Overborrowing and Systemic Externalities in the Business Cycle

Javier Bianchi *

University of Maryland

June 2009

Abstract

Credit constraints that link a private agent’s debt to market-determined prices embody a systemic credit externality that drives a wedge between competitive and constrained socially optimal equilibria, inducing private agents to “overborrow.” We quantify the effects of this externality in a two-sector DSGE model of a small open economy calibrated to emerging markets. Debt is denominated in units of tradable goods and is constrained not to exceed a fraction of individual income, including non-tradable income valued at the relative price of non-tradables. The externality arises because agents fail to internalize the price effects of their individual borrowing, hence the adverse debt-deflation amplification effects of negative income shocks that trigger the credit constraint. Quantitatively, the systemic credit externality causes the probability of financial crises to increase by a factor of 7, and consumption to drop 70 percent more during the most severe crisis episodes. On the normative side, we calculate the welfare cost of the systemic credit externality and compute a schedule of state-contingent taxes on capital flows that attains the constrained social optimum.

*I am greatly indebted to Enrique Mendoza for his guidance and advice. I am also grateful to Anton Korinek and John Shea for encouragement and invaluable suggestions. For useful suggestions and comments, I thank Juan Dubra, Pablo D’Erasmo, Bertrand Gruss, Alessandro Rebucci and seminar participants at the University of Maryland and the Atlanta Fed. bianchi@econ.umd.edu
Keywords: Financial Crises, Business Cycles, Amplification Effects, Sudden Stops, Systemic Externalities

JEL Classification Numbers: D62,E32,E44,F32,F41

“Theoretically there may be – in fact, at most times there must be – over- or under-production, over- or under-consumption, over- or under-spending, over- or under-saving, over- or under-investment, and over or under everything else. In the great booms and depressions, two dominant factors [are ...] over-indebtedness to start with and deflation following soon after...also that where any of the other factors do become conspicuous, they are often merely effects or symptoms of these two.” Irving Fisher – The debt-deflation theory of great depressions

1 Introduction

Recent episodes in the financial markets have shown that economies can experience deep recessions which differ from typical business cycles. In emerging markets, crises are often preceded by tranquil times during which the emerging economy experiences an increase in debt before suddenly losing access to the international financial market. The disruption associated with these episodes has led to a concern in academic and policy circles that countries borrow excessively. If agents make borrowing decisions from a privately optimal standpoint, why should the aggregate level of debt not be socially optimal? If rational agents make decisions that leave them vulnerable to a crisis, why should the incidence and the severity of financial crises not be socially optimal?

This paper addresses these questions in a two-sector dynamic stochastic general equilibrium small open economy model (DSGE-SOE) where a credit market externality drives a wedge between competitive and constrained socially optimum equilibria. Agents do not internalize how additional borrowing results in amplification during a financial crisis, hence they overborrow. Quantitatively, the credit externality causes a modest increase in average debt of 1.3 percentage points of GDP. However, the credit externality magnifies the incidence of these episodes by increasing the probability of financial crisis from 1.1 percent to 8.2 percent, and increases also the severity of these episodes. When the externality is not present, consumption drops 14 percent and capital outflows increase 11 percent in the most severe crisis episodes. In the presence of the externality, however, the private economy expe-
periences an even greater consumption collapse of 24 percent and an increase in capital outflows of 25 percent. In addition, the excessive debt caused by the credit externality reaches 14 percentage points of GDP in these episodes.

Our model features a credit constraint that requires debt, denominated in the international unit of account (i.e., tradable goods), not to exceed a fraction of income composed of tradables and non-tradables, as in Mendoza (2002). While the international demand for tradable goods is perfectly elastic, the price of non-tradables adjusts to equilibrate domestic supply and demand in the non-tradable sector. In case of a negative shock, for example, aggregate demand for non-tradable goods falls and their relative price suffers a decline (i.e. the real exchange rate depreciates). Because debt is partially leveraged in non-tradables income, changes in the relative price of non-tradable goods can induce sharp and sudden adjustments in access to foreign financing. When a negative shock to income makes the credit constraint binding, the economy suffers the economic dislocation typically associated with a financial crisis. Demand for consumption goods falls, which reduces the price of non-tradables. The drop in the price of non-tradables leads to a further tightening of the credit constraint, setting in motion Fisher’s debt deflation channel by which declines in consumption, real exchange rate, and access to foreign financing mutually reinforce each other. Households self-insure against these episodes by holding precautionary savings, but they will occasionally face binding credit constraints as an endogenous response to negative shocks when leverage is sufficiently high. In this way, financial crisis are nested within typical business cycles.

The systemic credit externality arises because agents fail to internalize the price effects of their own individual borrowing, hence the adverse debt-deflation amplification effects of negative income shocks that triggers the credit constraint. Private agents form rational expectations about the evolution of macroeconomic variables, in particular the price of non-tradables, and correctly perceive the risks and benefits of their consumption-savings decisions. Nevertheless, they do not internalize the general equilibrium effects of their consumption-savings decisions on the real exchange rate. This is a pecuniary externality that would not have welfare effects in the absence of the adverse debt-deflation amplification effects. However, by reducing the amount of debt in the economy, a social planner can mitigate the downward
spiral in the real exchange rate and the borrowing capacity of the economy during a crisis, which results in higher consumption smoothing and welfare gains.

On the normative side, the inefficiency of the decentralized equilibrium implies that there is a role for financial regulation taking the financial frictions considered as given. In our model, a schedule of state-contingent taxes on debt can attain the constrained social optimum. The rationale for this policy is to discourage leverage and reduce the economy’s vulnerability to financial crises. In the calibrated version of our model, the tax on debt necessary to correct the externality is 4.5 percent on average, increasing with leverage and the probability of a future financial crisis. The welfare gains from correcting the externality are associated with a smoother business cycle and these gains which average 0.1 percent of permanent consumption vary with the state of the economy. As a result of the macro-prudential nature of optimal policy, the benefits of the introduction of financial regulation to correct the externality are maximized outside crisis states, particularly in the run-up to a financial crash.

Our work builds on extensive research on the financial accelerator that started with Fisher (1933) and developed further with the contributions of Kiyotaki and Moore (1997), Bernanke, Gertler and Gilchrist (1998), and Aiyagari and Gertler (1999). We follow closely the model in Mendoza (2002), who shows that the quantitative predictions of a DSGE model with Fisher’s debt deflation channel are consistent with key features of emerging market crises (see also Mendoza, 2008). Our contribution to this literature is twofold. First, we show that the financial accelerator creates an externality by which excessive borrowing leads to a level of amplification that can differ from the optimal amplification in a quantitatively significant way. Secondly, we propose a policy that achieves the constrained optimal allocations and reduces the incidence and severity of financial crises.

Previous contributions that studied how pecuniary externalities can distort borrowing decisions have been primarily static and designed to address qualitative effects (see for example Caballero and Krishnamurthy, 2001 and Korinek, 2008a in the emerging market literature and Lorenzoni, 2008 and Farhi, Golosov, and Tsyvinski, 2007 in the closed economy macroeconomic literature). Therefore, the quantitative significance of pecuniary externali-

---

1The externality result of these papers is an application of a general proposition that economies with
ties, which is important for determining to what extent regulation is desirable for correcting the externalities, remains an open question. This paper fills in this gap by providing a dynamic stochastic general equilibrium (DSGE) framework, where the role of pecuniary externalities in macroeconomics can be analyzed and assessed quantitatively.

The existent literature has explored different explanations of why countries could borrow excessively. One explanation is moral hazard: banks could lend excessively to take advantage of some form of government guarantees (see e.g. McKinnon and Pill, 1996; Schneider and Tornell, 2004). Another explanation suggested in policy debates is that emerging markets tend to overborrow when the lending decisions of foreign investors are guided by macroeconomic indicators and not by evaluating an individual borrower’s abilities to repay. Nevertheless, Uribe (2006) found that equilibrium with an aggregate borrowing limit and an equilibrium where the borrowing limit is imposed on individuals deliver the same borrowing decisions. This result represents a form of “no overborrowing.” We will show, however, that in the presence of multiple goods, because individual agents do not internalize the adverse debt-deflation effects of additional borrowing, the private economy exhibits “overborrowing.”

The results of our normative analysis are related to Christiano, Gust, and Roldos (2004) and Benigno, Chen, Otrok, Rebucci, and Young (2008) who show that stabilization plans can be optimal when economies face Sudden Stops. While the policy implications of Christiano et al. (2004) and Benigno et al. (2008) suggest the need of a “reactive” policy to reduce the severity of Sudden Stops once they take place, our normative analysis suggests the need of a “prudential” policy during relatively tranquil times in order to reduce the economy’s vulnerability to these episodes. The fact that many stabilization plans have fallen during recent Sudden Stops may lend support to prudential regulation, which helps prevent the economy from exposure to these episodes. Our paper provides a quantitative framework to analyze policies that have this objective.

Our results are also related to the ongoing debate on the desirability of financial globalization. Standard neoclassical theory predicts that the liberalization of the capital account will generate international risk sharing and efficient capital reallocation. Critics like Stiglitz incomplete markets and multiple goods are generically inefficient (see Geneakoplos and Polemarchakis, 1986 and Stiglitz, 1982). The multiplicity of goods in our model is given by the presence of two types of goods: tradable and non-tradable.
(2002) and Bhagwati (2004) have argued against financial globalization on the grounds that it makes emerging markets vulnerable to financial crises. Recently, Korinek (2008b) develops this argument further in a theoretical model and shows how taxes on particular capital flows can be welfare improving. Our paper contributes to this debate by undertaking a quantitative investigation of how a state contingent tax on capital flows can be effective in reducing the vulnerability to financial crises while still allowing the benefits from access to the global financial market.

