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SOVEREIGN DEFAULT, BANKING CRISES, AND FINANCIAL REPRESSION

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KENNETH C. GRIFFIN DEPARTMENT OF ECONOMICS

BY
PIOTR ZOCH

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ABSTRACT

I extend the baseline framework used in quantitative studies of sovereign default by explicitly modeling a domestic financial sector and by allowing the government to force financial intermediaries to hold government debt on their balance sheets. Default is more costly when the government uses financial repression to increase domestic holdings of debt because it inhibits the flow of resources from savers to firms. Financial repression is costly because it reduces the accumulation of net worth of the banking sector. It is an imperfect commitment device as sufficiently bad shocks can lead to a default. A quantitative analysis of the model for Argentina shows that default that happens despite financial repression results in a deep and persistent output loss. Financial repression is usually used when the level of international interest rate is high and its absence results in large welfare losses.

CHAPTER 1

SOVEREIGN DEFAULT, BANKING CRISES, AND FINANCIAL REPRESSION

1.1 Introduction

Governments issue debt not only to international investors but also to domestic residents. Sometimes domestic investors do not lend to governments willingly but only because they are forced to do so, both by regulation and through moral suasion. This usually happens when fiscal needs are exceptionally high or when foreign investors abruptly decide they no longer want to lend. When government uses financial repression by setting high regulatory requirements, domestic financial institutions become exposed to sovereign risk. A sovereign default will harm the country's financial sector by its negative impact on banks' net worth. The flow of resources from savers to firms will be disrupted, which reduces output and ultimately tax revenue the government collects.

The primary question I ask in my paper is: when is financial repression optimal? In this paper I explore how financial repression affects incentives to default and allows the government to raise additional revenue. I use a quantitative sovereign default model enriched with a financial sector. In the model the government can default without any cost unless domestic banks hold at least some debt. Since they do not do it willingly, the government has to use financial repression in order to be able to convince investors that they can expect repayment. However, financial repression has several drawbacks. First, it reduces the amount of loans extended to firms and so leads to a decline in tax revenue. This is especially costly when the return on loans and the leverage ratio of the financial sector are large. If this is the case, financial repression can actually result in a lower revenue for the government. Second, even if financial repression makes a default more costly, it does not make the government immune from it. In times of extreme distress the government might actually be better off by defaulting, regardless of the exposure of banks to debt. If that happens, the harm to the country's financial sector is immense and the ensuing banking crisis results in a sizable decline in output.

I study the optimal policy of the government that maximizes its own objective function instead of being benevolent. The government balances costs and benefits of financial repression, and chooses the overall quantity of debt outstanding. The model is calibrated using macroeconomic and banking data for Argentina for the 1994.Q1-2012.Q4 period. The model is able to reproduce the key business cycle facts. I find that the government decides to use financial repression when the international interest rate is high so that it is costly to borrow from abroad and financial repression can be used as a source of revenue. The simulated output dynamics around episodes of sovereign default align closely with the observed behavior of output in Argentina during the 2001 default, but only under the assumption that in the periods preceding the default the government forced domestic banks to purchase its debt. A large fraction of output losses in these cases can be explained by the adverse shocks to productivity rather than by net worth losses - output would be low even if the government decided to repay. The welfare gains resulting from the ability of use financial repression are sizable. Absent financial repression, the government would suffer a welfare loss of approximately 10.3% permanent government consumption.

In the remainder of this section I review the related literature. In Section 1.2 I describe a quantitative sovereign default model. Section 1.3 explores the effects of financial repression on banks' lending, tax revenue and debt prices. Section 1.4 shows details of the calibration and the main results of my analysis. Section 1.5 concludes.

1.1.1 Related literature

This paper belongs to the quantitative literature on sovereign debt and default started by Eaton and Gersovitz (1981) and Arellano (2008). It is motivated to a large extent by the theoretical contributions of Chari et al. (2020) who study the optimality of financial repression in a closed economy with a financial sector. They find that financial repression can be optimal in an environment in which the government cannot credibly commit yet has to finance large government purchases. I extend their analysis to understand and explain financial repression in open economies. This brings the analysis closer to the quantitative sovereign default literature and introduces additional factors that affect the optimal degree of financial repression. In particular, Neumeyer and Perri (2005) and the recent paper by Khan et al. (2017) show the importance of interest rate shocks. If the price of government debt moves not only because of the changes in the default risk but also due to completely exogenous shifts in the foreign demand for debt, the government might be unable to raise enough revenue in debt auctions to repay its outstanding debt. This forces the government to default, even if the banking sector holds vast quantities of government issued securities.

My work is closely related to the rapidly growing literature that studies the interaction between credit, default and banks. The existing empirical work (Reinhart and Rogoff (2009); Baskaya and Kalemli-Ozcan (2016); Gennaioli et al. (2018)) suggests the importance of these links and documents that sovereign and banking crises tend to happen together. Several papers focus on the effect of sovereign default the balance sheets of banks and various channels through which a default affects the real economy. Balke (2018) explores how sovereign default can generate unemployment while Bocola (2016) shows that even an increase in the probability of a default leads to a fall in credit and capital accumulation. Sosa-Padilla (2018) studies how the negative effect of sovereign default on the net worth affects the incentives to repay and Perez (2015) analyzes the adverse implications of a default for the ability of the government to provide liquidity to banks. I contribute to this literature by exploring how the ability to force banks to hold government debt and thereby increase default costs interacts with the default decisions.

Financial repression is not merely a theoretical possibility nor something that belongs to the distant past - it has been and still is used in practice. Calvo and Mishkin (2003) argue that during the 2001 sovereign default in Argentina "banks were encouraged and coerced into purchasing Argentine government bonds to fund the fiscal debt." Reinhart et al. (2011); Reinhart (2012); Reinhart and Sbrancia (2015) claim that financial repression was used to reduce the massive stocks of debt issued to finance World War II. Becker and Ivashina (2017); Ongena et al. (2016) present evidence that an increase in domestic debt held by banks in the periphery countries of Europe during the Great Recession can be attributed to political pressure by governments.

1.2 A model of sovereign debt and a financial sector

In this section I formulate a dynamic model of a small open economy enriched with a financial sector (along the lines of Gertler and Kiyotaki (2010)) and a sovereign government that lacks commitment and has access to debt markets (as in Eaton and Gersovitz (1981); Arellano (2008)). There are five types of agents in the economy: households, bankers, producers, foreign investors and the government. I describe them below.

1.2.1 Households

There is a continuum of identical households of measure unity. Each household consumes, saves and supplies labor. Households can save by lending funds to financial intermediaries.

Within each household there are two types of members: workers and bankers. Workers supply labor and return wages they earn to the household. Each banker manages a financial intermediary and transfers any earnings back to the household. The household thus effectively owns the intermediaries that its bankers manage. The deposits it holds, however, are in intermediaries that is does not own. There is a perfect consumption insurance within the family.

At any moment in time the fraction $1-f$ of the household members are workers and the fraction f are bankers. Over time an individual can switch between the two occupations. In particular, all currently operating bankers become workers next period with probability one. A fraction $\frac{f}{1-f}$ of workers randomly become bankers, keeping the share of each type fixed. At the beginning of each period, exiting bankers transfer their terminal net worth to their respective household. At the same time, the household transfers some resources to new bankers.

Let C_t be consumption and H_t labor supply of the household. The household's preferences are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[C_t - \frac{1}{\chi} H_t \right] \tag{1.1}$$

where $\beta \in (0,1)$ is the discount factor and $\chi > 0$. Deposits D_t are riskless one period real bonds that pay the gross real return R_t from t to $t+1$. W_t is the real wage. Every period the household transfers some resources, N_t, to the new bankers and receives earnings of bankers that exit, N_t^E. In addition there is a large and constant endowment X. The household budget constraint in every period t is given by

$$C_t + D_t + N_t = W_t H_t + R_{t-1} D_{t-1} + N_t^E + X. \tag{1.2}$$

I assume that deposits cannot be negative

$$D_t \geq 0.$$

1.2.2 Financial intermediaries

Financial intermediaries (banks) invest funds obtained from the households, the initial transfer N_t and deposits D_t, in loans extended to firms and in government bonds. Let N_t be the resources that bankers received as the initial transfer, L_t loans given to firms, $B_{H,t}$ the quantity of government bonds held at the end of period t and Q_t the price of government debt. Bankers have the same discount factor β as their household and they choose $L_t, B_{H,t}, D_t$. They solve

$$v_t(N_t) = \max_{L_t, B_{H,t}, D_t} \beta E_t \left[N_{t+1}^E \right] \tag{1.3}$$

where the terminal net worth is given by

$$N_{t+1}^E = R_{L,t} L_t + R_{B,t,t+1} Q_t B_{H,t} - R_t D_t. \tag{1.4}$$

where$R_{L,t}$ is the rate of return (gross) on loans and $R_{B,t,t+1}$ denotes the rate of return on government debt. The balance sheet of banks is

$$L_t + Q_t B_{H,t} = N_t + D_t. \tag{1.5}$$

Banks are constrained in their portfolio choices by financial repression. They face a regulatory requirement that forces them to hold at least fraction $\underline{\phi}_t \in [0,1]$ of assets in government debt. $\underline{\phi}_t$ measures the degree of financial repression

$$Q_t B_{H,t} \geq \underline{\phi}_t \left(L_t + Q_t B_{H,t}\right). \tag{1.6}$$

To motivate an endogenous constraint on the bank's ability to obtain funds, I use the following agency problem: as in Gertler and Karadi (2011) I assume that after a bank obtains funds, the banker managing the bank may transfer a fraction θ of assets to the household. If a bank diverts assets it is forced into bankruptcy by its creditors and is shut down. The creditors may reclaim the remaining fraction $1-\theta$ of assets. Let $v_t(N_t)$ be the banker's value function after choosing optimal portfolio. In order to ensure the bank does not divert funds, the incentive compatibility constraint must hold:

$$\theta\left[L_t + Q_t B_{H,t}\right] \leq v_t(N_t). \tag{1.7}$$

Finally, I assume (similarly to Balke (2018))

$$N_t = \omega N_t^E + \Omega \tag{1.8}$$

where $\omega \in (0,1)$ and $\Omega > 0$. Equation 1.8 makes net worth of the banking sector persistent despite the fact that each generation of bankers operates for only one period. It is useful to define

$$\tilde{N}_t := \omega\left[R_{L,t-1}L_{t-1} - R_{t-1}D_{t-1}\right] + \Omega,$$

transfer to new banks independent of repayment decision of the government. This allows to write

$$N_t = \tilde{N}_t + \omega \iota_t B_{H,t-1} \tag{1.9}$$

1.2.3 Producers

A representative producer hires labor to produce output using a constant returns to scale technology

$$Y_t = Z_t H_t, \tag{1.10}$$

where Z_t is a total factor productivity shock. The producer has to pay the wage bill $W_t H_t$ in advance, after observing Z_t but before production. The wage bill is financed by intraperiod loans L_t obtained from the financial intermediaries. They are repaid at the end of the period, after production, at the gross interest rate $R_{L,t}$. The producer faces a constant tax rate $\tau \in (0, 1)$ on the revenue. The profit maximization problem is

$$\max_{Y_t, H_t, L_t} (1-\tau) Y_t - W_t H_t - \left(R_{L,t} - 1\right) L_t \tag{1.11}$$

subject to 1.10 and the working capital constraint

$$L_t = W_t H_t. \tag{1.12}$$

The TFP shock Z_t follows an AR(1) process

$$Z_t = (1-\rho_Z) \bar{Z} + \rho_Z Z_{t-1} + \sigma_Z \epsilon_{Z,t}$$

where $\rho_Z \in (-1, 1)$, $\bar{Z}$ is a positive constant, $\epsilon_{Z,t}$ is drawn from a standard normal distribution and $\sigma_Z > 0$.

