Revisiting Overborrowing and its Policy Implications*

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Abstract

This paper analyzes quantitatively the extent to which there is overborrowing (i.e., inefficient borrowing) in a business cycle model for emerging market economies with an occasionally binding credit constraint. It then discusses alternative policy regimes often advocated as second best remedies to cope with the consequences of imperfect access to capital markets. These include ex ante prudential taxation of capital flows and capital controls or ex post bail outs financed nationally and multilaterally. The main finding is that overborrowing is a quantitative matter: it depends on both the model specification and the assumptions on parameter values. The policy implication of the analysis is that there is no clear cut rationale to prefer ex ante or ex-post policies to minimize the likelihood or the severity of financial crises necessarily associated with imperfect access to capital markets. Both set of policies have costs and benefits that need to weighted carefully. And a desirable policy regime would likely feature both ex ante and ex post interventions. It follows that both sets of policy instruments should be put in place to "hedge" the model and parameter uncertainty the policy makers face. It also follows that policy should not loose focus on trying to achieve first best outcomes by removing the underlying sources of financial friction through more fundamental interventions, such as strengthening borrowers incentives to repay and lender incentives to stay.

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1 Introduction

Economies with imperfect financial market access may experience crises that cause significant economic dislocation. These crises are characterized by the sudden stop of domestic or international credit flows and are associated with large declines in consumption, output, relative prices, and asset prices.[1]

An important question for emerging-market economies is whether the likelihood and the severity of these crises is affected by excessive borrowing in normal times, when access to financial markets is unconstrained and plentiful. This question is important because the policy implications of alternative answers are very different. If there is excessive borrowing (i.e., inefficient or "overborrowing") in good times, policy should be geared primarily toward addressing the ex ante inefficiency that causes it; for example, by imposing a tax on capital flows or other forms of capital controls and prudential regulations to reduce the incentives to borrowing excessively.[2] In this case, policy should be less concerned about mitigating the consequences of the crisis, when one occurs, and instead strengthen the ex ante incentives to borrow efficiently in good times. In contrast, if there is no overborrowing in good times, policy should be geared primarily toward designing efficient ex post interventions mechanisms in bad times, trying to minimize the costs of the inevitable crises associated with imperfect access to financial markets.[3]

A fast growing literature has examined this issue in related work. In early contributions Fernandez-Arias and Lombardo (1998) and Uribe (2007) have examined the possibility of overborrowing in economies mainly subject to exogenous (either individual or aggregate) debt limits. Lorenzoni (2008) and Korinek (2009) have explored the possibility of overborrowing qualitatively in models in which the debt limit is no longer constant and it is endogenous. Uribe (2007) and Bianchi (2009) have examined the issue quantitatively with contrasting results. While Uribe (2007) finds no overborrowing, Bianchi (2009) finds that overborrowing is quantitatively relevant and have significant welfare implications. In a similar way, Nikolov (2009) in a richer framework with heterogenous firms' productivity based on a stochastic version of Kiyotaki and Moore (1997) finds that there is no significant overborrowing. As a result, Korinek (2008a,b) and Bianchi (2009) suggest that only prudential policy have scope for preventing and mitigating crises.

[1] The recent global crisis that stemmed from the US sub-prime mortgage market is the most vivid example of a financial sudden stop, but the long sequence of emerging market crashes since the mid-1990s is an equally important illustration of how disruptive financial "sudden stops" can be.

[2] See for instance the recent introduction of a tax on international portfolio flows by Brazil, or Chile's earlier experiance with capital controls on foreign inflows.

[3] See Caballero (2010) for a detailed discussion of alternative modalities of ex post interventions.

This paper analyzes quantitatively the extent to which there is overborrowing in a business cycle model for emerging market economies with production and an occasionally binding credit constraint. The main finding is that overborrowing is a quantitative matter: it depends on both the model specification and the values of the model parameters. The main policy implication of the analysis is that there is no clear cut rational for either ex ante or ex post policies.