The remainder of the paper is organized as follows: Section 2 presents the analytical framework; Section 3 characterizes the decentralized equilibrium and the social planner’s problem, in addition to demonstrating the externality results of the paper; Section 4 and Section 5 analyze the quantitative significance of the systemic credit externality; Section 6 discusses welfare and policy implications; and, Section 7 provides conclusions.

2 Analytical Framework

Consider an endowment version of the representative-agent two-sector DSGE-SOE model with tradable and non-tradable goods. Tradable goods can be used for external borrowing and lending transactions; non-tradable goods have to be consumed in the domestic economy. We assume that debt is denominated in units of tradables with a credit constraint that links credit-market access to income, including non tradable income. This setup, proposed by Mendoza (2002), captures the phenomenon called “liability dollarization” in a flexible-price environment setting, which the empirical literature has emphasized as being an important transmission mechanism of financial crisis in emerging markets.2

2.1 Households

There is a continuum of identical, infinitely lived households of measure unity. Preferences of the representative household are given by:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(c_t) \right\}$$

In this expression, $E(\cdot)$ is the expectation operator and $\beta$ is the discount factor. The period utility function $u(\cdot)$ has the constant-relative-risk-aversion (CRRA) form. The consumption basket $c_t$ is an Armington-type CES aggregator with elasticity of substitution $1/(\eta + 1)$ between tradable $c^T$ and non tradable goods $c^N$ given by:

$$c_t = \left[ \omega (c^T_t)^{-\eta} + (1 - \omega) (c^N_t)^{-\eta} \right]^{-\frac{1}{\eta}}, \quad \eta > -1, \omega \in (0,1)$$

Households receive a random endowment of tradables $y^T_t$ and a constant endowment of non-tradables $y^N$. The tradable endowment shock has a compact support and follows a finite-state stationary Markov process. Foreign assets are restricted to a one period, non-contingent bond denominated in units of tradables that pay a fixed interest rate $r$ determined exogenously in the world market. In order to have a well defined ergodic distribution of foreign assets, i.e. a well defined stochastic steady state, we assume that the discount factor and the interest rate are such that $\beta (1 + r) < 1$.\(^3\)

Normalizing the price of tradables to 1 and denoting the price of non-tradable goods by $p^N$, the budget constraint is:

$$b_{t+1} + c^T_t + p^N_t c^N_t = y^T_t + b_t (1 + r) + p^N_t y^N$$

where $b_{t+1}$ denotes foreign assets that households choose at the beginning of time $t$.\(^4\) Households can borrow up to a fraction $\kappa$ of their income, so that:

$$b_{t+1} \geq -\kappa (p^N_t y^N + y^T_t)$$

This type of credit constraint imposes an upper bound on leverage, defined as the debt-to-income ratio, which may arise in optimal contracts where a higher level of income supports debt repayment incentives under limited commitment.\(^5\) Borrowing constraints of this form

\(^3\)When $\beta (1 + r) < 1$, $\beta' (1 + r)^t u'(c_t) < 1$ is a nonnegative supermartingale that converges almost surely to a nonnegative random variable (see Chamberlain and Wilson (2000)). Hence the long-run averages of assets and consumption also remain finite. In contrast, with $\beta (1 + r) \geq 1$, assets diverge to infinity in the long run because the marginal utility converges to zero almost surely. See Schmitt-Grohe and Uribe (2003) for other specifications used for this purpose.

\(^4\)As there is only one asset, gross and net foreign assets (NFA) coincide.

\(^5\)For examples on how to derive credit constraints within an optimal contract framework, see e.g. Holm-
are widely used by lenders in determining maximum loan amounts and in setting borrowers’ qualification criteria, particularly in mortgage loans and in consumer debt contracts (see Arellano and Mendoza (2003) for a discussion).\footnote{While many credit markets are characterized by a constraint that is linear in current income, the externality result does not depend on this particular specification, which we assume here for simplicity.}

Given a stochastic sequence of prices, the consumer problem consists of maximizing the expected present discounted value of utility (1) subject to the sequence of borrowing and credit constraints given by (2) and (3). The optimization problem for a typical household of this small open economy is analogous to the optimization problem of a single household in the heterogeneous-agents models of precautionary savings (e.g., Aiyagari, 1994 or Hugget, 1993). As in those models, CRRA utility implies a strong aversion to a zero consumption basket. In addition, since the CES aggregator implies that $\lim_{c_T \to 0^+} u'(c) c_T (c^T, c^N) = \lim_{c_N \to 0^+} u'(c) c_N (c^T, c^N) = +\infty$ agents will self-insure to rule out stochastic sequences that could expose them to zero consumption of tradables or non-tradables at any date at any state of nature.

### 2.2 Decentralized Competitive Equilibrium Conditions

The optimality conditions of the household problem are:

\begin{align*}
\lambda_t &= u'(t)c_T(t) \quad (4) \\
\bar{p}_t^N &= \left(\frac{1 - \omega}{\omega}\right) \left(\frac{c_T}{c_N}\right)^{\eta+1} \quad (5) \\
\lambda_t &= \beta E_t \lambda_{t+1} (1 + r) + \mu_t \quad (6) \\
0 &= \mu_t \left[b_{t+1} + \kappa \left(\bar{p}_t^N y^N + y_t^T\right)\right] \quad (7)
\end{align*}

where $\lambda$ is the multiplier associated with the budget constraint and $\mu$ is the multiplier associated with the credit constraint. The optimality condition (4) equates the marginal utility of tradables consumption to the shadow value of current wealth. Condition (5) is a static condition linking the marginal rate of substitution of two goods, tradables and non-tradables, to their relative price. Equation (6) determines the intertemporal allocation of
wealth and consumption. When the credit constraint is binding, there is a wedge between the current shadow value of wealth and the expected value of reallocating wealth to the next period given by the shadow price of relaxing the credit constraint $\mu_t$. Condition (7) is the standard complementary slackness condition.

Since consumers are identical, market clearing conditions are given by:

\[ c^N = y^N \]  
\[ c^T = y^T + b_t(1 + r) - b_{t+1} \]

Note from (5) that when a negative shock occurs, the reduction in $c^T_t$ that follows generates on equilibrium a reduction in $p^N_t$, which by equation (3) reduces the collateral value. Therefore, the credit constraint produces asymmetric responses of the economy to shocks, as in Mendoza (2002). Binding credit constraints amplifies the consumption drop in response to negative shocks to tradables’ output, relative to perfect capital markets. But, there are no amplification effects when credit constraints are slack. As in a standard model of insurance, the demand for borrowing is decreasing with current income $y^T_t$. As a result, for a given $p_t^N$ there is a threshold $\hat{y}^T_t$ such that for any $y^T_t < \hat{y}^T_t$ the constraint becomes binding.

Given an initial foreign asset position $b_0$, the stochastic process for $y^T$ and the world real interest rate $r$, the competitive equilibrium is fully characterized by a set of stochastic sequences $\{c^T_t, c^N_t, b_{t+1}, p^N_t, \lambda_t, \mu_t\}_t=0^\infty$ such that (3)-(9) are satisfied.

3 Recursive Problem

3.1 Decentralized Competitive Equilibrium

We start by describing the optimization problem of a typical agent in recursive form. A crucial feature of this setup is that aggregate bond holdings, denoted by $B$, constitute a state variable in this problem. This feature arises because the representative agent needs to forecast aggregate variables beyond his control in order to form expectations of future prices. In particular, the representative agent needs to forecast aggregate tradable and non-tradable consumption to predict the price of non-tradables. Because the endowment of

\footnote{See Mendoza (2006) for an illustrative deterministic example of this mechanism.}
non-tradables is fixed, the forecast of non-tradables consumption is simply \( y^N \). In order to forecast tradable consumption, the representative agent must conjecture a law of motion for the aggregate foreign asset position. We denote by \( \Gamma(\cdot) \) the conjectured law of motion for the aggregate foreign asset position, which is a function of the current aggregate state \((B, y^T)\). Using (5), the forecast price for non-tradables at time \( t \) can be expressed as:

\[
 p^N(B_t, y^T_t) = \left(\frac{1 - \omega}{\omega}\right) \left(\frac{y^T_t + B_t(1 + r) - \Gamma(B_t, y^T_t)}{y^N}\right)^{\eta+1} \tag{10}
\]

The optimization problem of a typical agent is:

\[
 V(b, B, y^T) = \max_{b', c^T, c^N} u(c(c^T, c^N)) + \beta E_t V(b', B', y^T') \tag{11}
\]

subject to

\[
 b' + p^N(B, y^T)c^N + c^T = y^T + b(1 + r) + p^N(B, y^T)y^N \\
 b' \geq -\kappa \left(p^N(B, y^T)y^N + y^T\right) \\
 B' = \Gamma(B, y^T)
\]

where we have followed the convention of denoting current variables without subscript and denoting next period variables with the prime superscript.