1.2.4 Foreign investors

Every period there is a large mass of risk neutral foreign investors who, besides being able to trade government debt, have access to an asset that pays a risk-free gross interest rate R_t^*. The foreign investors cannot lend to producers nor supply bankers with deposits. Let $B_{F,t}$ denote the face value of government debt purchased in period t by the foreign investors. No arbitrage condition requires that the expected return on the government debt has to be the same as the return on a risk-free asset

$$E_t \left[R_{B,t,t+1} \right] = R_t^*. \tag{1.13}$$

The interest rate R_t^* is exogenous. It follows

$$R_t^* = \bar{R}^* + \rho_R \left(R_{t-1}^* - \bar{R}^* \right) + \sigma_R \epsilon_{R,t} \tag{1.14}$$

where $\rho_R \in (-1, 1)$, $\bar{R}^*$ is a positive constant $\epsilon_{R,t}$ is drawn from a standard normal distribution and $\sigma_R > 0$.

1.2.5 Government

The government finances its purchases G_t by issuing short-term bonds to bankers and foreigners and by taxing output. The government sets a reserve requirement $\underline{\phi}_t$ to force domestic banks to purchase government debt even if they expect lower return on debt than on loans.

The government lacks commitment to repay its debt and can choose to default on it, $\iota_t = 0$, or to repay it, $\iota_t = 1$. I assume default is not discriminatory and not partial. The realized return in period $t+1$ on one unit of goods invested in government debt in period t is

$$R_{B,t,t+1} = \iota_{t+1} \frac{1}{Q_t}. \tag{1.15}$$

Let B_t be the stock of government debt outstanding at the beginning of period t. The government budget constraint is

$$Q_t B_t = \iota_t B_{t-1} + G_t - T_t \tag{1.16}$$

where

$$T_t = \tau Y_t.$$

The government's objective is to maximize the present discounted value of flow utility derived from government purchases

$$E_0 \sum_{t=0}^{\infty} \beta_G^t \log G_t \tag{1.17}$$

The government's discount factor $\beta_G \in (0, 1)$ can differ from that of the households, β. The government understands how its policy choices affect the private sector and is constrained by the private sector optimality conditions. These involve the portfolio choices of financial intermediaries and the evolution of bankers' net worth. I show the constraints faced by the government (the equilibrium conditions) in appendix B. The government also understands that the price of debt has to be such that foreign investors break even in expectation according to equation 1.13.

1.2.6 Timing

I will restrict attention to a Markov Perfect Equilibrium in which the government is a Stackelberg leader. I drop time subscripts to denote current period's states and use " ' " to indicate next period's states.

The timing of the model is as follows. The government enters period with outstanding domestic debt B_H and foreign debt B_F. It also knows $\tilde{N}$ and observes Z, R^*. All these states are relevant for the government's decision whether to repay or not

$$S_\iota := \left(B_H, B_F.\tilde{N}, Z, R^*\right).$$

The government understands that its default decision will affect net worth of the banking sector according to 1.9. After repayment or default the government chooses financial repression and debt issuance. At this point the ownership structure of debt is irrelevant and the state is

$$S := (B, N, Z, R^*).$$

The government announces financial repression, debt issuance and government purchases. The announcement is credible. Bankers and foreign investors believe that in the future the government will follow some policies for repayment, debt issuance, government purchases and financial repression:

$$P_\iota(S_\iota), P_G(S), P_{B''}(S), P_{\underline{\phi}}(S)$$

1.2.7 Equilibrium

An equilibrium of this economy is defined in two steps. First I define a Private Equilibrium for a given government policy. Then I show the recursive formulation of the government problem and I define a Markov Perfect Equilibrium as a Private Equilibrium given the government policies that are chosen optimally given the time inconsistency problem.

Definition 1. Private Equilibrium. Given the state S, current government policies

$$P := \left\{G, B', \underline{\phi}\right\},$$

expected future policies

$$\tilde{P} := \left\{\tilde{P}_\iota\left(S_\iota\right), \tilde{P}_G\left(S\right), \tilde{P}_{B'}\left(S\right), \tilde{P}_{\underline{\phi}}\left(S\right)\right\}$$

and stochastic processes for Z and R^*, a Private Equilibrium consists of

- Households' policies for consumption $C\left(S, P, \tilde{P}\right)$, deposits $D\left(S, P, \tilde{P}\right)$ and labor supply $H^S\left(S, P, \tilde{P}\right)$
- Producers' demand for labor $H^D\left(S, P, \tilde{P}\right)$, demand for loans $L^D\left(S, P, \tilde{P}\right)$ and supply of goods $Y\left(S, P, \tilde{P}\right)$
- Banks' supply of loans $L^S\left(S, P, \tilde{P}\right)$ and purchases of debt $B'_H\left(S, P, \tilde{P}\right)$
- Foreigners' policies for debt purchases $B'_F\left(S, P, \tilde{P}\right)$
- Debt price $Q\left(S, P, \tilde{P},\right)$, return on deposits $R\left(S, P, \tilde{P}\right)$, return on loans $R_L\left(S, P, \tilde{P}\right)$, return on debt $R_B\left(S, P, \tilde{P}\right)$ and the real wage $W\left(S, P, \tilde{P}\right)$,

- The law of motion for $\tilde{N}\left(S,P,\tilde{P}\right)$

  such that:

1. The policies of households maximize 1.1 subject to the budget constraint 1.2.

2. The policies of producers maximize 1.11 subject to 1.10 and 1.12.

3. The policies of banks maximize 1.3 subject to 1.5 , 1.6 and 1.7.

4. The government budget constraint 1.16 is satisfied and the tax revenue is given by $\tau Y\left(S,P,\tilde{P}\right)$.

5. The no arbitrage condition of the foreign investors 1.13 is satisfied.

6. The return on government debt satisfies

$$R_B\left(S,S'_\iota,P,\tilde{P}\right)=\frac{\tilde{P}_\iota\left(S'_\iota\right)}{Q\left(S,P,\tilde{P},\right)}$$

7. The real wage $W\left(S,P,\tilde{P}\right)$ and the return on loans $R_L\left(S,P,\tilde{P}\right)$ satisfy

$$W\left(S,P,\tilde{P}\right)=\frac{1}{\chi}$$
$$R_L\left(S,P,\tilde{P}\right)=\left(1-\tau\right)Z\chi$$

8. The labor market and the deposit market clear.

9. The government debt market clears, i.e.

$$B'=B'_F\left(S,P,\tilde{P}\right)+B'_H\left(S,P,\tilde{P}\right)$$

10. The law of motion for $N'\left(S,Z',r'\right)$ satisfies 1.8.

I show the equilibrium conditions in appendix B.

In a Private Equilibrium, the private sector faces an arbitrary government policy $P := \left\{G, B', \underline{\phi}\right\}$ in the current period. In the next period the government is expected to revert to policy functions

$$\tilde{P} := \left\{\tilde{P}_{\iota}\left(S_{\iota}\right), \tilde{P}_{G}\left(S\right), \tilde{P}_{B'}\left(S\right), \tilde{P}_{\underline{\phi}}\left(S\right)\right\}.$$

Since the government is unable to commit to future policy rules, it chooses its policy in the current period taking as given the policy functions that represent future governments' decisions. A Markov Perfect Equilibrium is characterized by a fixed point in the government's policy functions. At this fixed point, the government does not have any incentive to deviate from policy rules expected to be used in the future periods, thereby rendering them time-consistent. Before defining a Markov Perfect Equilibrium I show the recursive formulation of the problem of the government.

Let $\tilde{V}\left(S_{\iota}\right)$ be the value with the option to default, i.e. before the government decides on repayment and $V\left(S\right)$ be the value function after the repayment decision. These value functions solve

$$\tilde{V}\left(S_{\iota}\right) = \max_{\iota \in \{0,1\}} V\left(\iota\left(B_H + B_F\right), \tilde{N} + \iota\omega B_F, Z, R^*\right) \tag{1.18}$$
$$V\left(S\right) = \max_{G, B' \geq 0, \underline{\phi} \in [0,1]} \log G + \beta_G E\left[\tilde{V}\left(S'_{\iota}\right)\middle| S\right]$$

subject to the Private Equilibrium. The full formal description of the government problem (in which I explicitly discuss the implementability constraints faced by the government) is in appendix C. Having defined the government problem I can now define a Markov Perfect Equilibrium.

Definition 2. Markov Perfect Equilibrium. A Markov Perfect Equilibrium consists of government policies for repayment $P_\iota(S_\iota)$, debt issuance $P_{B'}(S)$, financial repression $P_{\underline{\phi}}(S)$ and government purchases $P_G(S)$ and government value functions $\tilde{V}(S_\iota)$, $V(S)$ such that

- Taking as given future policy functions

$$\tilde{P} := \left\{ \tilde{P}_\iota(S_\iota), \tilde{P}_G(S), \tilde{P}_{B'}(S), \tilde{P}_{\underline{\phi}}(S) \right\}$$

  and future value functions, $\tilde{V}(S_\iota)$, $V(S)$, government policies and value functions solve its optimization problem 1.18.

- Government policies and values are consistent with future policies and values.

1.2.8 Discussion

Before proceeding to study the properties of the equilibrium in Section 1.3 I briefly discuss the assumptions underlying the setup.