We investigate overborrowing in the small open economy model with imperfect access to international capital markets. Our occasionally binding credit constraint is embedded in a standard two-sector (tradable and non-tradable good) small open economy in which financial markets are not only incomplete but also imperfect, as in Mendoza (2002). In this model, production takes place only in the non-tradable sector of the economy. The asset menu is restricted to a one period risk-free bond paying off the exogenously given foreign interest rate. In addition, we assume that access to foreign financing is constrained to a fraction of households' total income. Foreign borrowing is denominated in units of the tradable good but it is leveraged on income generated at different relative prices (i.e. the relative price of non-tradeable good). The specification of the borrowing constraint thus captures "liability dollarization" a key feature of emerging market capital structure (e.g., Krugman (2002)).[4]

There are two defining features of this environment. First the international borrowing constraint binds only occasionally: the crisis, defined as the event in which the constraint binds, is an endogenous event that depends on agents' decisions, the policy regime, and the state of the economy. Second, potential scope for policy intervention arises in this environment because of the existence of a pecuniary externality in the model as agents fail to internalize the aggregate price implications of their own borrowing decision (similarly to Korinek (2009) and Bianchi (2009)).[5]

To investigate overborrowing quantitatively we compare the competitive equilibrium (CE) with the constrained efficient allocation chosen by a welfare maximizing social planner (SP), solving them with global solution methods. That is we solve for decision rules across both states of the world, when the constraint binds and when it does not. Such an approach enforces that the behavior away from the crisis periods is based on full knowledge of what the equilibrium will be when the economy enters the crisis state. This solution method, while computationally costly, is critical for understanding the interaction between different states of the world.[6]

[4]The latest wave of crises in emerging Europe and the corporate sector problems in Mexico and Brazil in the fourth quarter of 2008 represent striking evidence of the importance of such feature.

[5]See Benigno et al. (2009) and section 2 below for a more detailed discussion.

[6]The technical challenge in solving such a model is that the constraint binds only occasionally and

We find that overborrowing is a quantitative matter: it depends on both the model specification and the values of the model parameters. In particular, in our baseline production economy there is underborrowing (i.e., the small open economy in the competitive equilibrium borrows less than socially efficient in the region in which the international borrowing constraint is not binding. However, we do find that there is overborrowing when we assume, for robustness, that the economy is populated by more impatient agents and faces larger shocks. Nonetheless, the analysis shows that in this production economy there is scope for both ex ante and ex post policy interventions regardless of the parameter values assumed. We then find that a small overborrowing also emerges in an endowment economy calibrated as our baseline production economy, and that this becomes larger in an endowment economy with more impatient agents and larger shocks. In these endowment economies, however, there is only scope for ex ante policy interventions because policy cannot manipulate the value of the collateral when the constraint binds since it cannot alter the production possibilities of the economy.

Overborrowing might arise because the social planner takes into account, even during tranquil times, of the effects that current consumption choices might have on future consumption path when the constraint would become binding: that is the fact that higher consumption today might imply inefficiently low consumption in the future. On the other hand the possibility that the constraint might be binding in the future will induce agents to supply more labor today and produce more of nontradable goods. So when goods are complements, this would result in an increase of current tradable consumption and might generate a path of tradable consumption in the social planner allocation that is higher than the competitive equilibrium allocation.[7]

The main policy implication of the analysis is that there is no clear cut rational for preferring either en ante or ex post policies. This is especially important in light of the fact that, in these models, the long run costs of the distortions associated with the implementation of either set of policies, such as moral hazard in the case of ex post policies and the efficient allocation of capital flows in the case of ex ante policies, are not present in the models. While it is well known that bail outs can induce moral hazard, it is less well understood that prudential regulations and capital controls can hamper long run growth. Nikolov (2009), for instance, finds that imposing tighter leverage ratios than those chosen in a competitive equilibrium does reduce aggregate volatility, but at the cost of lowering average growth with welfare reducing consequences.

changes location in the state space of the model depending on the state of the economy.

[7] In a production economy with a working capital constraint the second effect changes. Note however that working capital constrians.