The solution to the household problem provides decision rules for individual bond holdings \( \hat{b}(b, B, y^T) \), tradables consumption \( \hat{c}^T(b, B, y^T) \) and non-tradables consumption \( \hat{c}^N(b, B, y^T) \). The household optimization problem induces a mapping from the conjectured law of motion for the aggregate foreign asset position \( \Gamma(\cdot) \) to an actual law of motion, given simply by the representative agent’s choice \( \hat{b}(B, B, y^T) \). In a rational expectations equilibrium, as defined below, these two laws of motion must coincide.

**Definition 1 (Decentralized Recursive Competitive Equilibrium)**

A recursive decentralized competitive equilibrium for the SOE is a pricing function \( p^N(B, y^T) \), a perceived law of motion \( \Gamma(B, y^T) \) and decision rules \( \{\hat{b}(b, B, y^T), \hat{c}^T(b, B, y^T), \hat{c}^N(b, B, y^T)\} \) such that the following conditions hold:

1. Household optimization: taking as given \( p^N(B, y^T) \) and \( \Gamma(B, y^T) \), \( \{\hat{b}(b, B, y^T), \hat{c}^N(b, B, y^T), \hat{c}^N(b, B, y^N)\} \) solve the optimization problem of the house-
2. **Rational expectation condition:** the perceived law of motion is consistent with the actual law of motion: \( \Gamma(B, y^T) = \hat{b}(B, B, y^T) \).

3. **Markets clear:** \( y^N = \hat{c}^N(B, B, y^T) \) and \( \Gamma(B, y^T) + c^T = y^T + B(1 + r) \).

### 3.2 Social Planner

We previously described the equilibrium achieved when agents take aggregate variables as given, particularly the price of non-tradables. Consider now a benevolent social planner (SP) who directly chooses allocations subject to the collateral constraint and competitive market clearing in order to maximize a representative agent’s utility. As opposed to the representative agent, a social planner internalizes the effects of an agent’s decisions on the price of non-tradables. Critically, the social planner realizes that a lower debt level in a crisis mitigates the reduction in price of non-tradables that would tighten further the borrowing ability and amplify the reduction in tradable consumption. As a result, we will show that the decentralized equilibrium allocation is not constrained efficient, as defined below.

**Definition 2 (Constrained Efficiency)**

Let \( \{\hat{b}(b, B, y^T), \hat{c}^T(b, B, y^T), \hat{c}^N(b, B, y^T)\} \) be the solution to the competitive equilibrium yielding utility \( \hat{V} \). The competitive equilibrium is constrained efficient if a planner who directly chooses allocations, subject to the collateral constraint and competitive markets clearing, cannot improve welfare for the consumer over \( \hat{V} \).

The planner’s optimization problem can be stated as:

\[
V(b, y^T) = \max_{b', c^T} u(c(c^T, y^N)) + \beta E_t V(b', y^{T'})
\]

subject to

\[
b' + c^T = y^T + b(1 + r) \\
b' \geq -\kappa \left( \frac{1 - \omega}{\omega} \left( \frac{c^T}{y^N} \right)^{\eta+1} y^N + y^T \right)
\]

\[
\left( \frac{1 - \omega}{\omega} \right) \left( \frac{c^T}{y^N} \right)^{\eta+1} y^N + y^T
\]

Note that we substitute \( p^N \) with the equilibrium price \( \left( \frac{1 - \omega}{\omega} \right) \left( \frac{c^T}{y^N} \right)^{\eta+1} \) in the collateral constraint and \( c^N = y^N \) in the resource constraint.
Using superscript “SP” to distinguish the multipliers of the social planner from the decentralized equilibrium, this results in the following first order conditions for the social planner:

\[
\lambda_{t}^{SP} = u'(t)c_T(t) + \mu_{t}^{SP}\Psi_t
\]

\[
\lambda_{t}^{SP} = \beta E_t\lambda_{t+1}^{SP}(1 + r) + \mu_{t}^{SP}
\]

where \(\Psi_t = \kappa \frac{\partial p_N}{\partial c_T} y_N = \kappa \frac{1-\omega}{\omega} \left(\frac{c_T}{y_N}\right)^\eta (1 + \eta)\) represents how the collateral value changes in equilibrium when there is a marginal change in tradables consumption. This variable is not present in the corresponding equation for the decentralized equilibrium (4), since decentralized agents take the price of non-tradables as given. Condition (13) states that at the social optimum, the value of a marginal increase in current wealth equals the marginal utility of consumption plus the value of relaxing the credit constraint that arises from the subsequent increase in price of non-tradables. Condition (14) is identical to the decentralized equilibrium condition (6). Note that if the constraint does not bind in the stochastic steady states of the decentralized equilibrium and the social planner, the conditions characterizing both environments are identical and the allocations therefore coincide.

Consider an initial situation where the constraint is satisfied with equality, but is not binding, and a negative shock tightens the borrowing constraint by one unit. Because atomistic agents take prices as given, the perceived decrease in tradables consumption is one unit. However, the social planner internalizes the fact that a decrease in tradables consumption decreases the price of non-tradables, making the constraint even more binding, as captured by \(\Psi_t\). A direct consequence of the debt-deflation effect is summarized in the following proposition that will prove useful to show that the decentralized equilibrium is constrained inefficient.

**Proposition 1 (Wealth Undervaluation)**

Assume the credit constraint binds at time \(t\); let \((b_t, y_T)\) be the initial state and \((c_T^T, c_N^T, b_{t+1})\) be the allocations of the decentralized equilibrium and the social planner. The social planner’s shadow value of wealth is strictly higher than the decentralized agent’s shadow value of wealth.

**Proof.** The proof follows simply by comparing (4) and (13), which yields that the social shadow value of wealth exceeds the private value by \(\mu_{t}^{SP}\Psi_t\).  

11
As explained above, this result stems from the fact that the social planner internalizes that a marginal increase in wealth would allow a marginal increase in consumption, relaxing the credit constraint by $\Psi_t$ with a marginal utility of $\mu_{t}^{SP}$.

Suppose that at time $t$ the constraint is not binding, but it may become a binding constraint in the next period if a sufficiently high leverage is chosen. Using (6) and (4), the Euler equation for consumption for the decentralized equilibrium is simply:

$$u'(c_t) = \beta E_t u'(c_{t+1})(1 + r)$$

(15)

Using (14) and (13), the Euler equation for consumption for the social planner becomes:

$$u'(c_t) = \beta E_t \left[u'(c_{t+1}) + \mu_{t+1}^{SP} \Psi_{t+1}\right] (1 + r)$$

(16)

Consider now a reallocation of wealth by the social planner starting from the privately optimal allocations in the decentralized equilibrium. In particular, consider the welfare effects of a reduction of one unit of debt. Because decentralized agents are at the optimum,(15) shows that the first order private welfare benefits of an additional marginal unit of savings $\beta E_t u'(c_{t+1})(1 + r)$ are equal to the first order private welfare losses $u'(c_t)$. Using (16), the social planner has a marginal cost of reducing debt equal to the private marginal cost, but faces higher marginal benefits given by $\beta E_t \left[u'(c_{t+1}) + \mu_{t+1}^{SP} \Psi_{t+1}\right] (1 + r)$. The last term corresponds to the expectation on how an additional marginal unit of savings helps relax the credit constraint due to the debt-deflation channel when it becomes binding, a fact not internalized by the representative agent. This yields our externality result.

**Proposition 2 (Constrained Inefficiency)**

Assume the credit constraint binds in some state of nature in the decentralized equilibrium. Then, the decentralized equilibrium is not constrained efficient.

**Proof:** See appendix
4 Solution Method and Calibration

The previous section showed analytically that the decentralized equilibrium is constrained inefficient. In particular, it showed that the social shadow value of wealth exceeds the private shadow value of wealth during a crisis, hence a social planner has a higher incentive to save than an individual agent in the decentralized equilibrium when it is likely that the credit constraint will become binding in a future state of nature. In this section, we describe the solution method and the calibration used to evaluate the quantitative implications of the systemic credit externality.

4.1 Solution Method

The non-linearities introduced by the borrowing constraint require a global method to solve the planner’s problem and the decentralized equilibrium. To solve for the social planner’s problem, we use the algorithm described in Mendoza and Arellano (2004). This method is based on value function iteration and respects that the credit constraint is only occasionally binding. The key difference between this method and the one necessary to solve for the decentralized equilibrium is that atomistic agents must take prices as given. We develop a method to solve for the recursive competitive equilibrium by employing a doubly nested fixed point algorithm.

For any given belief of the evolution of aggregate bonds, there is an “inner” fixed-point algorithm that solves the Bellman equation. There is also an “outer” fixed point algorithm that searches iteratively on a conjecture for the evolution of aggregate bonds that satisfies the rational expectations and market clearing conditions. Once the Bellman equation is solved, the actual law of motion $\hat{b}(B, B, y^T)$ can be derived. If this law of motion do not coincide with the conjectured law of motion, a new trial is obtained and fed into the Bellman Equation again.

The new trial is based on a Gauss-Seidel algorithm that assigns a decreasing weight to the effective law of motion. It is important to adjust slowly to the new conjecture since iterations on the perceived laws of motions do not follow a contraction mapping and may not converge due to the well-known problem of unstable “hog cycles”. To obtain convergence in
the outer fixed point algorithm, it is also important to allow the agents in their optimization problem to choose a value of net foreign assets which is outside the grid, as in Krusell and Smith (1997). The algorithm to solve for the decentralized equilibrium for any given values of parameters follow these steps:

1. Generate a discrete grid for the economy’s asset and the shock state space.

2. Conjecture a law of motion for aggregate net foreign assets $B' = H(B, y^T)$ at each point of the state space, which implies a price given by (10).