First, I made very strong assumptions on the household's preferences: risk neutrality and linear disutility of labor. Risk neutrality, together with the assumption that there is a large endowment X in every period, guarantees that the interest rate on deposits in constant and equals β^{-1}. Otherwise, the Euler equation of the household would imply that R_t depends on the growth rate of the household's consumption. As the cost of issuing deposits is constant, it is possible to obtain a closed form expression for the optimal leverage ratio of the bankers.[1] With time varying interest rate, the computation of the Private Equilibrium would require a costly iterative procedure.

1. See equation 1.20.

Given the high dimensionality of the problem I study in this paper, the computational cost of finding a Markov Perfect Equilibrium would become prohibitively high. With risk neutrality and the infinite Frisch elasticity of labor supply, the real wage at which the household is willing to supply any quantity of labor is constant and equals χ^{-1}. This simplifies the expression for the return on loans considerably.

I assume there are two types of financial frictions in the domestic economy: firms need to pay the wage bill in advance and banks are constrained in their ability to lend by the net worth. These two frictions together ensure that the level of output depends on the net worth of the banking sector. In the absence of any of these two frictions there would be no cost of default. If firms were not required to borrow, their output would be independent of the condition of the banking sector. If banks did not face the incentive compatibility constraint 1.7, they could extend any desired amount of loans by issuing deposits. I depart from the standard assumption made in the literature (Gertler and Kiyotaki (2010); Gertler and Karadi (2011); Bocola (2016)) that firms need to issue claims in period t to finance their purchases of capital to be used in period $t+1$. Instead I make their borrowing intratemporal - loans are taken and repaid in the same period and firms post demand for loans after observing the current productivity level. There are four consequences of this assumption. First, loans to firms are not risky and thus banks never make any losses on them. Second, the government faces no within uncertainty about the tax revenue within a period. Third, the cost of default in period t manifests itself in period t rather than $t+1$. Fourth, it is sufficient to track the variable $\tilde{N}$ instead of having to know separately the quantity of deposits and loans to firms. This allows me to reduce the dimensionality of the problem by one.

The way in which I model the banking sector follows very closely Gertler and Kiyotaki (2010), the only difference being the assumption that bankers live for only one period. In this case the future expected marginal value of net worth does not enter the banker's problem. To generate persistence in the net worth I assume an ad hoc law of motion 1.8. Balke (2018) postulates a similar law of motion in a model with short-lived bankers.

The timing is similar to Eaton and Gersovitz (1981), standard in the sovereign default literature. The bond auction occurs after the default decision is made. The bonds issued in any given period do not face any within-period default risk and the debt price does not depend on the face value of debt that is outstanding before the repayment decision is made. This allows me to assume that the government faces a pricing schedule of debt for any potential level of government debt it chooses. The presence of a pricing schedule from which the government can choose is consistent with a sequential borrowing game in which the government announces how many bonds to issue and then each lender offers the government a price. I make this assumption for two reasons: it reduces dimensionality of the state space and it makes the existence of multiple equilibria less likely[2]. I do not show formally that an equilibrium is unique, but Auclert and Rognlie (2016) demonstrate that the Eaton-Gersovitz timing in simple environments results often in equilibrium uniqueness.

The government is not benevolent, it instead maximizes its own objective function 1.17. I make this assumption to introduce a degree of (public) consumption smoothing while still having analytically tractable risk neutral households. The existing work on sovereign default in environments with financial intermediation, for example Perez (2015); Sosa-Padilla (2018), studies the optimal policy of a benevolent government, but agents the government cares about are essentially hand-to-mouth.

2. Roll-over crises of Cole and Kehoe (2000) are thus ruled out

Finally, I rule out financial autarky as a punishment for defaulting, discriminatory default and bailouts to domestic banks. All of these could alter the conclusions of my paper. The absence of foreign investors in financial autarky would allow the government to manipulate the return on debt. Perez (2015) shows, in a model without financial repression, that the expected duration of exclusion from international financial markets affects the government's willingness to default and the average level of external debt it can sustain in equilibrium. Broner et al. (2014) demonstrate that discriminatory default can explain a home bias in debt holdings while Brunnermeier et al. (2016) illustrate the role of bailout in allowing a negative feedback between banks' balance sheets and the condition of the government budget to arise.

1.3 Financial intermediation, sovereign default and financial repression

Before performing a quantitative analysis of the model outlined in the previous section I show the effects of financial repression in the Private Economy. I seek to identify the channels through which changes in $\underline{\phi}$ affect financial intermediation, debt prices, future net worth and output.

I first describe the equilibrium in the loans market. The demand for loans is equal to the wage bill $W_t H_t$ in this economy. With linear production function 1.10 and working capital constraint 1.12

$$R_{L,t} = (1 - \tau) \frac{Z_t}{W_t}.$$

Workers are willing to supply any quantity of labor at $W_t = \chi^{-1}$. Therefore the demand for loans is perfectly elastic

$$R_{L,t} = (1 - \tau) Z_t \chi$$

and firms make zero profits. The demand for loans does not depend on the degree of financial repression nor on the quantity of government debt. It is also independent of the default risk and the willingness of foreign investors to pay for government debt. 3

Loans are provided by the banks. The leverage ratio

$$\psi_t := \frac{D_t + N_t}{N_t}$$

depends on the marginal value of net worth η_t. It satisfies

$$\psi_t = \frac{\eta_t}{\theta}$$

whenever the incentive compatibility constraint 1.7 is binding. In appendix A.1 I prove that if this is the case the leverage ratio is pinned down by

$$\beta \left[(1 - \phi_t) R_{L,t} + \phi_t E_t \left[R_{B,t,t+1} \right] - R_t \right] = \theta - \frac{1}{\psi_t} \tag{1.19}$$

where

$$\phi_t := \frac{Q_t B_{H,t}}{\psi_t N_t}$$

3. This is also true if i) the production function exhibits decreasing returns to scale in labor, ii) firms have to finance only a fraction of their wage bill in advance, iii) Frisch elasticity of the labor supply is finite. If there are decreasing returns to scale in labor or the Frisch elasticity is finite, the demand for loans is decreasing in the quantity of loans.

is the portfolio share of government debt. ψ_t is increasing in the spread between the expected return on portfolio and the interest rate on deposits. The supply of loans is

$$L_t = (1 - \phi_t)\,\psi_t N_t$$

and is increasing in $R_{L,t}$ (through ψ_t). Moreover, the expected return on debt and loans has to be equal unless $\phi_t = \underline{\phi}_t$. The no arbitrage condition of foreign investors 1.13 implies

$$E_t\left[R_{B,t,t+1}\right] = R_t^*$$

In the rest of the paper I maintain the following assumption:

Assumption 1. *For all possible realizations of* $\left(Z_t, R_t^*\right)$

$$1 + \theta > (1 - \tau)\, Z_t \chi > R_t^* \geq \beta^{-1}$$

The above assumption guarantees that the financial repression constraint 1.6 and the incentive compatibility constraint 1.7 are always binding and that the marginal value of net worth η_t is finite. The leverage ratio ψ_t does not depend on the probability of default. In equilibrium it is given by

$$\psi_t = \frac{1}{1 + \theta - \beta\left[\underline{\phi}_t R^* + \left(1 - \underline{\phi}_t\right) R_{L,t}\right]} \tag{1.20}$$

The supply of loans depends only $R_{L,t}, R_t^*$ and on $\underline{\phi}_t$.

Lemma 1. *An increase in the degree of financial repression* $\underline{\phi}_t$ *decreases the leverage ratio* ψ_t*.*

Proof. See Appendix A.2. □

Lemma 1 shows that whenever the government decides to increase $\underline{\phi}_t$ it will lead to a decline in the leverage ratio. As shown in Figure 1.1 this shifts the supply curve of loans to the left.

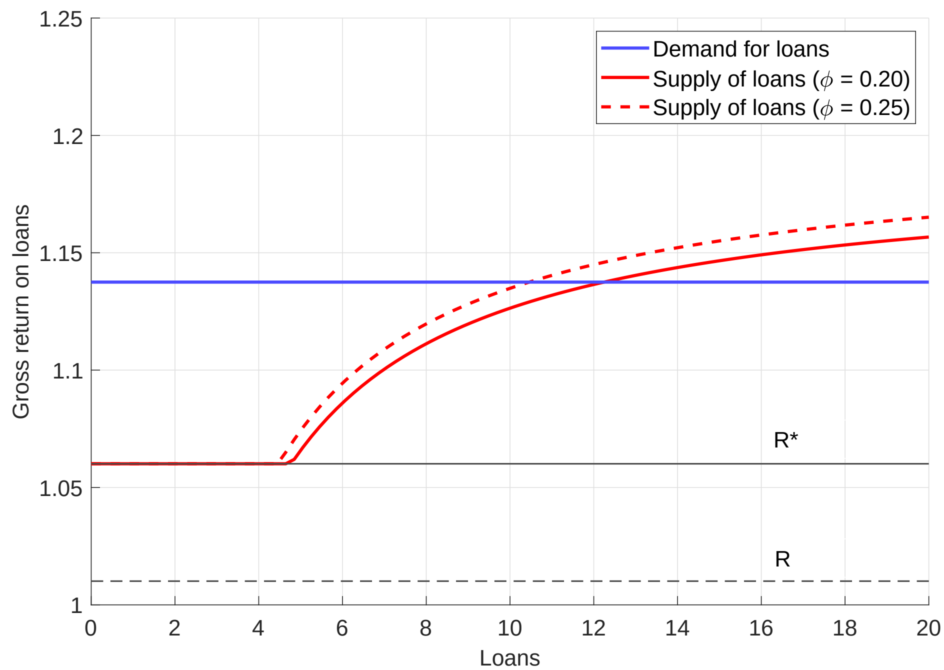

Figure 1.1. Financial repression reduces lending to firms.

It is possible to interpret the financial repression in this model as a tool of macro-prudential policy and the constraint 1.6 as a regulatory requirement. This is consistent with the narrative in Reinhart et al. (2011); Reinhart (2012); Reinhart and Sbrancia (2015). However, since the return on loans $R_{L,t}$ is known in period t when banks are choosing their portfolios, financial repression does not inhibit risk-taking or enhance the stability of the financial sector. If anything, it forces banks to substitute risky government debt for safe loans and exposes banks to sovereign default risk.

Financial repression plays two roles in this model: it has fiscal effects and it can affect incentives to default in the future. As the government varies $\underline{\phi}_t$, it changes the relative importance of taxes and bond sales as the means of financing government purchases. If financial repression in period t forces the domestic banking sector to allocate a large fraction of their portfolio in government debt, the net worth of the banking sector in period $t+1$ will drop sharply in case of a sovereign default.