In our baseline production model, there is a divergence between the CE and the SP allocations both when the constraint binds and when it does not, with under- or over-borrowing depending on the values of certain parameters. In the baseline calibration we find underborrowing in normal times when the constraint does not bind. In the alternative calibration, with more impatient agents and larger shocks, we find overborrowing in normal times. In both cases, however, when the constraints binds, there is inefficient under-borrowing. That is, when the constraint binds, agents in the CE reduce their consumption of tradable more than in the SP allocation as the planner takes into account the deflationary effect of lower tradable consupmtion on the value of the collateral in the economy. These findings suggests that there is clear scope for ex ante policy interventions to address either the under- or the over-borrowing (depending on parameter values), and ex post intervention to address the excessive adjustment to the sudden stop. Of course the type of ex ante intervention that can align the CE to SP may be different depending on whether there is under or over borrowing and hence depending on the parameter values.[8] So the analysis stresses the importance of both macro-prudential tools such as taxes on capital flows and capital controls, as well as global lending of last resort arrangements and reserve accumulation policies to help mitigate the effect of crises when they occurs. However, it is important to notice here that moral hazard considerations or inefficiencies induced by distortive policy interventions are not analyzed in the context of the current model. As a result, the case for policy intervention, be that ex ante or ex post, may be overstated by our analysis.[9]

In sum, the main conclusion of the analysis is that there is no clear cut rationale to prefer ex ante, or prudential policies, or ex-post policies that intervene after a crisis occurs. Indeed, the analysis and the discussion in the paper highlight that there is a very strong case for more fundamental policy actions geared toward ameliorating the underlying incentive problems of international borrowers and lenders so has to permit a smoother functioning of international capital markets without the necessity to impose tight credit constraints on borrowers or defaults on lenders to make up for the lack of commitment either on either side of the market.

The rest of the paper is organized as follows. Section 2 discusses the pecuniary externality that may give rise to under or over-borrowing. Section 3 describes the model we use. Section 4 discusses its parametrization and solution. Section 5 illustrates the working of the model and its basic properties, and report the main results of the paper, comparing the CE and the SP equilibria under alternative model specifications and parameter values.

[8] Implementation issues are not discussed in thei paper. See Benigno et al. (in progress) for more details.

[9] One important technical caveat to the analysis is that, like most of the literature above, the credit constraint is not microfounded. As we discuss at the end of the paper the specification of these microfundations may well affect some of the results and their policy implications.

Section 6 concludes. Technical details about the computational methods can be found in Benigno et al (2009).

2 Overborrowing and pecuniary externalities

Before turning to the presentation of the model we discuss the source of the externality that may give rise to over- or under-borrowing. Overborrowing has been discussed extensively in the literature so our discussion of the pecuniary externality than may give rise to it is in the form of a review of the literature closely related to our paper.

There is an extensive literature that provides different explanations for why countries might overborrow. In an early contribution, Fernandez-Arias and Lombardo (1998) investigate analytically whether an economy with an aggregate debt limit tends to overborrow relative to an economy in which the debt limit is imposed at the level of the individual agent. They find that when agents fail to internalize the debt limit the economy tends to overborrow. Uribe (2007) investigates overborrowing quantitatively and finds that the amount borrowed is independent on foreign lenders basing their decisions on individual as opposed to aggregate variables.

The models used in these early analyses are similar. The key difference among the two environments is that in Uribe (2007), when the constraint is binding, the domestic interest rate adjusts and induces agents to internalize the credit limit, while Fernandez-Arias and Lombardo (1998) assume that the domestic interest rate is equal to the world interest rate and agents fail to internalize the debt ceiling in their deterministic model. In both papers, however, there are two common ingredients. First, the debt ceiling is exogenously specified.[10] Second, the economy is a one good economy, in which the pecuniary externality we focus on cannot arise (See Benigno et al, 2009, section 2 for details).

More recent work has considered richer environments in which there are multiple goods and the borrowing limit is endogenous. In this environments, the interaction between borrowing constraint and the dependence of the borrowing limit on a relative price generates a pecuniary externality that is not internalized in the competitive equilibrium allocation and might give rise to overborrowing. The social planner on the other hand takes into account the way the relative price is determined in the competitive allocation when choosing its optimal plan and chooses accordingly the amount to borrow.[11] For instance, in a closed economy model, Lorenzoni (2008) shows that entrepreneurs do not take into account the

[10] **Uribe (2007) considers one exstension in which the constraint is endogenous in the sense explained above. Indeed, in this case, he finds a small overborrowing.**

[11] Again, see Benigno et al (2009) for more details.

effects of asset prices on the amount that they can borrow so that in the competitive equilibrium financial contracts result in excessive borrowing. Similar analysis has been conducted by Korinek (2009) and Bianchi (2009) in an open economy setting similar to our baseline model, but without production, in which the amount that individuals can borrow depends on the income generated in both sectors of the economy and their relative price. Both papers conclude that there is overborrowing, qualitatively (Korinek, 2009) and quantitatively with potentially significant welfare consequences (Bianchi, 2009). The policy implications of these analysis is to recommend a prudential taxation approach to limit capital flows.