3. Solve for the policy functions \( \{ \hat{b}(b, B, y^T), \hat{c}^T(b, B, y^T), \hat{c}^N(b, B, y^T) \} \) via value function iteration in the bellman equation (11).

4. Using the decision rules in the previous step, calculate the effective law of motion of net foreign assets $\hat{b}(B, B, y^T)$ and evaluate the previous conjecture. If $\sup_{B, y^T} \| \hat{b}(B, B, y^T) - \Gamma(B, y^T) \| < \epsilon$, the recursive competitive equilibrium is found. Otherwise, update $H(B, y^T)$ with a Gauss-Seidel algorithm and go to step 3.

The solution method is described in more detail in the appendix.\(^9\)

### 4.2 Calibration

The values assigned to all models’ parameters are listed in Table 1. A period in the model represents a year. As a baseline calibration, we use data from Argentina, an example of an emerging market with a business cycle that has been studied extensively.

The risk aversion parameter and the world interest rate are typical parameters in DSGE-SOE models. In order to make our results easier to compare with previous studies, we set the risk aversion parameter $\sigma=2$ and the world interest rate $r=4$ percent.\(^{10}\)

We assume that the endowment for tradables follows a log AR(1) process such that $\ln y^T_t = p \ln y^T_{t-1} + \varepsilon_t$ and $\varepsilon_t \sim N(0, \sigma^2_\varepsilon)$. This process is estimated using the annual sectorial data from the World Development Indicators (WDI) from 1965 to 2007, the longest time

---

\(^9\)See Rust (2008) for an extensive treatment of numerical methods to solve competitive equilibria and dynamic games.

\(^{10}\)See for example Mendoza (1991), Neumeyer and Perri (2005) and Aguiar and Gopinath (2007).
After de-trending the data with the HP filter with a parameter of 100, the standard value for annual data, the estimation of the cyclical component of the tradable output process yields a standard deviation $\sigma_y = 0.059$ and an autocorrelation coefficient $\rho = 0.54$. The shock is discretized into a finite first-order Markov process with five grid points using the quadrature based procedure of Tauchen and Hussey (1991). The endowment of non-tradables $y^N$ is normalized to one without loss of generality.

The elasticity of substitution is an important parameter because it affects the magnitudes of the price adjustment. For a given reduction in tradable consumption, a higher elasticity implies a lower change in the price of non-tradables and therefore a weaker debt-deflation mechanism. As the price effects are not internalized by decentralized agents, a higher elasticity would tend to reduce the externality. The range of estimations for the elasticity of substitution is between 0.40 and 0.83. As a conservative benchmark, we set $\mu$ such that the elasticity of substitution equal the upper bound of this range.

The three remaining parameters are the discount factor $\beta$, the weight of tradable goods in the utility function $\omega$ and the credit constraint coefficient $\kappa$, which are set so that the long run moments of the decentralized equilibrium matches three historical moments of the data. The discount factor is set so that the average net foreign asset position-to-GDP ratio in the model equals its historical average in Argentina, which is equal to -29 percent in the dataset constructed by Lane and Milesi-Ferretti (2001). This calibration results in a value of $\beta$ equal to 0.91, a standard value for annual frequency (see e.g. Aguiar and Gopinath, 2007).

The weight of tradables consumption in the CES aggregator $\omega$ is calibrated to match a share of tradables production of 32 percent. This is a reasonable approach to calibrate series available from official sources. We classify manufacturing industry and primary products as tradables, following the standard methodology. After de-trending the data with the HP filter with a parameter of 100, the standard value for annual data, the estimation of the cyclical component of the tradable output process yields a standard deviation $\sigma_y = 0.059$ and an autocorrelation coefficient $\rho = 0.54$. The shock is discretized into a finite first-order Markov process with five grid points using the quadrature based procedure of Tauchen and Hussey (1991). The endowment of non-tradables $y^N$ is normalized to one without loss of generality.

The elasticity of substitution is an important parameter because it affects the magnitudes of the price adjustment. For a given reduction in tradable consumption, a higher elasticity implies a lower change in the price of non-tradables and therefore a weaker debt-deflation mechanism. As the price effects are not internalized by decentralized agents, a higher elasticity would tend to reduce the externality. The range of estimations for the elasticity of substitution is between 0.40 and 0.83. As a conservative benchmark, we set $\mu$ such that the elasticity of substitution equal the upper bound of this range.

The three remaining parameters are the discount factor $\beta$, the weight of tradable goods in the utility function $\omega$ and the credit constraint coefficient $\kappa$, which are set so that the long run moments of the decentralized equilibrium matches three historical moments of the data. The discount factor is set so that the average net foreign asset position-to-GDP ratio in the model equals its historical average in Argentina, which is equal to -29 percent in the dataset constructed by Lane and Milesi-Ferretti (2001). This calibration results in a value of $\beta$ equal to 0.91, a standard value for annual frequency (see e.g. Aguiar and Gopinath, 2007).

The weight of tradables consumption in the CES aggregator $\omega$ is calibrated to match a share of tradables production of 32 percent. This is a reasonable approach to calibrate

---

11See for example Garcia (2008) and Mendoza and Terrones (2008).

12This results in actual standard deviation and autocorrelation which are 99.8 percent of the true values.


14We then show in the sensitivity analysis how a lower elasticity of substitution can increase the distortions produced by the externality even more compared to the baseline scenario.

15Garcia(2008) reports an average share of tradables of 32 percent using almost a century data from
Table 1: Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>( r = 0.04 )</td>
<td>Standard Value DSGE-SOE</td>
</tr>
<tr>
<td>Risk Aversion</td>
<td>( \sigma = 2 )</td>
<td>Standard Value DSGE-SOE</td>
</tr>
<tr>
<td>Elasticity of substitution</td>
<td>( \frac{1}{(1 + \eta)} = 0.83 )</td>
<td>Conservative value</td>
</tr>
<tr>
<td>Non tradable endowment</td>
<td>( y^N = 1 )</td>
<td>Normalization</td>
</tr>
<tr>
<td>Stochastic Structure</td>
<td>( \sigma_{yt} = 0.059 )</td>
<td>Argentina’s economy</td>
</tr>
</tbody>
</table>

**Calibration**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Factor</td>
<td>( \beta = 0.91 )</td>
<td>Average NFA-GDP ratio=29%</td>
</tr>
<tr>
<td>Weight on Tradables in CES</td>
<td>( \omega = 0.31 )</td>
<td>Share of Tradable Output=32%</td>
</tr>
<tr>
<td>Credit Coefficient</td>
<td>( \kappa = 0.32 )</td>
<td>Frequency of Sudden Stops 8.2%</td>
</tr>
</tbody>
</table>

\( \omega \) since manipulating (5) yields that the ratio of non-tradables-tradables GDP denoted by \( \frac{\tilde{p}^N y^N}{\tilde{p}^T y^T} \) equals \( \left( \frac{1-\omega}{\omega} \right) \left( \frac{\tilde{c}_T}{\tilde{c}_N} \right)^\eta \). This calibration results in a value of \( \omega \) of 0.31, close to the values used in the literature.\(^{16}\)

The maximum amount that can be borrowed \( \kappa \) is calibrated to match the observed frequency of Sudden Stops of Argentina which is about 8.2 percent in Eichengreen, Gupta, and Mody (2006)’s data set. To be consistent with the Sudden Stops definition of Eichengreen et al. (2006), we define Sudden Stops in our model as events where the credit constraint binds and the increase in net capital outflows-to-GDP ratio exceeds one standard deviation. This calibration results in a value of \( \kappa \) equal to 0.32.

## 5 Results of the Quantitative Analysis

This section reports the results of the quantitative analysis that evaluate the significance of the systemic credit externality by comparing the results from simulating the social planner’s solution and the decentralized equilibrium. We are particularly interested in how the distortion introduced by the systemic credit externality affects the vulnerability to financial crises and the aggregate level of debt. We start by showing how the policy functions of the social planner and the decentralized equilibrium differ and then analyze the consequences for the long run distribution of debt and for the probability and the severity of a financial crisis. To complete the quantitative analysis, we present a comparison of the simulation results to Argentina. The average share of tradables in the data used from WDI is also 32 percent for the period 1980-2006.

\(^{16}\)For example, Durdu, Mendoza, and Terrones (2008) sets \( \omega \) to 0.34.
the data and an extensive sensitivity analysis.

5.1 Policy Functions

Figure 1 shows how the policy function for the social planner differs from the decentralized equilibrium policy function when the shock is one standard deviation below trend.\textsuperscript{17} Since the mean value of tradables output is 1, we can interpret all results in terms of this variable. Without the endogenous borrowing constraint, the policy function for next period’s net foreign assets would be monotonically increasing in current net foreign assets. However, when the actual model economy is hit by the negative shock while the credit constraint binds, a lower current net foreign asset position reduces the level of tradables consumption consistent with the credit constraint, thereby reducing the price of non-tradables. Because the credit constraint depends endogenously on the price of non-tradables, this means that the credit constraint becomes tighter. Therefore, the economy displays a policy function for next period foreign assets that is decreasing in current foreign assets in the range for which the credit constraint binds.