Lemma 2 shows the fiscal effects of changes in $\underline{\phi}_t$.

Lemma 2. *An increase in the degree of financial repression* $\underline{\phi}_t$ *decreases the tax revenue* T_t *. The revenue from bond sales to domestic sector,* $Q_t B_{H,t}$ *goes up. The effect on the total resources obtained by the government from the domestic sector,* $\Gamma_t := T_t + Q_t B_{H,t}$ *is ambiguous, but the sign of* $\frac{d\Gamma_t}{d\underline{\phi}_t}$ *is the same for all* $\underline{\phi}_t \in [0,1]$.

Proof. See Appendix A.3. □

When the government forces banks to purchase debt they will reduce their lending to firms. The supply of loans declines, firms use less labor and generate lower tax revenue. The effect on the revenue obtained from domestic bond sales is seemingly unclear as the leverage ratio falls, but, as Lemma 2 shows, it turns out to be always positive. As I show in Appendix A.3 Γ_t never exhibits a Laffer curve effect, it is either decreasing or increasing in financial repression regardless of $\underline{\phi}_t$ and the sign of the derivative depends only on $\left(Z_t, R_t^*\right)$. It is more likely to be negative for high Z_t and low R_t^* and more likely to be positive when Z_t is low and R_t^* is high. The ability to finance government purchases through the means of financial repression is state dependent. Moreover, as shown in Lemma 3, financial repression is costly as it slows down expected net worth accumulation.

Lemma 3. *An increase in the degree of financial repression* $\underline{\phi}_t$ *decreases the expected next period net worth,* $E_t\left[N_{t+1}\right]$.

Proof. See Appendix A.4. □

How does forcing domestic banks to hold sovereign debt affect default incentives? Sovereign default in period $t+1$ reduces net worth N_{t+1} by $\omega B_{H,t}$. Because Γ_{t+1} is strictly increasing in N_{t+1} for a fixed financial repression in period $t+1$ Γ_{t+1} will be lower. The government will be able to raise less revenue from the domestic economy, even if it sets $\underline{\phi}_{t+1} = 1$. Lemma 4 shows that these revenue losses are persistent.

Lemma 4. *Fix* $S_t := \left\{B_{H,t-1}, B_{F,t-1}, \tilde{N}_t, Z_t, R_t^*\right\}$ *and a feasible sequence of government policies* $\left\{\underline{\phi}_{t+s}, \iota_{t+s+1}, G_{t+s}, B_{t+s}\right\}_{s=0}^{\infty}$. *Expected* $\{N_{t+s}\}_{s=0}^{\infty}$ *conditional on* $\iota_t = 1$ *and* S_t *is weakly greater (pointwise) than expected* $\{N_{t+s}\}_{s=0}^{\infty}$ *conditional on* $\iota_t = 0$ *and* S_t.

Proof. See Appendix A.5. □

The government can use financial repression to affect the speed at which the net worth will recover, as demonstrated in Lemma 3.

So far I have not discussed how financial repression affects Q_t, the price of debt. Since

$$Q_t = \frac{1}{R_t^*} E_t \left[\iota_{t+1}\right]$$

has to hold and R_t^* is a state variable, financial repression can change Q_t only through its effect on $E_t\left[\iota_{t+1}\right]$. I discuss the intuition below.

1.3.1 A two-period example

In this section I consider a simplified two-period example to understand how financial repression allows the government to affect the probability of default and Q_t . In period 1 the government starts with no debt and can issue one-period bonds to domestic banks and foreign investors. The interest on the riskless asset available to the foreign investors equals R_1^* and productivity is Z_1. The only shock is Z_2 with CDF $\Phi\left(Z_2\right)$.

I assume that the government cannot issue any debt in period 2 and thus has to rely only on its tax revenue. For the purpose of this example I assume the government maximizes

$$u\left(G_2\right)$$

where $u\left(\cdot\right)$ is any strictly increasing function. In addition, I make the assumption that $\beta = 1$, $\chi = 1$ and that Z_2 is independent of Z_1. I assume that both Z_1 and all possible realizations of Z_2 exceed $\frac{1}{1-\tau}R_1^*$, are bounded from above by $\frac{1+\theta}{1-\tau}$, that $\frac{\tau}{1-\tau}\frac{\omega}{\theta} < 1$ and that Φ is strictly increasing and differentiable.

Allocations in period 2 depend on the default decision of the government, the level of productivity Z_2, net worth accumulation between periods 1 and 2 and, if the government decides to repay its debt, on the quantity of debt outstanding. Total tax revenue in period 2 is given by

$$T_2 = \tau \frac{Z_2}{\theta + 1 - (1-\tau) Z_2} N_2$$

so it depends linearly on the net worth N_2. Net worth itself depends on the default decision of the government and is given by

$$N_2 = \tilde{N}_2 + \iota\omega B_{H,1}$$

where $\tilde{N}_2$ captures everything that will not be affected by the default decision in period 2. Default in period 2 entails a loss of tax revenue $\Lambda_2\left(Z_2, B_{H,1}\right)$

$$\Lambda_2\left(Z_2, B_{H,1}\right) = \tau \frac{Z_2}{\theta + 1 - (1-\tau) Z_2} \omega B_{H,1}$$

directly proportional to quantity of debt held by the domestic banking sector. The loss is increasing in Z_2.

Since the government consumption in period 2, G_2, equals the tax revenue net of debt repayment, the government decides to honor its obligations when tax losses resulting from a default exceed debt due in period 2

$$\Lambda_2 \left(Z_2, B_{H,1}\right) > B_{H,1} + B_{F,1}$$

Lemma 5. *Let* $s_{H,1} := \left(\frac{B_{H,1}}{B_{H,1}+B_{F,1}}\right)$. *The default decision is governed by a threshold*

$$\upsilon \left(s_{H,1}\right) = \frac{1+\theta}{\omega\tau s_{H,1} + (1-\tau)}$$

and the probability of default is given by $\Phi\left(\upsilon\left(s_{H,1}\right)\right)$ *with* $\frac{\partial\Phi}{\partial s_{H,1}} \leq 0$. *Moreover,*

$$\Phi\left(\upsilon\left(1\right)\right) > 0.$$

The price of debt satisfies

$$Q\left(s_{H,1}, R_1^*\right) = \frac{1}{R_1^*}\left(1 - \Phi\left(\upsilon\left(s_{H,1}\right)\right)\right)$$

Proof. See Appendix A.6. □

Lemma 5 demonstrates that in this example the default decision depends only on the share of debt held by the domestic sector and not on the total amount of debt $B_1 = B_{H,1} + B_{F,1}$. It is also independent of $\tilde{N}_2$. The price of debt, Q, depends thus only on $\frac{B_{H,1}}{B_{H,1}+B_{F,1}}$ and R_1^*. In principle, the government could issue any quantity of debt without affecting its price, as long as it held the share of domestic debt constant. Moreover, Q is increasing in $B_{H,1}$. $B_{H,1}$ makes default more costly by increasing $\Lambda_2\left(Z_2, B_{H,1}\right)$ which reduces incentives to default. By issuing $B_{H,1}$ the government commits itself to repay its debt. However, domestic debt issuance is not a perfect commitment device. When Z_2 is sufficiently low, banks will choose a low leverage ratio so lending to firms and ultimately tax revenue will be insufficient to allow the government to honor its obligations. Finally, notice that when, for a fixed total debt B_1, $s_{H,1}$ is higher, the the sovereign default frequency will be reduced but the average size of tax losses conditional on default will be increasing, i.e.

$$E\left[\Lambda_2\left(Z_2, s_{H,1}B_1\right)\middle|\, Z_2 < \upsilon\left(s_{H,1}\right)\right]$$

is increasing in $s_{H,1}$.

1.4 Quantitative analysis of the model

In this section I perform a quantitative analysis of the model by calibrating it to the Argentinean economy for the period 1994-2012. The Argentinean economy is my choice for several reasons. Calvo and Mishkin (2003) describe the sovereign default and banking crisis in Argentina in the late 2001. They argue that the government coerced banks to hold government debt on their balance sheets. Perez (2015) reports that Argentina had high levels of external public debt (23% of annual GDP on average) and domestic public debt held in the banking system (9% of annual GDP on average). Argentina defaulted on its external debt in December 2001. According to Sturzenegger and Zettelmeyer (2008) this default was effectively nondiscriminatory as the government implicitly defaulted on the outstanding stock of domestic debt by imposing unfavorable swaps and the conversion of dollars to pesos.

Parameter		Value	Comment
Literature			
HH's discount factor	β	1.01^{-1}	Standard RBC value
Average intl. risk free rate	$\bar{R}^*$	1.01	Sov. def. literature
Labor disutility	χ	1	Normalization
External Data			
Tax rate	τ	0.1	Tax revenue to GDP ratio (0.1)
Average TFP	$\bar{Z}$	1.153	Return on assets (3.1%)
Autocorrelation of TFP	ρ_Z	0.771	TFP autocorrelation
Std. deviation of TFP shocks	σ_Z	0.0151	TFP volatility
Fraction of divertable assets	θ	0.155	Leverage ratio (7.5)
Intl. risk free rate autocorrelation	ρ_R	0.9126	T-bill real return
Std. deviation of intl. risk free rate shocks	σ_R	0.0028	T-bill real return
Calibrated			Targets
Govt's discount factor	β_G	0.761	Average public debt/GDP (128%)
Persistence of net worth	ω	0.381	Share of domestic debt (27%)
Endowment to bankers	Ω	3.212	Debt to assets (26.5%)

Table 1.1: Calibrated parameters

1.4.1 Calibration

One period in the model corresponds to one quarter. The are three classes of parameters: private economy related parameters $(\beta, \chi, X, \omega, \Omega, \theta, \tau)$, government related parameters (β_G) and parameters related to the stochastic processes for Z_t and R_t^* $\left(\bar{Z}, \rho_Z, \sigma_Z, \bar{R}^*, \rho_R, \sigma_R\right)$. The model parameter values are summarized in Table 1.4.1. The discount factor of the households, β, is set to 1.01^{-1} implying the gross interest rate on deposits $R_t = 1.01$ which is the standard value in quantitative business cycle studies. The average level of the international interest rate is set to the same number. X, the endowment received by the households does not matter for any of my results. I normalize $\chi = 1$.