In related work, Nikolov (2009), in a stochastic version of the Kiyotaki and Moore (1997) model, finds that these pecuniary externalities do not induce sizable divergence between the CE and the SP when a leverage ratio is a variable of choice because Interestingly, in Nikolov's (2009) model, there is not only production but also firm heterogeneity. In this environment there is a trade off between the higher volatility associated with higher leverage ratio and the lower average growth associated with lower leverage ratios. So mandating lower regulatory leverage ratios may impose significant efficiency costs in terms of lower average growth. Note however that in neither of these two analyses it is established that there is always overborrowing in an endowment economy. In contrast, Nikolov (2009), in a stochastic version of the Kiyotaki and Moore (1997) model, finds that these pecuniary externalities do not induce sizable divergence between the CE and the SP when the leverage ratio is the variable of choice. Interestingly, in Nikolov's (2009) model, there is not only production but also firm heterogeneity. In this environment there is a trade off between the higher volatility associated with higher leverage ratio and the lower average growth associated with lower leverage ratios. So mandating lower regulatory leverage ratios may impose significant efficiency costs in terms of lower average growth.

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3 Model

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3.1 Households

There is a continuum of households $j \in [0,1]$ that maximize the utility function

$$U^j \equiv E_0 \sum_{t=0}^{\infty} \left\{ \beta^t \frac{1}{1-\rho} \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta} \right)^{1-\rho} \right\}, \tag{1}$$

with C_j denoting the individual consumption basket and H_j the individual supply of labor. For simplicity we omit the j subscript for the remainder of this section, it is understood that all choices are made at the individual level. The elasticity of labor supply is δ, while ρ is the coefficient of relative risk aversion. In (1) the preference specification follows from Greenwood, Hercowitz and Huffman (1988): in the context of a one-good economy this specification eliminates the wealth effect from the labor supply choice. Here, in multi-good economy the sectoral allocation of consumption will affect the labor supply decision through relative prices. The consumption basket, C_t, is a composite of tradable and non-tradable goods:

$$C_t \equiv \left[\omega^{\frac{1}{\kappa}} \left(C_t^T \right)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}} \left(C_t^N \right)^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}}. \tag{2}$$

The parameter κ is the elasticity of intratemporal substitution between consumption of tradable and nontradable goods, while ω is the relative weight of the two goods in the utility function.

We normalize the price of traded goods to 1. The relative price of the nontradable good is denoted P^N. The aggregate price index is then given by

$$P_t = \left[\omega + (1-\omega) \left(P_t^N \right)^{1-\kappa} \right]^{\frac{1}{1-\kappa}},$$

where we note that there is a one to one link between the aggregate price index P and the relative price P^N. Households maximize utility subject to their budget constraint, which is expressed in units of tradeable consumption. The constraint each household faces is:

$$C_t^T + P_t^N C_t^N = \pi_t + W_t H_t - B_{t+1} + (1+i) B_t, \tag{3}$$

where W_t is the wage in units of tradable goods, B_{t+1} denotes the foreign lending at the end of period t with gross real return $1+i$. Households receive profits, π_t, from owning the representative firm. Their labor income is given by $W_t H_t$.

International financial markets are incomplete and access to them is also imperfect. The asset menu includes only a one-period bond denominated in units of tradable consumption. In addition, we assume that the amount that each individual can borrow internationally is limited by a fraction of his current total income:

$$B_{t+1} \geq -\frac{1-\phi}{\phi}\left[\pi_t + W_t H_t\right]. \tag{4}$$

This constraint captures the effects of liability dollarization since foreign borrowing is denominated in units of tradables while the income that be pledged as collateral is generated also in the non-tradable sector. This constraint is also endogenous as it depends on the current realization of profits and wage income. We don't derive explicitly the credit constraint as the outcome of an optimal credit contract between lenders and borrowers.[12] We could interpret this constraint as the outcome of the interaction between lenders and borrowers in which the lenders is not willing to permit borrowing beyond a certain limit. This limit depends on ϕ that measures the tightness of the borrowing constraint and depend on current gross income that could be used as a good proxy of future income. [13]