In terms of Figure 1, this range corresponds approximately to a level of foreign assets lower than -0.94 for the social planner, but lower than -0.93 for the decentralized equilibrium.\textsuperscript{18} Because atomistic agents do not internalize the price effects of their actions, they continue to borrow enough to trigger the binding credit constraint over some range of current assets for which the social planner would choose a lower borrowing level that is monotonically increasing in current foreign assets.

We can distinguish three regions in Figure 1 according to the level of current net foreign assets: a “constrained region,” a “high externality region” and a “low externality region.” For low levels of net foreign assets, the allocations of future bonds coincide, since both the planner and the atomistic agents in the decentralized equilibrium choose the maximum they can borrow. This constitutes the constrained area. At moderately higher current levels of net foreign assets, the economy is still highly leveraged, and a future financial crisis is relatively likely. Consequently, the social planner who internalizes that additional borrowing may result in amplification effects increases future net foreign assets relative to decentralized agents who

\textsuperscript{17}By policy function in the decentralized equilibrium, we refer to the equilibrium law of motion $\hat{b}(B, B, y^T)$.

\textsuperscript{18}Unless otherwise noted, all figures are expressed as percentages of mean tradables output.
take prices as given. This high externality region ends approximately when foreign assets reach -0.77. Finally, as net foreign assets further increase and the probability of a financial crisis becomes relatively low, the policy functions become similar to each other. Comparing the policy functions against the 45-degree line also shows that for relatively low current levels of bonds, the economy increases savings in response to a negative shock, resulting in capital outflows.

5.2 Long Run Distribution of Debt

It is clear from Figure 1 that the decentralized equilibrium will display higher levels of debt than what the social planner would command. Figure 2 shows how the ergodic distri-
bution of net foreign assets for the decentralized equilibrium assigns higher probability to higher levels of debt. The shaded region in Figure 2 illustrates the mass of probability in the decentralized equilibrium’s distribution allocated to high levels of debt that receive no probability in the social planner’s distribution. While the maximum level of debt occurring with positive probability for the planner is approximately 0.91, in the decentralized equilibrium the economy exceeds this level of debt about 80 percent of the time.

These results are critical for understanding why the credit externality makes the economy vulnerable to more frequent and more severe financial crises, as will be shown below. The higher the existing leverage, the greater the adjustment in tradables consumption needed in order to satisfy the credit constraint. Consequently, Figure 2 shows that the social planner
reduces the exposure to states in which the contraction in consumption needed to satisfy the collateral constraint is large. Even if atomistic agents foresee the probability of a large reduction in consumption during a crisis event, the agents do not internalize the impact that their actions have on amplifying the debt-deflation effects.

Table 2 shows how average debt levels differ in the two cases. The mean Debt-to-GDP ratio is 29.2 percent for the private economy and 27.9 for the social planner. A more relevant indicator of the distortion is perhaps the debt-to-GDP conditional on financial crises. In the most severe crisis episodes, the overborrowing reaches 14 percentage points of GDP.

5.3 Financial Crises: Incidence and Severity

In this section we establish that overborrowing in the decentralized equilibrium leaves the economy vulnerable to more frequent and more severe financial crises, i.e. sudden stops.\textsuperscript{19} To demonstrate this result, we use the policy functions of the model to conduct an event analysis exercise. We perform a 50,000-period stochastic time series simulation of the social planner and the decentralized equilibrium’s allocations, and use the resulting artificial data to study the changes on impact during Sudden Stop (SS) events as defined above (i.e. periods in which the credit constraint becomes binding and the increase in the current account-GDP ratio exceeds one standard deviation ).\textsuperscript{20}

According to the simulation, the social planner cuts the long-term probability of a financial crisis by a factor of more than seven, from 8.2 percent to 1.1 percent. For chosen

---

\textsuperscript{19}Since financial crises in our model take the form of Sudden Stops, we use these terms interchangeably.

\textsuperscript{20}A binding credit constraint in our simulations may not always deliver capital outflows, consumption drops, and real exchange rate depreciation, although they conceptually increase the amplification relative to perfect capital markets. Therefore, we set as a threshold an increase in capital outflows equivalent to one-standard-deviation of capital outflows in the decentralized equilibrium, which is consistent with the empirical literature. Our results are robust to different alternative definitions of a crisis event.
levels of debt higher than 0.85, there is a positive probability in our simulations under both environments that a negative shock will trigger the credit constraint in the next period. Because the social planner reduces leverage relative to the private economy, the chances that a negative shock will trigger the credit constraint decreases. In fact, in the social planner’s problem, financial crises occur with positive probability only if a negative shock that is larger than two standard deviations is realized. In contrast, the economy in the decentralized equilibrium has about a 23 percent chance of carrying a debt level such that a negative one-standard-deviation shock would cause a financial crisis.

The fact that the credit externality produces excessive levels of debt implies that for a given negative shock triggering the credit constraint, the magnitudes of financial crises will become more severe. In fact, about 19 percent of the crises of the decentralized equilibrium are more severe in terms of the consumption drop than the most severe financial crisis of the social planner.

According to the social planner, crises occur only when the economy is hit by a shock larger than two standard deviations, hence the average financial crises are still quite similar with and without the externality. On average, the current account increases 6 percentage points of GDP and consumption decreases about 9 percent in both environments. A more accurate indicator of the distortion compares how the most severe crisis episodes differ with and without the credit externality. As Table 3 shows, the drops of consumption, the real exchange rate and capital flows on impact are more pronounced in the most severe crises of the decentralized equilibrium relative to the most severe crisis episodes of the social planner. Capital outflows in the decentralized equilibrium increases 25 percentage points of GDP (versus 11 percent in the social planner), consumption collapses 24 percent (versus 14 percent in the social planner) and the real exchange rate falls 49 percent (versus 33 percent in the social planner) relative to long run values. \(^{21}\)

The more severe and the more frequent financial crises that the decentralized economy experiences is a result of the fact that private agents take prices as given and do not internalize that their additional borrowing results in amplification effects when negative income

\(^{21}\)We utilize the maximum financial crisis for both environments for simplicity; in general, any statistic that captures the tail of the distribution of the most severe episodes will deliver very similar results.
Table 3: Incidence and Severity of Financial Crises

<table>
<thead>
<tr>
<th>Crises Statistic</th>
<th>Decentralized Equilibrium</th>
<th>Social Planner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>8.2%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Consumption</td>
<td>-24%</td>
<td>-14%</td>
</tr>
<tr>
<td>Current Account</td>
<td>25%</td>
<td>11%</td>
</tr>
<tr>
<td>Real exchange Rate</td>
<td>-49%</td>
<td>-33%</td>
</tr>
</tbody>
</table>

Note: Financial Crises are defined as events where the credit constraint binds and the current account-GDP ratio increases more than one standard deviation. The changes on impact correspond to the maximum changes during financial crises.

shocks trigger the credit constraint. Larger leverage requires a more drastic reduction in consumption, which in equilibrium depreciates the real exchange rate and reduces the value of collateral. As a result, consumption is reduced even further through the spiral decline in consumption, real exchange rate, and collateral value.

5.4 Comparison to the Data

The business cycle moments for emerging economies and the regularities of Sudden Stops are well documented and the results obtained in this paper are consistent with previous studies.\textsuperscript{22} Table 6 shows the business cycle statistics computed for the decentralized equilibrium’s simulation, and Table 4 reports the business cycle statistics for Argentina. To make the results comparable, we express both sets of moments in units of tradables. A comparison between these two sets of moments shows that the decentralized equilibrium succeeds at accounting for key business cycle regularities. Consumption is more volatile than output, displaying positive correlation with output and serial autocorrelation. Another feature of the model which is consistent with the data is that the current account is negatively correlated with output. This result is driven by the endogenous borrowing constraint, which becomes tighter during crises due to the real depreciation that erodes the ability to borrow. The magnitudes of Sudden Stops reported in the event analysis are also in the same orders of magnitudes of actual Sudden Stops as reported in Table 7.

Most of the long run business cycle moments of the social planner and the decentral-
ized equilibrium do not present substantial differences, because the differences between the simulations are concentrated on relatively low probability events, i.e. when the constraint is binding. Still, in the decentralized equilibrium, capital inflows are more procyclical and consumption is relatively more volatile.

5.5 Sensitivity Analysis

How does the magnitude of the externality change with different values assigned to the parameters? According to Proposition 1, the difference between the social shadow value of wealth and the private shadow value of wealth is given by the “externality term” $\mu_t \Psi_t$ where $\Psi_t = \kappa \frac{1-\omega}{\omega} \left( \frac{y_T}{y_T^p} \right)^{\eta} (1 + \eta)$. Therefore, changes in parameter values will affect the externality directly through $\Psi_t$ or through general equilibrium effects in the externality term.

Table 8 present the results of the sensitivity analysis with respect to the elasticity of substitution parameter $\mu$, credit coefficient $\kappa$, risk aversion $\sigma$, standard deviation of tradable output $\sigma_{yT}$ and the weight share of tradables in the utility function $\omega$. Overall, the sensitivity analysis suggests that the credit externality creates for plausible parameterizations moderate distortions in the decentralized equilibrium either because they increase the incidence of financial crises or because they increase the severity of these episodes—in general both. We analyze here how the distortion changes with the elasticity of substitution between tradables and non-tradables and leave the rest of the analysis for the appendix.