The constant tax rate τ is set to 0.1. This is approximately the tax revenue to GDP ratio in Argentina, as reported by the World Bank, in the period I analyze. The average level of TFP, $\bar{Z}$, is set to match the average (quarterly) return on assets equal to 3.1%. It equals 1.153. To calibrate ρ_Z and σ_Z I proceed as Sosa-Padilla (2018) and I use TFP estimates from ARKLEMS. θ, is chosen to match the leverage ratio of 7.5 in the sample period. To set this parameter I use equation 1.19 together with the average the return on assets seen in the data (3.1%). The implied value is 0.155. To recover parameters governing the stochastic process for R_t^* I estimate equation 1.14 using data on the real international risk free rate. I calculate this rate by subtracting expected inflation from the quarterly US T-bill rate. As in Neumeyer and Perri (2005); Khan et al. (2017). I assume that the expected inflation can be proxied by the average of the US CPI inflation in the current quarter and in the three preceding quarters. The autocorrelation ρ_R is 0.9126 and the standard deviation σ_R equals 0.0028.

The other parameters are jointly calibrated to match three moments in the data. These moments are: the average external (93%) and internal debt to GDP ratios (35%)[4] and the banks' exposure ratio (share of debt in assets, 26.5%). All these parameters jointly affect the targeted moments. Intuitively, the discount factor of the government, β_G, affects the desire to borrow. The parameter governing the persistence of net worth (and tax losses after sovereign default), ω, controls the size and persistence of punishment after defaulting. It pins down the optimal split between domestic and external debt. Given this split, Ω affects the average level of net worth and thus the ratio of debt to assets in the banking sector. Moments from the model correspond to average statistics of moments from 1,000 simulations, each one of them 1,000 periods long.

The shocks are modeled as a joint discrete Markov process that approximates the statistical moments of their actual time-series processes. This procedure is used for

4. These are ratios of outstanding debt to quarterly GDP.

example in Mendoza (2010). The Markov process is defined by a set of all combinations of realizations of the shocks, each combination given by a pair (Z, R^*), and by a matrix P of transition probabilities of moving from (Z, R^*) to $\left(Z', R'^*\right)$. I use 20 grid points for Z and 7 for R^*.

1.4.2 Business cycle moments

In this section I study the model's quantitative performance by comparing moments from the data with moments generated by simulating the model. I compute the empirical moments for the sample period 1994-2012, excluding the period 2002-2005 in which the Argentinean government was in default. I simulate the model 1,000 times, each simulation consisting of 1,000 periods, and calculate statistics dropping the first 100 periods. I then report average statistics over the 1,000 simulations. Table 1.4.2 compares the model moments with their data counterparts. The three moments at the top are those I target in the calibration procedure. These are matched perfectly. The model is able to generate significant levels of external debt sustained in equilibrium (93% of quarterly GDP). This suggests the ability to use financial repression and commit (although imperfectly) to repayment allows the government to sustain high levels of external debt.

Moment	Data	Model
First moments		
External public debt (% of GDP)	93%	93%
Domestic public debt (% of GDP)	35%	35%
Domestic public debt / bank assets	0.265	0.265
Interest rate spread	1.7%	0.4%
Default probability	2.5%	5.4%
Standard deviation		
Public debt	7.7%	14.5%
Interest rate spread	1.5%	2.9%
Correlations		
Output - Interest rate spread	-40.9%	-34.2%
Public debt - Interest rate spread	11.7%	1.12%

Table 1.2: Business cycle statistics

The share of domestic debt in total debt as well as the average share of debt in assets are also correctly matched. The other moments reported in table 1.4.2 are not targeted. The model undershoots the quarterly bond spread - equal to 1.7% in the data and only to 0.4% in the model. This is due to risk neutrality of foreign investors. The probability of sovereign default is more than twice as high in the model (5.4%) as in the data (2.5%[5]. Notice that I did not assume any exclusion from financial markets after a default. The government is thus able to declare default in several consecutive periods. This happens primarily in the region of state space with low productivity, low net worth and low international interest rates. The government has weak incentives to use financial repression and the cost of default is endogenously low, making a default more likely. This feature of the model could be modified by assuming autarky after a default (so that serial default would not be possible) or by introducing and additional, endogenous, cost of defaulting - for example a drop in the TFP. Other than that, the probability of default could be lower in the model had the government forced banks

5. This number is reported by Reinhart and Rogoff (2009). Argentina defaulted 5 times since its independence in 1816.

to hold more debt. That would be inconsistent with the observed share of debt in assets. The model overestimates the volatility of public debt and the interest rate spread. The excessive volatility of debt results from the always present opportunity to place debt with domestic banking sector. Financial repression does not entail any adjustment cost and the government can change it sharply when needed. In addition, frequent defaults contribute to the excessive volatility of debt and the large standard deviation of interest rate spreads. The model is also consistent with a negative co-movement between interest rate spreads and output, and very weak zero correlation between public debt and interest rate spreads. The counter-cyclicality of interest rate spreads can be explained by the fact that default is more likely in a state of the world with low TFP. The second result is related to the fact that the probability of default depends more on the ownership structure of debt rather than the size of public debt.

1.4.3 Determinants of financial repression

What determines financial repression in the model? In figure 1.2 I show the histogram of financial repression observed in the simulation. The black line is the unconditional histogram, the blue line is the histogram conditional on R_t^* being below its median while the red line shows the frequency of various levels of financial repression conditional on R_t^* being above the median.

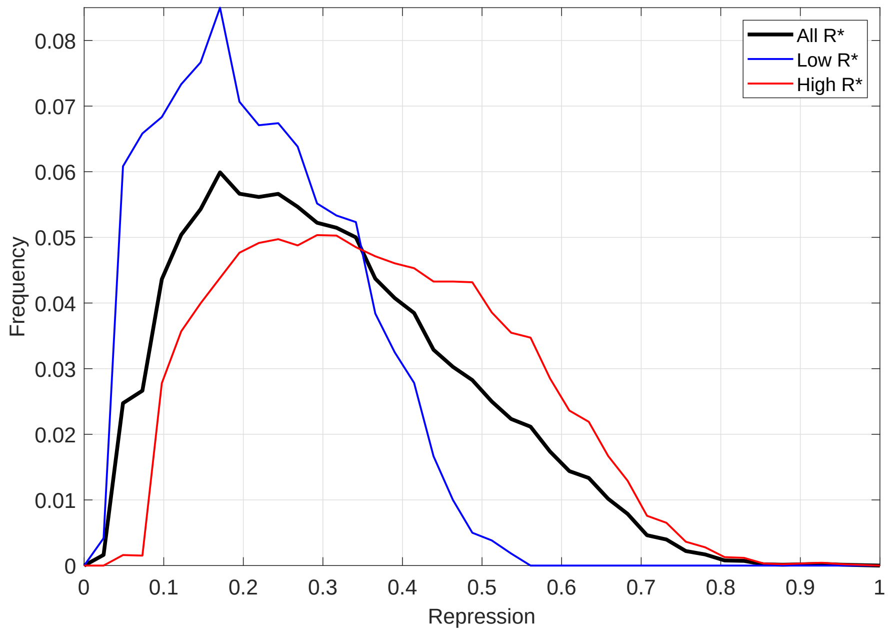

Figure 1.2. Histogram of financial repression
Notes: I simulate the model 1,000 times, each simulation consisting of 1,000 periods. I then report the average frequency of $\underline{\phi}_t$ over the 1,000 simulations.

The government never sets financial repression to 0 and only rarely chooses $\underline{\phi}_t$ below 0.1. Occasionally, financial repression becomes very high and it is not uncommon to see that banks have to hold more than 50% of their assets in government debt. This happens almost exclusively when R_t^* is high for two reasons. First, the price of debt Q_t becomes low and it becomes difficult to raise the desired level of revenue by selling debt to foreigners. Second, as discussed in Lemma 2, the government can increase the amount of resources obtained from the domestic economy by practicing financial repression when the negative effect of financial repression on the leverage ratio is weak. States with high R_t^* are precisely those which are characterized by a weak response of the leverage ratio to changes in the degree of financial repression. In contrast, when R_t^* is low, the incentive to use financial repression is weak. The price of debt is high so it is easy to obtain enough revenue from bond sales to foreigners. Financial repression reduces the leverage ratio by a lot and so the government is unable to extract needed resources from the domestic economy by using it. Hence the government chooses to set $\underline{\phi}_t$ to rather low levels (but never 0) in order to let the banking sector accumulate net worth at a higher pace.

1.4.4 Output dynamics around defaults

I compare the model output dynamics after a default to the data. Figure 1.3 shows percentage deviation of output from its Hodrick-Prescott trend after a sovereign default (as well as in two quarters preceding a default). The dynamics of output in the model are calculated as the average path of output around the episodes of default identified in the simulations[6]. I plot the path of output conditional on financial repression being lower than the median (29.3%) in the period preceding default (blue line) or higher than the median (red line).

The model can match the evolution of output during the 2001 sovereign default of Argentina only under the assumption that financial repression was higher then the median before the default. First, as in the data, this type of default happens after a sharp drop in output. Output is on average 12.3% below the trend in the period of default. This number is twice as large as its empirical counterpart (6.22%). The large discrepancy in the period of default can be explained by the fact that I assumed that net worth losses affect output immediately, rather than slowing down capital accumulation. The speed of recovery in the model is slightly lower than in the data - output returns to its trend one year later than in the data. In contrast, sovereign

6. I analyze only those periods in which the government defaults and there is no default in the preceding 10 periods nor in the 10 following periods.

default preceded by a period of low repression results in much smaller output losses, just 3.1% in the period of default.