Households maximize (1) subject to (3) and (4) by choosing C_t^N, C_t^T, B_{t+1}, and H_t. The first order conditions of this problem are the following:

$$C_T : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} \omega^{\frac{1}{\kappa}} \left(C_t^T\right)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_t, \tag{5}$$

$$C_N : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} (1-\omega)^{\frac{1}{\kappa}} \left(C_t^N\right)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_t P_t^N, \tag{6}$$

$$B_{t+1} : \mu_t = \lambda_t + \beta\left(1+i\right) E_t\left[\mu_{t+1}\right] \tag{7}$$

and

$$H_t : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} \left(H_{j,t}^{\delta-1}\right) = \mu_t W_t + \frac{1-\phi}{\phi} W_t \lambda_t. \tag{8}$$

Note that when the credit constraint is binding ($\lambda_t > 0$), the standard Euler equation (7) incorporates effects that can be interpreted as arising from a country-specific risk premium on external financing. The extent of this affect is governed by the degree of risk aversion. Moreover in this framework there is an intertemporal effect coming from the possibility

[12] As emphasized in Mendoza (2002), this form of liquidity constraint shares some features, namely the endogeneity of the risk premium, that would be the outcome of the interaction between a risk-averse borrower and a risk-neutral lender in a contracting framework as in Eaton and Gersovitz (1981). It is also consistent with anecdotal evidence on lending criteria and guidelines used in mortgage and consumer financing. However, it is not derived as the outcome of an optimal credit contract.

[13] As we discuss in Benigno et al. (2009), a constraint expressed in terms of future income which could be the outcome of the interaction between lenders and borrowers in a limited commitment environment would introduce further computational difficulties that we are avoiding at first pass.

that the constraint might be binding in the future: this effect is embedded in the term $E_t\left[\mu_{t+1}\right]$ and implies that consumption of tradeable goods would be lower compared to the unconstrained case. From the previous conditions, we can combine (5) and (6) to obtain the intratemporal allocation of consumption and (5) with (**??**) to obtain the labor supply schedule.

$$\frac{(1-\omega)^{\frac{1}{\kappa}}\left(C_t^N\right)^{-\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}}\left(C_t^T\right)^{-\frac{1}{\kappa}}}=P_t^N \tag{9}$$

$$\left(H_{j,t}^{\delta-1}\right)=\left(\frac{\omega C}{C_T}\right)^{\frac{1}{\kappa}}W_t\left(1+\frac{1-\phi}{\phi}\frac{\lambda_t}{\mu_t}\right) \tag{10}$$

Note that $\left(\frac{\omega C}{C_T}\right)^{\frac{1}{\kappa}}=\left(1+\left(\frac{1-\omega}{\omega}\right)^{\frac{1}{\kappa}}\left(\frac{C_t^N}{C_t^T}\right)^{\frac{\kappa-1}{\kappa}}\right)^{\frac{1}{\kappa-1}}=\left(1+\left(\frac{1-\omega}{\omega}\right)\left(P_t^N\right)^{1-\kappa}\right)^{\frac{1}{\kappa-1}}$. So that, if we were in a one good economy there would not be any effect coming from marginal utility of consumption on the labour supply choice because of the GHH specification. At this point it is important to note that an increase of P_N would lower $\left(\frac{\omega C}{C_T}\right)^{\frac{1}{\kappa}}$. so that the labor supply curve will become flatter.

3.2 Firms

The firms are endowed with a stochastic stream of tradable goods, $\exp(\varepsilon_t^T)Y^T$, where ε_t^T is a stochastic process, and produces non-tradable goods, Y^N. We assume that ε^T follows an autoregressive process of the first order (AR(1)). We abstract from other sources of macroeconomic uncertainty, such as shocks to the technology for producing non-tradables and the world interest rate.

Firms produce non-tradables goods, Y_t^N, with a variable labor input and Cobb-Douglas technology

$$Y_t^N=AH_t^{1-\alpha},$$

where A is a scaling factor. The firm's problem is static and current-period profits (π_t) are:

$$\pi_t=\exp\left(\varepsilon_t^T\right)Y^T+P_t^N AH_t^{1-\alpha}-W_tH_t.$$

The first order condition for labor demand is:

$$W_t=(1-\alpha)\,P_t^N AH_t^{-\alpha}, \tag{11}$$

so the value of the marginal product of labor is set equal to the real wage (W_t). For the case in which we have constant return to scale ($\alpha = 0$) we obtain:

$$W_t = P_t^N A$$

so that the real wage in terms of the relative price of non-tradable is constant as long as we don't have any shock to productivity of non-tradable and labor is determined by the supply side while the wage from the demand side.