As mentioned above, we chose as a conservative baseline an elasticity of substitution that is in the upper bound of the estimations. With a lower elasticity of substitution, a given decrease in consumption requires a greater adjustment in the real exchange rate in order to equilibrate the market. Because the social planner internalizes the price effects of individual actions, the distortion introduced by the externality increases with a lower elasticity of substitution. In fact, with an elasticity of substitution lower than 0.7 the social planner does not experience financial crises while the decentralized equilibrium still experiences financial crises 2.3 percent of the time, and the severity of these episodes is even stronger.

Figure 3 shows how overborrowing changes with the elasticity of substitution conditional on the most severe crisis episodes.\(^{23}\) The differences in the probability of a financial crisis

\(^{23}\)When the social planner does not experience financial crises, we replace the Debt-to-GDP ratio in the most severe crisis episodes with the maximum Debt-to-GDP from the simulations.
and the changes conditional on these episodes follow a similar pattern. When the elasticity of substitution is 0.4 which is the lower bound of the estimations, overborrowing can reach 37 percentage points of GDP. The overborrowing decreases sharply as the social planner starts to experience financial crises with positive probability and then is reduced more gradually. While theoretically, the distortion is qualitatively present for any finite value of the elasticity, for values of the elasticity greater than 4, the allocations of the social planner and the decentralized equilibrium becomes almost indistinguishable.\footnote{For values of the elasticity of substitution above 5, the probability of financial crises as well as the changes conditional on these episodes are the same when rounded these figures to the first decimal place.}

![Figure 3: Sensitivity Analysis: Elasticity of Substitution and Overborrowing. Note: Overborrowing is measured as the difference in the Debt-to-GDP ratio between the decentralized equilibrium and the social planner conditional on the most severe crisis episodes.](image)

### 6 Welfare and Policy Implications

First, best policy measures are necessary to address the root of the externality: the borrowing constraint. Examples of such policies are enhancing the enforcement of contracts and increasing transparency. We focus here on second-best policy measures. The questions that we address in this section are what policies should the government pursue to correct the externality and how big are the welfare gains associated with these policies.\footnote{This form of taxation is often denominated as Pigouvian}
Theoretically, a wide range of policy measures can improve welfare from the decentralized equilibrium outcome; our focus is on how state contingent taxation on debt can correct the systemic credit externality. The following proposition summarizes our results:

**Proposition 3 (Optimal Policy)**

Consider the social planner’s solution be \( \{ c^T_t, c^N_t, b^T_t, p^N_t, \lambda^SP_t, \mu^SP_t \}_{t=0}^{t=\infty} \). Let the linear tax rate on debt contingent on the level of borrowing chosen at time \( t \) and collected at time \( t + 1 \) be:

\[
\tau^*_{t,t+1} = \begin{cases} 
(1 + r) \frac{E_t \mu^SP_{t+1} \Psi_{t+1}}{E_t u_T(t+1)} & \text{if } \mu^SP_t = 0 \\
0 & \text{if } \mu^SP_t > 0 
\end{cases}
\]

(17)

which is returned to households in the form of lump sum transfers \( T_{t,t+1} = b_{t+1} \tau^*_{t,t+1} \). Then the social planner’s allocations \( \{ c^T_t, c^N_t, b^T_t \} \), price \( \{ p^N_t \} \) and policies \( \{ \tau^*_{t,t+1}, T_{t,t+1} \} \) constitute a decentralized competitive equilibrium.

**Proof:** See appendix

The intuition for this expression is straightforward: (17) represents the non-internalized marginal cost of raising debt for the next period. If the constraint is triggered for the next period, a marginal increase in debt requires a further tightening of the credit constraint of \( \Psi_{t+1} \), which has a marginal utility cost of \( \mu^SP_{t+1} \). The non-internalized marginal cost of raising debt is then given by the expected marginal utility cost of tightening the credit constraint \( E_t (1 + r) \mu^SP_{t+1} \Psi_{t+1} \), normalized by the expected marginal utility \( E_t u_T(t+1) \).

For a given state, the tax that will be paid the next period depends on the level of borrowing chosen in the current period. When the level of borrowing is relatively low, the economy is not vulnerable to a financial crisis in the next period, and no tax is charged. As the economy increases borrowing, it becomes likely that a financial crisis will take place; therefore, a tax is charged. The tax increases with the terms \( \Psi_{t+1} \) and \( \mu^SP_{t+1} \) for the reasons explained above. The tax’s dependence on the expectation operator implies that the tax

\[\text{In the empirical literature, taxes on capital flows are also implemented as taxes on foreign debt so we use these terms interchangeably, see Gallego, Hernández, and Schmidt-Hebbel (1999).}\]
rate should be higher the more likely a financial crisis will occur the next period.\textsuperscript{27}

How large must the tax be in order to correct the externality? Note that because the tax paid at time \( t+1 \) is contingent on the level of borrowing chosen at time \( t \), there is a subset of taxes that is not paid in equilibrium. We denominate effective tax rates, those taxes that are actually paid in equilibrium. The maximum effective tax rate that decentralized agents pay with positive probability is 17 percent and the average effective tax rate is 4.5 percent.

Figure 4 shows the effective tax rate when tradables output is one standard deviation below trend for different levels of current net foreign assets. There is a parallel between the effective tax rate and the three regions described in Figure 1. In the constrained region, when the crisis is already underway, taxing of borrowing is ineffective. In the high externality region, where decentralized agents take on a level of debt that leaves the economy substantially more vulnerable to a financial crisis than the social optimum, a tax must be imposed to discourage borrowing. As the initial level of net foreign assets decrease, the choice of net foreign asset position for next period implies a higher debt, and therefore a higher expected shadow value of wealth next period. In this way, the tax tends to increase when current net foreign assets decreases. Finally, in the low externality region, borrowing in the private economy is low enough to avoid future financial crises, and no tax is needed.

It is worth noting that in general correcting the externality reduces the vulnerability to financial crises but does not rule them out in the long run. Because a constrained social planner cannot brake Fisher’s debt deflation, it is still socially optimal to experience a crisis in some unfortunate states of nature. The trade-off of the optimal policy should be clear: discouraging leverage reduces systemic risk, yet postponing consumption is not free. Our policy trade-off resembles the dilemma in Bordo and Jeanne (2002) about how optimal monetary policy should respond to a credit boom: preventing a credit boom reduces the probability of a future bust, but this prevention entails immediate costs in terms of output.

The relation between the optimal tax and the business cycle is highly non-linear. Specifically, in our model, taxes on debt are charged outside crisis states in order to reduce the vulnerability to financial crisis. The optimal policy also reduces the procyclicality of capital

\textsuperscript{27}Note that the tax is not dependent on next period state of nature; therefore, the Government is not effectively introducing new risk markets, (see Stiglitz,1982).
flows as discussed above, which in Kaminsky, Reinhart, and Végh (2004) is documented as an important regularity of emerging markets that makes these countries financially more unstable. In broader terms, our analysis can be seen as a case for macro-prudential regulation or prudential taxation (see for example Jeanne, 2008).

We now analyze the welfare gains associated with correcting the systemic credit externality. It is well-known that the welfare cost of business cycles is typically small. Since the welfare gains from correcting the credit externality are associated with a smoother business cycle, the benefits from correcting the externality are also quite small. Following Lucas (1987), we first calculate the increase in consumption across all states of nature in the decentralized equilibrium necessary to make a consumer indifferent between living in the decentralized equilibrium (without government intervention) and correcting the externality starting at a particular state. Formally, for an initial state \((b, y)\), the welfare gain is \(\gamma\) such that:

\[
E_0 \sum_{t=0}^{\infty} \beta^t u(c_{t}^{DE} (1 + \gamma)) = E_0 \sum_{t=0}^{\infty} \beta^t u(c_{t}^{SP})
\]

where \(c_{t}^{DE}\) is the agent’s consumption in the decentralized equilibrium and \(c_{t}^{SP}\) is the agent’s
consumption in the social planner when starting at an initial state \((b, y)\).\(^{28}\)

For a given initial negative shock, the welfare gains graph displays a hump shape; Figure 5 shows the welfare gains of correcting the externality when tradable output is one standard deviation below the mean. For high values of leverage, the economy is already constrained so the welfare gains from correcting the externality occur in the distant future. At higher levels of current foreign assets, the economy is vulnerable to a financial crisis in the next period. Since the social planner acts in a precautionary way, the welfare gains from correcting the externality increase. Finally, in the low externality region, financial crises become less likely and the present discounted value of correcting the externality is reduced.

On average the welfare gains from correcting the externality are approximately 0.1 percent of permanent consumption. Even if the optimal policy does not introduce additional securities that partially complete the market, the welfare gains are larger than the benefits from introducing asset price guarantees (see Mendoza and Durdu, 2007) or the benefits from introducing indexed bonds (see Durdu, 2008), often suggested as policies to address Sudden Stops (see Caballero (2002)). We see these welfare gains of correcting the externality only as a lower bound. First, we take as given the supply side of the economy. If a financial crisis affects for example the access of firms to working capital, it is likely that more severe financial crises as a result of the externality will produce output effects, therefore delivering higher welfare costs. Second, the risk we have considered is only aggregate; Chatterjee and Corbae (2007) shows that the welfare gains of eliminating the possibility of a crisis state can be as large as 7 percent of permanent consumption when considering idiosyncratic risk.

Our welfare analysis provides insights on how the benefits of the introduction of new financial regulation can be linked to the business cycle. There is some debate among policy-makers on the right timing to introduce financial regulation. Often a concern is that introducing financial regulation during the early stages of a financial crisis can cause this regulation to be counterproductive. The results in this paper suggest that financial reform delivers the maximum benefits as financial crisis become relatively likely.