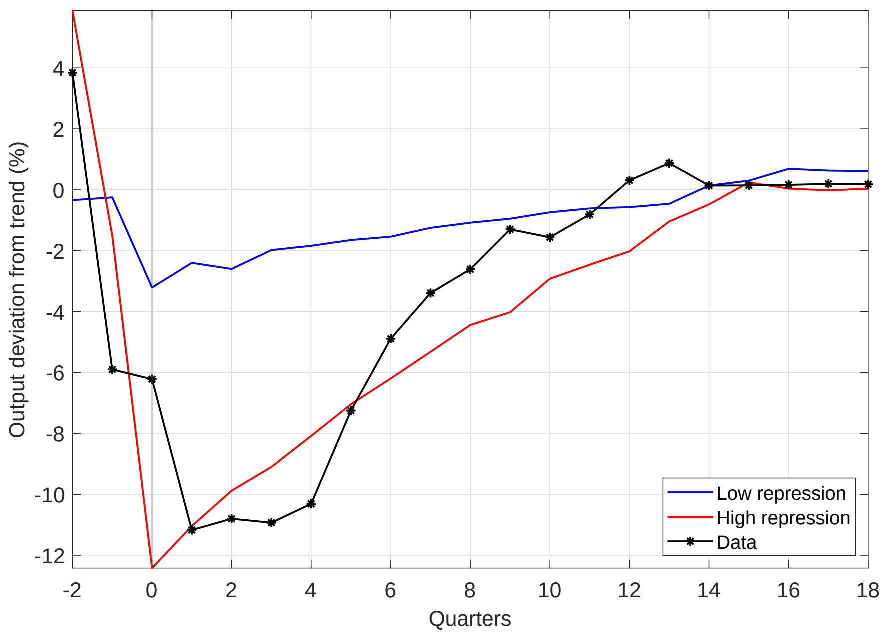

Figure 1.3. Output dynamics around default episodes
Notes: Model data is obtained from identifying 321 default episodes that are preceded and followed by at least 10 periods without default in simulations and computing the average behavior of output around those episodes. The blue line shows output dynamics conditional on $\underline{\phi}_t$ being below the median of $\underline{\phi}_t$ one period before default. The red line shows output dynamics conditional on $\underline{\phi}_t$ being above the median of $\underline{\phi}_t$ one period before default. The black line is data.

The size of output losses after a default depends on several factors. The government can adjust financial repression in the period of default and in subsequent periods. If $\underline{\phi}_t$ is increased following a default, the level of output will decline even further. I show the dynamics of financial repression after a default in figure 1.4.

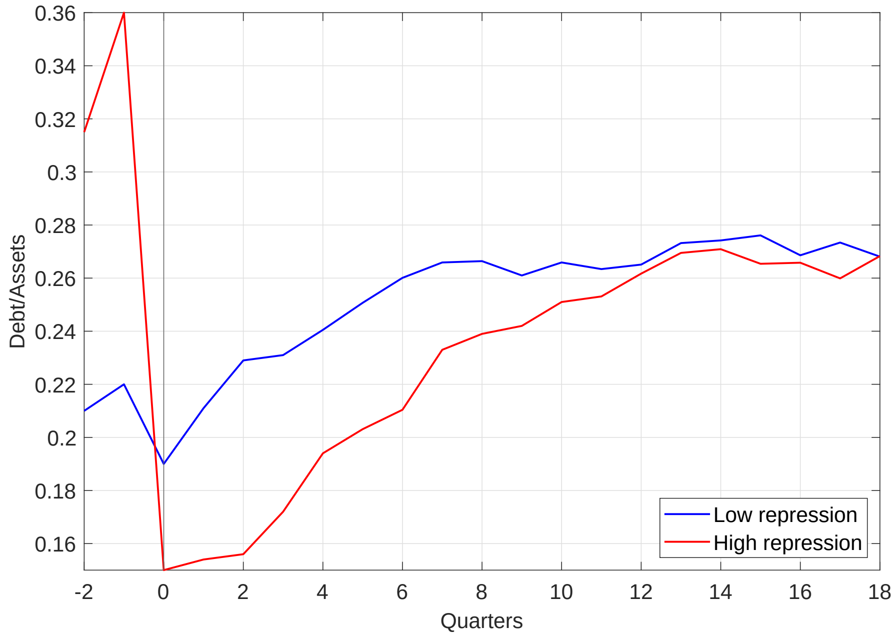

Figure 1.4. Financial repression around default episodes
Notes: Model data is obtained from identifying 321 default episodes that are preceded and followed by at least 10 periods without default in simulations and computing the average behavior of output around those episodes. The blue line shows paths of $\underline{\phi}_t$ conditional on $\underline{\phi}_t$ being below the median of $\underline{\phi}_t$ one period before default. The red line shows $\underline{\phi}_t$ dynamics conditional on $\underline{\phi}_t$ being above the median of $\underline{\phi}_t$ one period before default.

Default episodes preceded by a high degree of financial repression (red line) are characterized by a large decrease in $\underline{\phi}_t$. It falls, on average, from 0.36 to 0.15. The government decides to keep $\underline{\phi}_t$ persistently low in order to quickly restore a pre-default level of net worth of the banking sector. Financial repression goes back to its ergodic mean of 26.5% only after 12 quarters. The adjustment in the regulatory requirement $\underline{\phi}_t$ is much weaker conditional on $\underline{\phi}_t$ being low before a default (blue line). The level of repression before and after a default is similar.

Sovereign default episodes are triggered by the low TFP. The fall in the TFP has to be sufficiently large to make a default optimal when banks have a lot of government debt on their balance sheets. The second component of a decline in output is the loss in net worth due to a default. To disentangle these effects I perform an exercise in which I compare default episodes with a counterfactual scenario in which the government honored its obligations. First, I identify all states in the simulation in which the government decides to default such that there is no default during 10 periods preceding and 10 periods following the period with default. Beginning in each of these states I simulate the model 50 times for 20 periods under two different assumptions. In the first scenario I assume the government defaults in the initial period of the simulation and then follows the optimal policy. In the second scenario the government repays in the initial period and follows the optimal policy afterwards. The solid lines in figure 1.5 show the average difference in the level of output between these two scenarios conditional on low (blue) or high (red) financial repression in the period preceding default.

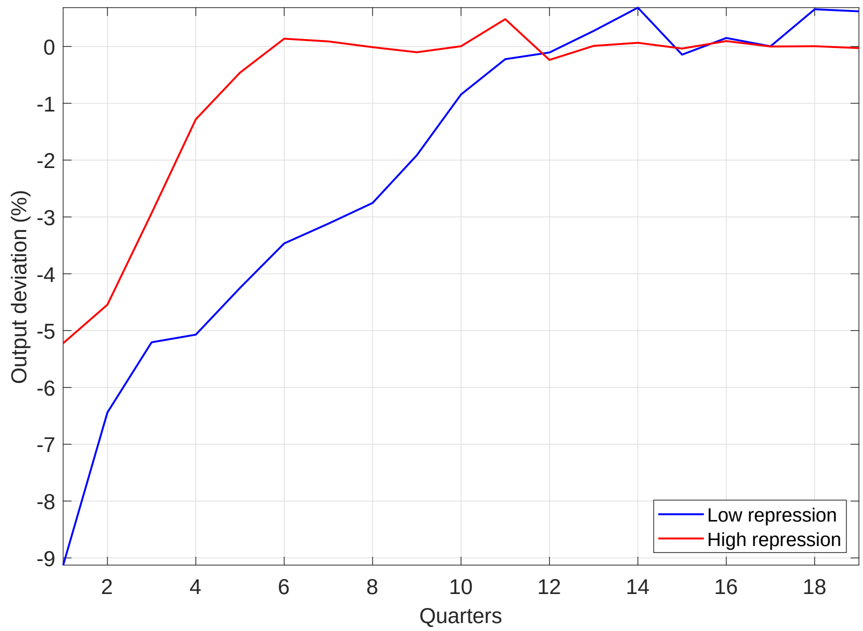

Figure 1.5. Output cost of default
Notes: I find states in each of the 321 default episodes identified to plot Figure 1.3. Beginning in each of these states I simulate the model 50 times for 20 periods under two different assumptions. In the first scenario I assume the government defaults in the initial period of the simulation and then follows the optimal policy. In the second scenario the government repays in the initial period and follows the optimal policy afterwards. The blue line shows the average difference (in percent) between these scenarios conditional on $\underline{\phi}_t$ being below the median of $\underline{\phi}_t$ one period before default. The red line shows the average difference (in percent) between these scenarios conditional on $\underline{\phi}_t$ being above the median of $\underline{\phi}_t$ one period before default.

Output losses conditional on high repression are lower and less persistent than conditional on low repression before a default. First, recall that the drop in TFP must be big in order to trigger a default despite large bond holdings of the domestic banking sector. According to equation 1.19 the leverage ratio is low in states with low TFP. Tax revenue per one unit of net worth must be low as well. Second, periods of high financial repression are often associated with high R_t^*as discussed in section

1.4.3. To the extent that R_t^* is persistent, many default episodes preceded by high $\underline{\phi}_t$ are associated with high R_t^*, When R_t^* is high and Z_t is low, the government has an incentive to use financial repression if N_t is sufficiently high[7]. Therefore the counterfactual scenario in which the government repays debt is states in which it would normally default (conditional on high financial repression in the preceding period) is characterized by a relatively high degree of financial repression and low levels of output. This explains why the output loss conditional on default is just 5.1% in the period of default. The output loss is not very persistent either, it vanishes after 6 quarters. This happens because high financial repression conditional on not defaulting reduces the accumulation of net worth leading to a slow growth in output. Furthermore, quite often the government decides to default anyway in the subsequent periods.

1.4.5 Gains from financial repression

Finally, I discuss whether financial repression makes the government better off. I solve the model imposing an additional restriction $\underline{\phi}_t < \bar{\phi}$. The government cannot choose financial repression above $\bar{\phi}$. I repeat this exercise for 26 values for $\bar{\phi}$, equally spaced between 0 and 1. After finding a Markov Perfect Equilibrium given $\bar{\phi}$ I simulate the model for 2,000 periods and calculate the average value for the government, $E\left[V^{\bar{\phi}}(S)\right]$ and permanent government consumption $G^{\bar{\phi}}$

$$G^{\bar{\phi}} := \exp\left[(1-\beta_G)\, E\left[V^{\bar{\phi}}(S)\right]\right].$$

7. Note that financial repression is not a good source of revenue when N_t is low as the government will not be able to obtain more than $\psi_t N_t$ units of goods even if it sets $\underline{\phi}_t = 1$.

I define welfare loss as

$$\frac{G^{\bar{\phi}}}{G^1} - 1$$

and plot it in figure 1.6.