3.3 Aggregation and equilibrium

We first analyze the implication of our production economy by focusing on the labor market equilibrium condition when firms have constant returns to scale technology ($\alpha = 0$). Combining (11) with (10) we obtain:

$$\left(H_{j,t}^{\delta-1}\right) = \left(\frac{\omega C}{C_T}\right)^{\frac{1}{\kappa}} P_t^N A \left(1 + \frac{1-\phi}{\phi}\frac{\lambda_t}{\mu_t}\right)$$

When the international borrowing constraint is not binding ($\lambda_t = 0$), a shock that triggers a decrease in P_t^N will reduce the supply of labor and the amount of non-tradable goods produced by a lesser amount if goods are complement than if goods were substitute. Indeed the equilibrium in the labor market would become:

$$\left(H_{j,t}^{\delta-1}\right) = \left(1 + \left(\frac{1-\omega}{\omega}\right)\left(P_t^N\right)^{1-\kappa}\right)^{\frac{1}{\kappa-1}} P_t^N A$$

When the constraint is binding the marginal utility of supplying one more unit of labor is higher as this would help in relaxing the constraint to that labor supply becomes steeper and agents will tend to substitute leisure with labor to increase the value of their collateral for given wages and prices.

In terms of goods market equilibrium condition, combining the household budget constraint and the firms' profits with the equilibrium condition in the nontradables good market, we obtain the current account equation of our small open economy:

$$C_t^T = Y_t^T - B_{t+1} + (1+i)\,B_t. \tag{12}$$

Nontradable goods market equilibrium condition implies that

$$C^N = Y^N = AH$$

Note finally that, using the definitions of firm profits and wages, the credit constraint implies that the amount that the country as a whole can borrow is constrained by a fraction of the value of its GDP:

$$B_{t+1} \geq -\frac{1-\phi}{\phi}\left[\exp\left(\varepsilon_t^T\right)Y^T + P_t^N Y^N\right], \tag{13}$$

so that (12) and (13) determines the evolution of the net foreign debt.

3.4 Social Planner Problem

Let's now consider the social planning problem: In this case the planner maximizes (1) subject to the resource constraints, the international borrowing constraint from an aggregate perspective and the pricing rules as dictated in the competitive equilibrium allocation. In particular we can rewrite (13) by noting that the relative price is determined by the competitive rule (9):

$$B_{t+1} \geqslant -\frac{1-\phi}{\phi}\left[\exp\left(\varepsilon_t^T\right)Y^T + \left(\frac{(1-\omega)\left(C_t^T\right)}{\omega}\right)^{\frac{1}{\kappa}} (AH_t)^{\frac{\kappa-1}{\kappa}}\right].$$

The planner chooses the optimal path of C_t^T, C_t^N, B_{t+1} and H_t. The first order conditions for the planner problem are given by

$$C_T : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} \omega^{\frac{1}{\kappa}} \left(C_t^T\right)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_{1,t} - \lambda_t \frac{1-\phi}{\phi}\frac{1}{\kappa}\frac{(1-\omega)}{\omega}\left(\frac{(1-\omega)\left(C_t^T\right)}{\omega}\right)^{\frac{1}{\kappa}-1} (AH_t)^{\frac{\kappa-1}{\kappa}}, \tag{14}$$

$$C_N : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} (1-\omega)^{\frac{1}{\kappa}} \left(C_t^N\right)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_{2,t}, \tag{15}$$

$$B_{t+1} : \mu_{1,t} = \lambda_t + \beta(1+i)E_t\left[\mu_{1,t+1}\right] \tag{16}$$

and

$$H_t : \left(C_t - \frac{H_t^{\delta}}{\delta}\right)^{-\rho}\left(H_t^{\delta-1}\right) = \mu_{2,t}A + \frac{1-\phi}{\phi}\lambda_t\left(\frac{(1-\omega)\left(C_t^T\right)}{\omega}\right)^{\frac{1}{\kappa}}\frac{\kappa-1}{\kappa}A\left(AH_t\right)^{-\frac{1}{\kappa}}. \tag{17}$$

At this point it is important to understand how the first order condition differs compared to the competitive equilibrium allocation.

