0.0913
dSBC						-0.190**	-0.178**
Observations	2158	2158	2158	2158	2158	2158	2158
R-squared	0.337	0.340	0.341	0.356	0.337	0.341	0.365
Countries	108	108	108	108	108	108	108
Adj R2	0.335	0.338	0.340	0.354	0.336	0.339	0.362

Robust standard errors in parentheses,*** p<0.01, ** p<0.05, * p<0.1

Table 1.10: Dependent variable: log of Reserves as a share of GDP.

All variables in logs of shares of GDP (except year, inflation, exchange rate and dummies)

Country fixed effects regressions between 1980-2007; clustered standard errors (country level).

	R	GDP	M2	Trade	Inf	Exch	FD	STD	CC	SBC
Reserves	1									
GDP	0.141	1								
M2	0.275	0.313	1							
Trade	0.338	0.249	0.405	1						
Inflation	-0.158	0.013	-0.211	-0.130	1					
Exchange Rate	-0.182	0.036	-0.229	-0.216	0.450	1				
Fin. Dev.	-0.089	-0.266	-0.103	0.064	0.084	0.043	1			
Short T Debt	-0.079	0.077	-0.002	0.148	0.070	-0.003	0.597	1		
Currency Dummy	-0.082	-0.031	-0.063	-0.049	0.195	0.225	0.094	0.037	1	
Banking Dummy	-0.077	-0.006	-0.019	-0.057	0.061	0.061	0.020	0.009	0.078	1

Table 1.11: Correlations

Appendix B

Appendix to chapter two

B.1 Reform dates

To obtain these dates I define a reform event as a change in policy where at least one of the subindices moves above or below the 0.5 threshold. A *Macro* (*Micro*) reform is such that following the policy change, only *Macro* (*Micro*) dimensions are reformed (where the corresponding subindex is larger than 0.5). A *Simultaneous* reform is such that both dimensions are reformed. To isolate events, I employ 3 year bands around the date of the event ($T = 0$).

Country	Macro Reform	Country	Macro Reform	Country	Macro Reform	Country	Micro Reform	Country	Simultaneous
Albania	1994	Italy	1982	Turkey	1986	Paraguay	1982	Hungary	1996
Albania	2003	Jamaica	1991	Tanzania	1993	Sweden	1980	Indonesia	1999
Argentina	1977	Japan	1979	Uganda	1994	Uzbekistan	2002	Ireland	1985
Argentina	1990	Kazakhstan	1994	Ukraine	1994	Venezuela	1994	Israel	1994
Australia	1984	Kenya	1991	Uruguay	1979	Zimbabwe	2002	Italy	1992
Austria	1980	Kyrgyz Rep	1993	Venezuela,	1978			Jamaica	2000
Austria	1990	Korea, Rep	1984	Venezuela	1989	Country	Simultaneous	Jordan	1990
Azerbaijan	1995	Korea	1997	Vietnam	2002	Albania	1999	Japan	1991
Burkina Faso	1989	Sri Lanka	1992	South Africa	1982	Australia	1988	Kazakhstan	2000
Bangladesh	1992	Lithuania	1993	Zimbabwe	1991	Azerbaijan	2004	Kenya	1996
Bulgaria	1994	Madagascar	1990			Belgium	1977	Kyrgyz Rep	1996
Bolivia	1985	Mexico	1989	Country	Micro Reform	Burkina Faso	1998	Sri Lanka	2000
Chile	1977	Mozambique	1994	Argentina	1982	Bangladesh	2005	Lithuania	1997
China	2004	Malaysia	1978	Austria	1985	Bulgaria	2000	Latvia	1994
Costa Rica	1991	Nicaragua	1993	Bulgaria	1997	Belarus	2004	Malaysia	1989
Czech Rep	1992	Norway	1983	Belarus	1993	Bolivia	1992	Nigeria	1996
Denmark	1982	Nepal	2001	Brazil	1996	Chile	1986	Nicaragua	1997
Dominican Rep	1991	New Zealand	1976	Chile	1982	Côte d'Ivoire	1992	Pakistan	2004
Algeria	1994	New Zealand	1984	Côte d'Ivoire	1976	Colombia	1991	Peru	1993
Ecuador	1992	Pakistan	1995	Cameroon	1996	Germany	1975	Philippines	1994
Ecuador	1998	Peru	1990	Ecuador	2005	Dominican Rep	1999	Paraguay	1993
Egypt,	1991	Philippines	1984	Spain	1983	Ecuador	2001	Russian Fed	1995
Spain	1977	Portugal	1988	Finland	1982	Egypt	1996	Senegal	1996
Ethiopia	1974	Paraguay	1988	Korea, Rep.	1989	Spain	1987	Sweden	1985
Ghana	1990	Romania	1993	Morocco	1994	Estonia	1994	Thailand	1992
Greece	1990	Senegal	1989	Malaysia	1975	France	1984	Turkey	1995
Guatemala	1990	El Salvador	1992	Nigeria	1988	United Kingdom	1979	Tanzania	1998
Indonesia	1983	Thailand	1989	Nepal	2005	Georgia	1996	Ukraine	1997
India	1998	Thailand	1998	New Zealand	1981	Ghana	2004	Uruguay	1990
Israel	1987	Tunisia	1994	Poland	1992	Greece	1993	South Africa	1986
						Guatemala	2002	Zimbabwe	1997

Table 2.9: Reform Dates

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