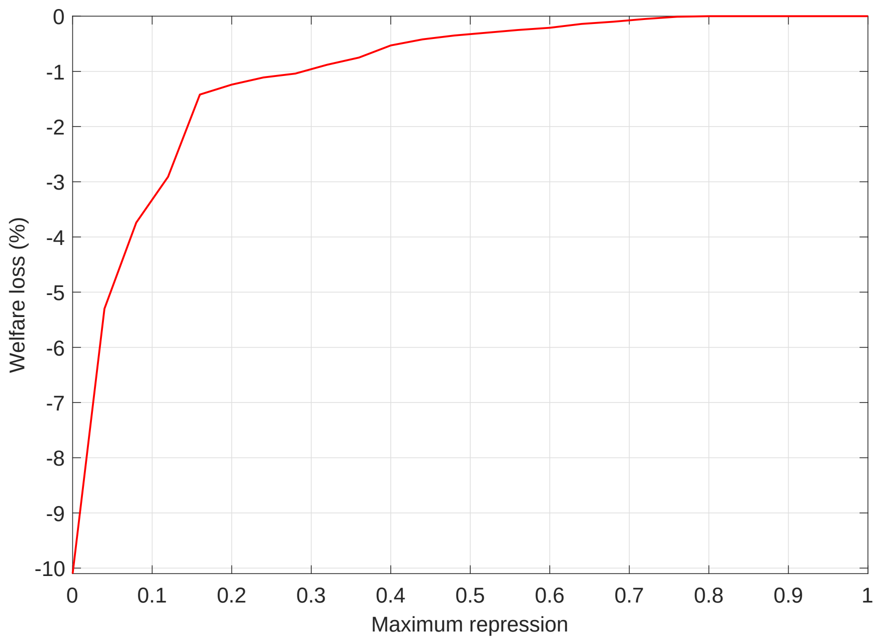

Figure 1.6. Gains from financial repression

If the government cannot use any financial repression ($\bar{\phi} = 0$) the model collapses to a financial autarky. Default is costless if domestic banks do not hold any government debt and the government is expected to default in every period. It is impossible to place any debt and the government has to rely only on (exogenous) tax revenue. Welfare loss amounts to 10.2% in this case. The largest welfare gains are observed for low $\bar{\phi}$. Setting $\bar{\phi}$ to as low as 0.3 results in a welfare loss equal to only -1.05%, despite the fact that it is just above the median of financial repression seen in the baseline version of the model (0.293).

1.5 Conclusions

In this paper I study the effects of financial repression in a quantitative sovereign default model with a financial sector. The government can use financial repression and force domestic banks to hold government debt on their balance sheets. The government does it for two reasons. First, financial repression can be used to increase the amount of resources obtained from the domestic economy. The fiscal incentive is especially strong in periods of low tax revenue and when foreign investors demand high interest rates. Second, financial repression can be used as a commitment device. If banks hold government debt their net worth will be adversely affected by a default. This leads to a decline in lending, output and tax revenue following a default and makes defaulting less attractive. As the foreign investors perceive default as less likely, the government can sell its bonds at a higher price. However, in an unlikely event of sufficiently bad shocks the government decides to default anyway which results in a sharp drop in output.

I calibrate the model to the Argentinean economy. I find that if a government defaults after practicing financial repression the dynamics of output resemble those seen in the sovereign default and banking crisis in Argentina in 2001. While output falls by a lot during these default episodes, its deviation from the counterfactual path assuming repayment is actually smaller than in default episodes preceded by periods of low financial repression. This is suggestive of a strong selection.

Finally, I use the model to explore the welfare effects of financial repression. Since net worth losses are the only reason why default is costly in my model, financial repression must be used if the government wants to issue any debt. In the counterfactual scenario in which financial repression cannot be used, the government would be in financial autarky and would suffer from a welfare losses equivalent to a decrease of 10.3% in permanent government consumption.

REFERENCES

Arellano, Cristina, "Default Risk and Income Fluctuations in Emerging Economies," *American Economic Review*, June 2008, *98* (3), 690–712.

Auclert, Adrien and Matthew Rognlie, "Unique equilibrium in the Eaton-Gersovitz model of sovereign debt," *Journal of Monetary Economics*, 2016, *84* (C), 134–146.

Balke, Neele, "The Employment Cost of Sovereign Default," 2018 Meeting Papers 1256, Society for Economic Dynamics 2018.

Baskaya, Yusuf Soner and Sebnem Kalemli-Ozcan, "Sovereign Risk and Bank Lending: Evidence from 1999 Turkish Earthquake," NBER Working Papers 22335, National Bureau of Economic Research, Inc June 2016.

Becker, Bo and Victoria Ivashina, "Financial Repression in the European Sovereign Debt Crisis," CEPR Discussion Papers 12185, C.E.P.R. Discussion Papers July 2017.

Bocola, Luigi, "The Pass-Through of Sovereign Risk," *Journal of Political Economy*, 2016, *124* (4), 879–926.

Broner, Fernando, Aitor Erce, Alberto Martin, and Jaume Ventura, "Sovereign debt markets in turbulent times: Creditor discrimination and crowding-out effects," *Journal of Monetary Economics*, 2014, *61* (C), 114–142.

Brunnermeier, Markus K., Luis Garicano, Philip Lane, Marco Pagano, Ricardo Reis, Tano Santos, David Thesmar, Stijn Van Nieuwerburgh, and Dimitri Vayanos, "The Sovereign-Bank Diabolic Loop and ESBies," NBER Working Papers 21993, National Bureau of Economic Research, Inc February 2016.

Calvo, Guillermo A. and Frederic S. Mishkin, "The Mirage of Exchange Rate Regimes for Emerging Market Countries," *Journal of Economic Perspectives*, Fall 2003, *17* (4), 99–118.

Chari, V. V., Alessandro Dovis, and Patrick J. Kehoe, "On the Optimality of Financial Repression," *Journal of Political Economy*, 2020, *128* (2), 710–739.

Cole, Harold L. and Timothy J. Kehoe, "Self-Fulfilling Debt Crises," *Review of Economic Studies*, 2000, *67* (1), 91–116.

Eaton, Jonathan and Mark Gersovitz, "Debt with Potential Repudiation: Theoretical and Empirical Analysis," *Review of Economic Studies*, 1981, *48* (2), 289–309.

Gennaioli, Nicola, Alberto Martin, and Stefano Rossi, "Banks, government Bonds, and Default: What do the data Say?," *Journal of Monetary Economics*, 2018, *98* (C), 98–113.

Gertler, Mark and Nobuhiro Kiyotaki, "Financial Intermediation and Credit Policy in Business Cycle Analysis," in Benjamin M. Friedman and Michael Woodford, eds., *Handbook of Monetary Economics*, Vol. 3 of *Handbook of Monetary Economics*, Elsevier, 2010, chapter 11, pp. 547–599.

—— **and Peter Karadi**, "A model of unconventional monetary policy," *Journal of Monetary Economics*, January 2011, *58* (1), 17–34.

Khan, Shahed, Alok Johri, and Cesar Sosa-Padilla, "Interest Rate Uncertainty and Sovereign Default Risk," 2017 Meeting Papers 1192, Society for Economic Dynamics 2017.

Mendoza, Enrique G., "Sudden Stops, Financial Crises, and Leverage," *American Economic Review*, December 2010, *100* (5), 1941–1966.

Neumeyer, Pablo A. and Fabrizio Perri, "Business cycles in emerging economies: the role of interest rates," *Journal of Monetary Economics*, March 2005, *52* (2), 345–380.

Ongena, Steven, Alexander Popov, and Neeltje Van Horen, "The invisible hand of the government: Moral suasion during the European sovereign debt crisis," Working Paper Series 1937, European Central Bank July 2016.

Perez, Diego J., "Sovereign Debt, Domestic Banks and the Provision of Public Liquidity," Discussion Papers 15-016, Stanford Institute for Economic Policy Research June 2015.

Reinhart, C. M., "The return of financial repression," *Financial Stability Review*, April 2012, (16), 37–48.

Reinhart, Carmen, Jacob Kirkegaard, and Belen Sbrancia, "Financial repression redux," MPRA Paper 31641, University Library of Munich, Germany June 2011.

Reinhart, Carmen M. and Kenneth S. Rogoff, *This Time Is Different: Eight Centuries of Financial Folly* number 8973. In 'Economics Books.', Princeton University Press, 2009.

—— **and M. Belen Sbrancia**, "The liquidation of government debt," *Economic Policy*, 2015, *30* (82), 291–333.

Sosa-Padilla, Cesar, "Sovereign defaults and banking crises," *Journal of Monetary Economics*, 2018, *99* (C), 88–105.

Sturzenegger, Federico and Jeromin Zettelmeyer, "Haircuts: Estimating investor losses in sovereign debt restructurings, 1998-2005," *Journal of International Money and Finance*, September 2008, *27* (5), 780–805.

APPENDIX A

PROOFS

A.1 The problem of the bank

We have

$$v_t\left(N_t\right) = \max_{B_{H,t},L_t,D_t} \beta E_t\left[R_{L,t}L_t + R_{B,t,t+1}B_{H,t} - R_tD_t\right]$$

subject to incentive compatibility constraint

$$\theta\left(Q_tB_{H,t} + L_t\right) \leq v_t\left(N_t\right)$$

financial repression

$$Q_tB_{H,t} \geq \underline{\phi}_t\left(Q_tB_{H,t} + L_t\right)$$

and balance sheet

$$Q_tB_{H,t} + L_t = N_t + D_t.$$

Guess that $v_t\left(N_t\right) = \eta_tN_t$. The problem of the bank can be rewritten as

$$\begin{aligned} v_t\left(N_t\right) = \max_{\phi_t,\psi_t} &\beta E_t\left[R_{L,t}\left(1-\phi_t\right)\psi_t + R_{B,t,t+1}\phi_t\psi_t - \left(\psi_t - 1\right)R_t\right]N_t \\ &+ \mu_t\left[\eta_t - \theta\psi_t\right]N_t + \gamma_t\left[\phi_t - \underline{\phi}_t\right]\psi_tN_t \end{aligned}$$

where μ_t is the Lagrange multiplier on the IC constraint and γ_t is the constraint on the financial repression constraint. First order condition with respect to ψ_t is

$$\beta E_t \left[(1 - \phi_t) R_{L,t} + \phi_t R_{B,t,t+1} - R_t \right] = \theta \mu_t$$

We can plug it to get

$$v_t (N_t) = [\beta R_t + \mu_t \eta_t] N_t$$

which shows that

$$\eta_t = \frac{\beta R_t}{1 - \mu_t}$$

and since in equilibrium $\beta R_t = 1$

$$\eta_t = \frac{1}{1 - \mu_t}.$$

The incentive compatibility constraint (with equality) can be now rewritten as

$$\theta \psi_t N_t = \frac{1}{1 - \mu_t} N_t$$

and solved for

$$\mu_t = 1 - \frac{1}{\theta \psi_t}.$$

Plugging this in the first order condition with respect to ψ_t I obtain

$$\beta E_t \left[(1 - \phi_t) R_{L,t} + \phi_t R_{B,t,t+1} - R_t \right] = \theta - \frac{1}{\psi_t}$$

A.2 Proof of Lemma 1

Rearrange 1.19 to get

$$\psi_t = \frac{1}{1 + \theta - \underline{\phi}_t \beta \left(R_t^* - R_{L,t}\right) - \beta R_{L,t}}$$