The first equation (14) shows that the planner takes into account, in choosing tradable consumption, of the effects that a change in tradable consumption has on the value of the collateral (see also Korinek, 2009 and Bianchi, 2009). This is what is usually referred as the price externality and it occurs when the constraint is binding (i.e. $\lambda_t > 0$).

What is important to note is that, even if the constraint is not binding today, the possibility that it might bind in the future will affect the marginal value of tradable consumption today (i.e. the marginal value of saving). Indeed as it is noticed in Bianchi (2009) the Euler equation from the planner perspective becomes

$$\left(C_t - \frac{H_{,t}^{\delta}}{\delta}\right)^{-\rho} \omega^{\frac{1}{\kappa}} \left(C_t^T\right)^{-\frac{1}{\kappa}} C_{t+1}^{\frac{1}{\kappa}} =$$

$$= \beta (1+i) E_t \left[\left(C_{t+1} - \frac{H_{t+1}^{\delta}}{\delta}\right)^{-\rho} \omega^{\frac{1}{\kappa}} \left(C_{t+1}^T\right)^{-\frac{1}{\kappa}} C_{t+1}^{\frac{1}{\kappa}} + \lambda_{t+1} \frac{1-\phi}{\phi} \frac{1}{\kappa} \frac{(1-\omega)}{\omega} \left(\frac{(1-\omega)\left(C_{t+1}^T\right)}{\omega}\right)^{\frac{1}{\kappa}-1} (AH_{t+1}) \right.$$

In the production economy another effect occurs. In particular, we can rewrite the labor supply equation by using (15) and the equilibrium condition in the non-tradable goods market as.

$$\left(H_t^{\delta-1}\right) = \left(\frac{(1-\omega)C_t}{AH_t}\right)^{\frac{1}{\kappa}} A \left\{ 1 + \frac{1-\phi}{\phi} \frac{\lambda_t}{\mu_{2,t}} \left(\frac{(1-\omega)\left(C_t^T\right)}{\omega}\right)^{\frac{1}{\kappa}} \frac{\kappa-1}{\kappa} (AH_t)^{-\frac{1}{\kappa}} \right\}$$

We note here that when the constraint is binding the marginal utility of supplying one more unit of labor is affected by the degree of substitutability between tradables and non-tradables. If the goods are substitutes then, when the international borrowing constraint is binding, it is worth supplying one more unit of labor as that help in relaxing the constraint. When goods are complement on the other hand, it is worth decreasing the amount of labor supplied. In both cases the planner tends to relax the international borrowing constraint by increasing the value in units of tradable of non-tradable production: in the case of complements this is achieved by an increase in prices that dominates the negative effect of lower non-tradable production and consumption, while in the case of substitutes this is achieved by an increase of non-tradable production and consumption that dominates the effect of lower prices.

But changes in labor supply occur also when the constraint is not binding. Indeed in this case, taking the ratio of (15) and (14)

$$\frac{(1-\omega)^{\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}}} \frac{\left(C_t^N\right)^{-\frac{1}{\kappa}}}{\left(C_t^T\right)^{-\frac{1}{\kappa}}} \mu_{1,t} = \mu_{2,t}, \tag{18}$$

so we can see how higher marginal utility of tradable consumption (that arises because of the possibility that the constraint might bind in the future) implies that also marginal utility of non-tradable consumption is higher and that increases the marginal utility of supplying one unit of labor so that in the social planner allocation labor supply and so non-tradable production is higher than in the competitive equilibrium allocation even when the constraint is not binding. When goods are complement this increases in nontradable consumption will push for an increase in tradable consumption reducing the amount agents save in the social planner equilibrium (this then could push for underborrowing in the competitive equilibrium allocation compared to the social planner one) The opposite would occur if goods were substitute.

4 Parameter values and solution method

In this section we discuss the parameter values chosen and briefly describe the global solution method that we use in the numerical computations.

4.1 Parameter values

The parameter values we use are reported in Table 1. As in Benigno et al (2009) these values are set following the work of Mendoza (2002, 2008) and Kim and Ruhl (2008) to the extent possible, but also to facilitate the convergence of the numerical solution procedure.