The results of our normative analysis are related to Christiano et al. (2004) and Benigno

\[ V^{SP}(b, y) = (1+\gamma(b, y))^{1-\sigma} V^{DE}(b, y) \]

\(^{28}\)Because of the homotheticity of the utility function, (18) can be written as: (1+\gamma(b, y))^{1-\sigma} V^{DE}(b, y) = V^{SP}(b, y)
et al. (2008) who study optimal policy in a setup where credit-market access is linked to the non-tradables output as in this paper. Christiano et al. (2004) studies optimal monetary policy in response to an unanticipated Sudden Stop and shows that raising the interest rate may be optimal. The argument for this policy is to limit the depreciation of the domestic currency that makes the borrowing constraint tighter. Benigno et al. (2008) analyzes instead the desirability of a subsidy on non-tradable goods when the economy may face in the future a Sudden Stop. They find that is optimal to subsidize non-tradable goods to mitigate the real exchange rate depreciation during a financial crisis. In contrast, our policy instrument which achieves the second best solution is characterized by a “prudential” motive: the regulator intervenes before the crisis is in place to reduce leverage, and hence the incidence and the severity of Sudden Stops.

In the context of the debate of financial globalization desirability, Mishkin (2006) among others argues that domestic financial development is necessary to reap the benefits of financial globalization.\textsuperscript{29} Our analysis suggests that when financial development is not complete,

\textsuperscript{29}See also Edwards (1999), Mendoza, Quadrini and Rios-Rull (2007)
countries should integrate with the global financial market, but impose a state contingent
tax on capital inflows to reduce their vulnerability to financial crises. In the long term,
however, by improving the contractual environment of credit markets, countries that address
the underlying root of the externality, i.e. the credit constraint, could obtain higher welfare
gains.

Our rationale for taxing debt differs from the argument that agents do not internalize how
their private debt levels increase the country’s average cost of funds because of monopoly
power in the financial market. Tobin (1978) also proposed a tax on capital flows, but he
claimed it was beneficial solely on the grounds that it reduced volatility per se. In our model,
our policy measure is justified as a response to a well-specified externality.

Our results complement Korinek (2008b), who uses a three-period model to illustrate how
taxing securities that deliver capital outflows in constrained states can be optimal. While
the regulation target in Korinek (2008b) is to alter the financial structure of a given amount
of debt, our regulation target is to reduce the absolute level of debt. Interestingly, the
empirical estimations of the optimal taxes on non-contingent dollar debt in Korinek (2008b)
are of similar orders of magnitudes as the ones we obtain in our DSGE framework.

7 Conclusions

This paper examined how credit constraints that link a private agent’s debt to prices
create a systemic credit externality that magnifies the incidence and the severity of finan-
cial crises. When a negative shock triggers the credit constraint, agents are forced to cut
consumption, which reduces the price of non-tradables and erodes the collateral backed by
non-tradables income. This in turn leads to a further decrease in consumption, which tight-
ens credit constraints even further. Consequently, the economy is plunged into a downward
spiral where the drops in consumption, in the real exchange rate, and in the value of collat-
eral mutually reinforce each other. Although agents are fully rational, they fail to internalize
how additional borrowing results in these adverse debt-deflation amplification effects when
a negative shock triggers the credit constraint.

30 Chile’s experience with taxes on capital inflows is generally seen as successful, see Eichengreen and
31 See Harberger (1985) and Bardhan (1967).
In our quantitative analysis, we found that the credit externality increases the probability of financial crises by a factor of seven, and roughly doubles the average consumption and current account reversals during the most severe episodes. These conclusions are obtained in the context of a two-sector DSGE-SOE model with occasionally binding endogenous credit constraints and an event analysis of financial crises that compares the economy with and without the systemic credit externality.

On the normative side, we have shown that a state contingent tax on debt can decentralize the constrained optimum. The tax should be charged in relatively tranquil times to discourage leverage and decrease the vulnerability to financial crises. While we have described this tax as a tax on capital flows, in an extension of the model where financial intermediation plays a role, it could take the form of a capital requirement. This form of capital requirement would go beyond the microeconomic risks of a financial institution and would fit in a context of macro-prudential regulation. We leave this issue for future research.

Although our financial accelerator stems from a feedback loop between the real exchange rate and output, our results suggest that systemic externalities are likely to play an important role for closed economy macroeconomic models as well. A similar mechanism linking asset pricing and economic activity offers promising results to account for the fluctuations observed in the current global financial crises. We also leave this issue for future research.
References


Lorenzo, F., D. Aboal, and R. Osimani (2005): The elasticity of substitution in demand
for non-tradable goods in Uruguay. Inter-American Development Bank, Latin American Research Network.


### Table 4: Argentina-Business Cycle Statistics

<table>
<thead>
<tr>
<th></th>
<th>standard deviation in percent</th>
<th>standard deviation relative to GDP</th>
<th>correlation with GDP</th>
<th>first-order autocorrelation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>15.3</td>
<td>1.00</td>
<td>1.00</td>
<td>0.61</td>
</tr>
<tr>
<td>Consumption</td>
<td>15.5</td>
<td>1.02</td>
<td>0.97</td>
<td>0.51</td>
</tr>
<tr>
<td>Trade Balance-GDP ratio</td>
<td>3.3</td>
<td>0.22</td>
<td>-0.74</td>
<td>0.67</td>
</tr>
<tr>
<td>Current Account-GDP ratio</td>
<td>4.4</td>
<td>0.29</td>
<td>-0.82</td>
<td>0.68</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>27.4</td>
<td>1.79</td>
<td>0.80</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Note: Annual data from International Financial Statistics (IFS), World Economic Outlook (WEO) and World Development Indicators (WDI) for the period 1980-2007. Consumption and GDP are deflated using the price index of tradable goods obtained from WDI, logged and detrended using a Hodrick Prescott filter with a smoothing parameter 100. The Real exchange rate is calculated using the IMF definition \( RER_i = NER_i \times CPI_i / CPI_{US} \) for country \( i \). Standard Deviations of consumption and real exchange rate are expressed in percentage of the mean.

### Table 5: Sudden Stop Events

(Percental Change on impact during Sudden Stop relative to previous year)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Account</td>
<td>10.3</td>
<td>4.9</td>
<td>14.5</td>
<td>5.6</td>
<td>6.5</td>
</tr>
<tr>
<td>Consumption</td>
<td>-22.3</td>
<td>-11.7</td>
<td>-5.6</td>
<td>-4.5</td>
<td>-6.4</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>-57.6</td>
<td>-37.3</td>
<td>-31.2</td>
<td>-25.4</td>
<td>-31.0</td>
</tr>
<tr>
<td>Output</td>
<td>-15.1</td>
<td>-7.5</td>
<td>-6.3</td>
<td>-4.5</td>
<td>-5.8</td>
</tr>
</tbody>
</table>

Note: Own calculations based on data from IFS and WEO. The change in the current account is measured in percentage points of GDP.
### Table 6: Decentralized Equilibrium - Long Run Business Cycle Moments

<table>
<thead>
<tr>
<th></th>
<th>standard deviation</th>
<th>standard dev. deviation relative to GDP</th>
<th>correlation with GDP</th>
<th>first-order autocorrelation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>8.9</td>
<td>1.00</td>
<td>1.00</td>
<td>0.21</td>
</tr>
<tr>
<td>Consumption</td>
<td>10.4</td>
<td>1.16</td>
<td>0.97</td>
<td>0.10</td>
</tr>
<tr>
<td>Trade Balance-GDP ratio</td>
<td>2.8</td>
<td>0.31</td>
<td>-0.71</td>
<td>-0.21</td>
</tr>
<tr>
<td>Current Account-GDP ratio</td>
<td>2.7</td>
<td>0.30</td>
<td>-0.69</td>
<td>-0.21</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>7.9</td>
<td>0.88</td>
<td>0.99</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Note: Standard Deviations of consumption and real exchange rate are expressed in percentage of the mean.