By assumption of binding financial repression $R_t^* - R_{L,t} < 0$ and

$$\frac{\partial \psi_t}{\partial \underline{\phi}_t} = \beta \left(R_t^* - R_{L,t}\right) \psi_t^2 < 0$$

A.3 Proof of Lemma 2

Tax revenue is

$$\begin{aligned} T_t &= \tau Y_t \\ &= \tau Z_t \frac{L_t}{W_t} \\ &= \tau Z_t \chi \left(1 - \underline{\phi}_t\right) \psi_t N_t \end{aligned}$$

and thus

$$\frac{dT_t}{d\underline{\phi}_t} = \tau Z_t \chi N_t \left(-\psi_t + \left(1 - \underline{\phi}_t\right) \frac{\partial \psi_t}{\partial \underline{\phi}_t}\right) < 0$$

The value of bonds purchased by the domestic banks satisfies

$$Q_t B_{H,t} = \underline{\phi}_t \psi_t N_t$$

so

$$\frac{d\left(Q_t B_{H,t}\right)}{d\underline{\phi}_t} = \psi_t \left[1 - \psi_t \underline{\phi}_t \beta \left(R_{L,t} - R_t^*\right)\right]$$

which is positive if

$$1 > \psi_t \underline{\phi}_t \beta \left(R_{L,t} - R_t^*\right)$$

or, using the expression for ψ_t

$$1 + \theta - \underline{\phi}_t \beta \left(R_t^* - R_{L,t}\right) - \beta R_{L,t} > \underline{\phi}_t \beta \left(R_{L,t} - R_t^*\right)$$

i.e.

$$1 + \theta > \beta R_{L,t}$$

which is assumed to hold (otherwise there is no equilibrium if there is no financial repression). Therefore

$$\frac{d\left(Q_t B_{H,t}\right)}{d\underline{\phi}_t} > 0$$

Finally,

$$\begin{aligned}\Gamma_t &= T_t + \underline{\phi}_t \psi_t N_t \\ &= \left[\tau Z_t \chi \left(1 - \underline{\phi}_t\right) + \underline{\phi}_t\right] \psi_t N_t\end{aligned}$$

and

$$\frac{d\Gamma_t}{d\underline{\phi}_t} = \left[\left[1 - \tau Z_t \chi\right] \psi_t - \left[\left(1 - \underline{\phi}_t\right) \tau Z_t \chi + \underline{\phi}_t\right] \beta \left(\left(1 - \tau\right) Z_t \chi - R_t^*\right)\right] \psi_t N_t$$

the sign of which is ambiguous. It can be shown that the above expression is monotone in $\underline{\phi}_t$ and has the same sign for $\underline{\phi}_t = 0$ and $\underline{\phi}_t = 1$ to prove that the sign depends only on R_t^* and Z_t.

A.4 Proof of Lemma 3

Recall that

$$E_t\left[N_{t+1}\right] = \omega E_t\left[\left(1 - \underline{\phi}_t\right) R_{L,t} + \underline{\phi}_t R_t^* - R_t\right] \psi_t N_t + \omega R_t N_t + \Omega$$

where I used 1.4, 1.8, the definitions of ψ_t, ϕ_t, the no arbitrage equation of foreign investors and Assumption 1. First order condition with respect to ψ_t allows to rewrite it as

$$E_t\left[N_{t+1}\right] = \omega\beta^{-1}\theta\psi_t N_t + \Omega.$$

Since ψ_t is decreasing in $\underline{\phi}_t$ (Lemma 1) $E_t\left[N_{t+1}\right]$ is also decreasing in $\underline{\phi}_t$.

A.5 Proof of Lemma 4

As shown in the proof of Lemma 3 we have

$$E_t\left[N_{t+1}\right] = \omega\beta^{-1}\theta\psi_t N_t + \Omega$$

so

$$E_t\left[N_{t+s}\right] = \omega\beta^{-1}\theta E_t\left[\psi_{t+s-1}N_{t+s-1}\right] + \Omega$$

and using the fact that for a fixed sequence of feasible policies ψ_{t+s} is independent of N_{t+s} we can write

$$E_t\left[N_{t+s}\right] = \omega\beta^{-1}\theta E_t\left[\psi_{t+s-1}\right] E_t\left[N_{t+s-1}\right] + \Omega$$

Let $N_{t+s}^{\iota=1}$ denote the sequence of net worth after repayment and $N_{t+s}^{\iota=0}$ be the sequence of net worth after default. We have

$$N_t^{\iota=1} - N_t^{\iota=0} = \omega B_{H,t-1} \geq 0$$

so

$$E_t\left[N_{t+1}^{\iota=1} - N_{t+1}^{\iota=0}\right] = \omega\beta^{-1}\theta\psi_t\omega B_{H,t-1}$$

and

$$E_t\left[N_{t+s}^{\iota=1} - N_{t+s}^{\iota=0}\right] = \left(\omega\beta^{-1}\theta\right)^s \omega B_{H,t-1} \prod_{i=0}^{s-1} E_t\left[\psi_{t+i}\right] \geq 0$$

for all $s \geq 0$.

A.6 Proof of Lemma 5

The government defaults when

$$\Lambda_2\left(Z_2, B_{H,1}\right) < B_{H,1} + B_{F,1}$$

i.e. when

$$\tau\frac{Z_2}{\theta + 1 - (1-\tau)Z_2}\omega B_{H,1} < B_{H,1} + B_{F,1}.$$

Define $s_{H,1} := \frac{B_{H,1}}{B_{H,1}+B_{F,1}}$ and divide both sides by $B_{H,1} + B_{F,1}$ to get

$$\tau \frac{Z_2}{\theta + 1 - (1-\tau) Z_2} \omega s_{H,1} < 1.$$

This can be rearranged as a condition in terms of Z_2

$$Z_2 < \frac{1+\theta.}{\tau \omega s_{H,1} + 1 - \tau} := \upsilon \left(s_{H,1} \right)$$

Probability that $Z_2 < \upsilon \left(s_{H,1} \right)$ is $\Phi \left(\upsilon \left(s_{H,1} \right) \right)$. Since $\upsilon \left(s_{H,1} \right)$ is decreasing in Z_2 and $\Phi (\cdot)$ is weakly increasing in its argument $\frac{\partial \Phi}{\partial s_{H,1}} \leq 0$.

Tax loss for the lowest possible realization of Z_2, $\frac{1}{1-\tau}$, is equal to

$$\frac{\tau}{1-\tau} \frac{\omega}{\theta} B_{H,1}$$

and given the assumption $\frac{\tau}{1-\tau} \frac{\omega}{\theta} < 1$, it is lower than $B_{H,1}$. It implies

$$\Phi \left(\upsilon (1) \right) > 0$$

Finally, since $\upsilon (0) = \frac{1+\theta}{1-\tau}$ we have

$$\Phi \left(\upsilon (0) \right) = 1$$

APPENDIX B

EQUILIBRIUM CONDITIONS

Private Equilibrium is characterized by the following equilibrium conditions:

$$
\begin{aligned}
\psi_t &= \frac{1}{1+\theta-\beta\left[\left(1-\underline{\phi}_t\right)(1-\tau)Z_t\chi+\underline{\phi}_t R_t^*\right]} \\
N_{t+1} &= \omega\left[\left(1-\underline{\phi}_t\right)(1-\tau)Z_t\chi+\underline{\phi}_t\frac{\iota_{t+1}}{Q_t}-\beta^{-1}\right]\psi_t N_t+\beta^{-1}N_t+\Omega \\
Q_t B_t &= \iota_t B_{t-1}+G_t-\tau Z_t\chi\left(1-\underline{\phi}_t\right)\psi_t N_t \\
B_{F,t} &= B_t-B_{H,t} \\
Q_t B_{H,t} &= \underline{\phi}_t\psi_t N_t \\
Q_t &= \frac{1}{R_t^*}E_t\left[\iota_{t+1}\right]
\end{aligned}
$$

with

$$
\begin{aligned}
R_{L,t} &= (1-\tau)Z_t\chi \\
L_t &= \left(1-\underline{\phi}_t\right)\psi_t N_t \\
W_t &= \frac{1}{\chi} \\
H_t &= \chi\left(1-\underline{\phi}_t\right)\psi_t N_t \\
Y_t &= Z_t\chi\left(1-\underline{\phi}_t\right)\psi_t N_t \\
C_t &= W_t H_t+R_{L,t-1}L_{t-1}+\iota_t B_{H,t-1}-\psi_t N_t+X
\end{aligned}
$$

APPENDIX C

RECURSIVE FORMULATION OF THE GOVERNMENT PROBLEM

After deciding whether to repay or not the government solves

$$V(B, N, Z, R^*) = \max_{G, B' \geq 0, \underline{\phi} \in [0,1]} \log G + \beta_G E\left[\tilde{V}\left(B'_H, B'_F . \tilde{N}', Z', R'^*\right) \middle| B', N, Z, R^* \right]$$

subject to

$$\begin{aligned}
\psi &= \frac{1}{1 + \theta - \beta\left[\left(1 - \underline{\phi}\right)(1 - \tau) Z\chi + \underline{\phi} R^*\right]} \\
\tilde{N}' &= \omega\left[\left(1 - \underline{\phi}\right)(1 - \tau) Z\chi - \beta^{-1}\right]\psi N + \beta^{-1} N + \Omega \\
Q\left(B'_H, B'_F, N, Z, R\right)\left(B'_H + B'_F\right) &= B + G - \tau Z\chi\left(1 - \underline{\phi}\right)\psi N \\
B'_F &= B' - B_H \\
Q\left(B'_H, B'_F, N, Z, R\right) B'_{H,} &= \underline{\phi}\psi N \\
Q\left(B'_H, B'_F, N, Z, R\right) &= \frac{1}{R^*} E\left[\tilde{P}_\iota\left(B'_H, B'_F . \tilde{N}', Z', R'^*\right) \middle| B', N, Z, R^* \right]
\end{aligned}$$

The above constraints are the equilibrium conditions relevant for the government. I write the price of debt Q as a function of B'_H, B'_F, N, Z, R. It is shaped by the expectation of default next period and the decision whether to default depends on $\tilde{N}'$, but given B'_H, B'_F, N, Z, R this variable is determined uniquely. Finally, the repayment decision is just

$$\tilde{V}\left(B_H, B_F, \tilde{N}, Z, R\right) = \max_{\iota \in \{0,1\}} V\left(\iota\left(B_H + B_F\right), \tilde{N} + \iota\omega B_F, Z, R^*\right)$$