### Table 7: Social Planner - Long Run Business Cycle Moments

<table>
<thead>
<tr>
<th></th>
<th>standard deviation</th>
<th>standard dev. deviation relative to GDP</th>
<th>correlation with GDP</th>
<th>first-order autocorrelation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>7.5</td>
<td>0.84</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>Consumption</td>
<td>7.9</td>
<td>0.89</td>
<td>0.99</td>
<td>0.36</td>
</tr>
<tr>
<td>Trade Balance-GDP ratio</td>
<td>1.0</td>
<td>0.11</td>
<td>-0.54</td>
<td>-0.24</td>
</tr>
<tr>
<td>Current Account-GDP ratio</td>
<td>0.9</td>
<td>0.10</td>
<td>-0.48</td>
<td>-0.25</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>5.9</td>
<td>0.66</td>
<td>1.00</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Note: Standard Deviations of consumption and real exchange rate are expressed in percentage of the mean.
Table 8: Sensitivity Analysis
(Probability of financial crises and debt, current account and consumption changes on impact during the most severe crises)

<table>
<thead>
<tr>
<th></th>
<th>Probability</th>
<th>Debt-GDP</th>
<th>Current Account</th>
<th>Consumption</th>
<th>RER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DE</td>
<td>SP</td>
<td>DE</td>
<td>SP</td>
<td>DE</td>
</tr>
<tr>
<td>Baseline</td>
<td>8.2</td>
<td>1.1</td>
<td>57.3</td>
<td>43.5</td>
<td>-24.1</td>
</tr>
<tr>
<td>Low Elast. ($\frac{1}{1+\mu} = 0.6$)</td>
<td>2.2</td>
<td>0.0</td>
<td>67.1</td>
<td>na</td>
<td>-30.4</td>
</tr>
<tr>
<td>High Elast. ($\frac{1}{1+\mu} = 1$)</td>
<td>12.0</td>
<td>2.1</td>
<td>51.0</td>
<td>45.5</td>
<td>-20.0</td>
</tr>
<tr>
<td>High Risk Aversion ($\sigma = 5$)</td>
<td>2.1</td>
<td>0.3</td>
<td>50.9</td>
<td>35.2</td>
<td>-19.8</td>
</tr>
<tr>
<td>High Cred-Coef ($\kappa = 0.36$)</td>
<td>2.2</td>
<td>0.0</td>
<td>60.0</td>
<td>na</td>
<td>-23.2</td>
</tr>
<tr>
<td>Low Cred-Coef ($\kappa = 0.28$)</td>
<td>11.5</td>
<td>2.1</td>
<td>44.7</td>
<td>40.2</td>
<td>-18.2</td>
</tr>
<tr>
<td>Low share trad. ($\kappa = 0.28$)</td>
<td>2.2</td>
<td>0.4</td>
<td>67.2</td>
<td>39.0</td>
<td>-29.7</td>
</tr>
<tr>
<td>High share trad. ($\omega = 0.35$)</td>
<td>12.4</td>
<td>2.2</td>
<td>49.0</td>
<td>44.2</td>
<td>-19.3</td>
</tr>
<tr>
<td>Low Stdev ($\sigma_y = 0.049$)</td>
<td>10.6</td>
<td>1.1</td>
<td>55.1</td>
<td>48.8</td>
<td>-22.1</td>
</tr>
<tr>
<td>High Stdev ($\sigma_y = 0.069$)</td>
<td>2.2</td>
<td>0.5</td>
<td>61.0</td>
<td>41.1</td>
<td>-27.0</td>
</tr>
</tbody>
</table>

Note: 'DE' represents the decentralized equilibrium, 'SP' represents the social planner, 'na' means that financial crises do not occur with positive probability. Financial crises are defined as events where the credit constraint binds and the current account-GDP ratio increases more than one standard deviation. The changes on impact correspond to the maximum changes during financial crises.
Appendix 1

Proposition 1 (Constrained Inefficiency)

Proof.

This is a proof by contradiction. Suppose the decentralized equilibrium is constrained optimal. Because the utility function is strictly concave, the social planner has a unique maximum which coincides with the decentralized equilibrium allocations. Then, using (4) and (13) yields:

\[ \lambda^t_{DE} = \lambda^t_{SP} + \mu^t_{SP} \Psi_t \]  

(19)

where we denote with superscript ‘SP’ the multipliers of the social planner and with ‘DE’ those of the decentralized equilibrium. Updating this equation one period forward and taking conditional expectations at time \( t \):

\[ E_t \lambda^t_{DE} + 1 = E_t \lambda^t_{SP} + 1 + E_t \mu_{SP}^t \Psi_{t+1} \]

(20)

Suppose that at time \( t \), the borrowing constraint does not bind. Combining (6) and (14) we obtain:

\[ E_t \lambda^t_{DE} = E_t \lambda^t_{SP} \]

(21)

Because at time \( t + 1 \) the borrowing constraint binds with positive probability, comparing (21) and (20) yields a contradiction: ■

Proposition 2 (Optimal Tax)

Proof.

When a state contingent tax is placed on borrowing in the decentralized equilibrium, the only first order condition that changes is the Euler intertemporal condition (6) that becomes

\[ \lambda^t_{DE} = \beta E_t \lambda^t_{DE} (1 + r + \tau_{t,t+1}) + \mu^t_{DE} \]

(22)

Combining the optimality conditions for the social planner (13) and (14) yields:

\[
\frac{u_T(t)}{\beta E_T u_T(t + 1)} = (1 + r) + (1 + r) \frac{E_t [\mu^t_{SP} \Psi_{t+1}]}{E_t u_T(t + 1)} + \frac{\mu_t (1 - \Psi_t)}{E_t u^t_{SP}(t + 1)}
\]

(23)

When the constraint binds for the social planner, it also binds for the decentralized equilibrium and allocations coincide. If the constraint does not bind, it follows then by construction of the tax rate (17) that combining (17) with (22) yields an equations identical to (23) ■
Appendix 2 - Numerical Solution Method

The algorithm employed to solve for the recursive competitive decentralized equilibrium is the following:

1. Start with an initial set of Parameters \( \{\beta, \omega, \kappa\} \)

2. Generate a discrete grid for the economy’s asset of size \( NB \) and the shock state space \( NS \).

3. Conjecture a law of motion for aggregate net foreign assets \( B' = H(B, y^T) \) at each point of the state space, which implies a price given by (10).

4. Solve for the policy functions \( \{\hat{b}(b, B, y^T), \hat{c}_T(b, B, y^T), \hat{c}_N(b, B, y^T)\} \) via value function iteration in the bellman equation (11).

5. Using the decision rules in the previous step, calculate the effective law of motion of aggregate bonds \( \hat{b}(B, B, y^T) \) and evaluate the previous conjecture. If \( \sup_{B, y^T} \| \hat{b}(B, B, y^T) - \Gamma(B, y^T) \| < \epsilon \), the recursive competitive equilibrium is found. Otherwise, update \( H(B, y^T) \) with a Gauss-Seidel algorithm and go to step 4.

6. Simulate the model. If the defined model’s moments match the data, we stop, otherwise, adjust parameters and grid and go to step 3.

We use 80 points in the grid for individual and aggregate bonds with relatively more points located at the beginning of the grid where the value function displays more curvature.\(^{32}\) We choose the first and the last point in the grid so that they are not binding in the ergodic distribution. To solve for the optimization problem in step 4, we do not restrict the choice of assets to lie in the grid. We use various interpolation schemes to compute the value function at points not on the grid. Linear interpolation and Schumaker spline preserving shape do not deliver noticeable differences. In order to solve the constrained optimization problem, we first assume that the credit constraint is binding and calculate the marginal utility of relaxing the constraint. If the marginal utility is positive, the solution is at the boundary. Otherwise, we solve for the optimization solution when the credit constraint does not bind using a bisection procedure. Because it is a strictly concave optimization problem with a convex constraint set, the method guarantees that the global maximum is achieved.\(^{33}\) To accelerate the algorithm, we use Howard improvement steps and the grid refinement proposed

\(^{32}\)Increasing the grid to 160 points do not produce noticeable differences in the results.

\(^{33}\)For the social planner, the constraint set may not be convex, so we perform an extensive grid search to ensure that the choice is the global maximum.
by Chow and Tsitsiklis (1991). We start with a coarse grid, that we extend to a finer grid (with linear interpolation to fill the unknown values), and recompute the value function.
Appendix 3 - Sensitivity Analysis Ctd

Risk Aversion
An increase in the risk aversion leads both the social planner and decentralized agents to accumulate more precautionary savings and to become less exposed to financial crises. This result is reflected in lower probabilities of financial crisis as Table 8 shows. When we set the risk aversion parameter equal to 5, we can see that the distortion created by the externality increases. The reason for this is that as risk averse increases, the welfare cost of the risk of a drop in consumption during a crisis becomes higher. Therefore, the social planner who internalizes the social cost of these episodes reduces more debt than decentralized agents when risk aversion is high. In this way, the drop in consumption in the most severe crisis episodes is 20 percent in the decentralized equilibrium and only 7 percent in the social planner’s solution.

Credit Coefficient
A higher $\kappa$ tends to increase the externality term, since when the constraint binds, the social planner internalizes that an increase in wealth would appreciate the real exchange rate and relax the credit constraint proportionally to $\kappa$. On the other hand, if $\kappa$ increases up to a point that the credit constraint never binds in the two environments, there is no debt-deflation effect in equilibrium; therefore, the externality would trivially disappear. When $\kappa$ increases by 4 percentage points, the social planner does not experience a financial crisis in the long run while the decentralized agents still experience a crisis with a 2.3 percent probability in the long run. In a similar way, if $\kappa$ is reduced to zero, there is no debt-deflation effect, and the externality disappears. Reducing $\kappa$ also by 4 percentage points reduces the distortions measured by the differences in the incidence and the severity of financial crises.

Share of tradables
With a higher preference for tradables captured by $\omega$, for a given reduction of tradable consumption, the magnitude of the adjustment in the price of non-tradables is lower, but not in percentage which is only determined by $\mu$. An increase in $\omega$, however, implies a higher preference for tradable consumption and a higher disutility from becoming credit constrained. The effect of a change in $\omega$ over the credit externality is therefore qualitatively ambiguous. Quantitatively, an increase in $\omega$ of 0.04, which makes the share of tradable output equal to 0.36 (versus 0.32 in the baseline), tends to reduce the effects of the externality. A decrease in $\omega$ of 0.04 which makes the share of tradable output equal to 0.30 produces more differences in the severity of a financial crisis measured by the drops in consumption in the most severe episodes.

Standard Deviation
Finally, changes in the standard deviation of tradable output of around 1 percent do not produce significant changes in the distortions introduced by the credit externality.