We set the world interest rate to $i = 0.0159$, which yields an annual real rate of interest of 6.5 percent; a value that is between the 5 percent of Kehoe and Ruhl (2008) and the 8.6 percent of Mendoza (2008). The elasticity of intratemporal substitution between tradables and nontradables follows from Ostry and Reinhart (1992) who estimates a value of $\kappa = 0.760$ for developing countries.[14] The value of δ is set to 2 implying a Frisch elasticity of labor of 2. For simplicity, the elasticity of intertemporal substitution is unitary ($\rho = 1$).

For simplicity, the labor share of production in the non-tradable sector is also assumed to be unitary ($\alpha = 1$). We then normalize steady-state tradable output to one (i.e., $Y_T = 1$) and set ω and A to obtain a steady-state ratio of tradable to non-tradables output of 0.75 (slightly higher than Mendoza, 2002) and a unitary relative price of non-tradables in steady state (i.e., $P^N = 1$).

The tax rate on non-tradable consumption is fixed at $\tau = 0$ as a benchmark to compare the two allocations (CE and SP). Government spending and lump sum taxes are also set to zero.

[14] There is considerable debate about the value of this parameter. The estimate we use is consistent with Kehoe and Ruhl (2005) who set this parameter to 0.5.

We set $\beta = 0.98$ (implying an annual value of 0.92237) to obtain a foreign borrowing to annualized GDP ratio of about 25 percent.[15] The value of the credit constraint parameter (ϕ) determines the probability of a sudden stop. We set this parameter to 0.7, which makes the constraint binding in the deterministic steady state and yields a realistic probability of sudden stop, as typically defined in the empirical literature. In the competitive equilibrium the unconditional probability of being in a sudden stop is about 2 percent (or 8 percent annually) of consumption at every date and state. For this calculation a sudden stop is defined as the event in which the constraint becomes binding.

Finally, in our analysis, we focus on the behavior of the economy subject to only one stochastic shock, to the endowed tradeable output, which we model as an AR(1) process. Specifically, the shock process for tradable GDP is,

$$\varepsilon_t^T = \rho_\varepsilon \varepsilon_{t-1}^T + v_t, \tag{19}$$

where v_t is an iid N(0,σ_ε^2) innovation. The parameters of this process are set to $\rho_\varepsilon = 0.55^4$ and $\sigma_\varepsilon = 0.59^4$, which are the the first autocorrelation and the standard deviation of total GDP reported by Mendoza (2008).

As paramterized, as Benigno et al (2009) show, the model produces a sharp reversal in capital flows, a large drop in output and consumption, and a large real exchange rate depreciation (proxied by the fall in the relative price of non-tradable goods) that is typical of a sudden stop. In this sense, our model is quantitatively capturing the sudden stop phenomena we observe in the data.

4.2 Solution

The algorithm for the solution of the competitive equilibrium is that proposed by Benigno et al (2009). Here we summarize their solution procedure and explain how we compute the solution to the social planner problem. A key ingredient is a transformation of the system of Kuhn-Tucker conditions into a standard system of nonlinear equations that is due to Garcia and Zangwill (1981). The transformed system can then be solved using standard nonlinear equation solution methods.

The equilibrium of the model can be represented as a recursive dynamic programming problem summarized by the following Bellman equation:

$$V(b, B, \varepsilon) = \max_{B'} \left\{ u\left(C - z(H)\right) + \beta E\left[V\left(b', B', \varepsilon'\right) |\varepsilon\right] \right\}. \tag{20}$$

[15] For this calculation we added an elastic discount factor to the model to pin down foreign debt in steady state.

The value function, $V(b, B, \varepsilon)$, depends on three state variables: individual borrowing (b), aggregate borrowing (B), and the stochastic shock to the tradable endowment (ε). In equilibrium, individual and aggregate borrowing must coincide, but from the perspective of the representative agent of our model the borrowing constraint is imposed at the individual level, taking relative prices as given. Our solution explicitly accounts for this feature of the model specification by treating aggregate and individual debt separately in the value function.

A solution for the decentralized equilibrium defined above will be given by (i) a value function $V(B, \varepsilon)$ and (ii) a set of laws of motion (hereafter, also called decision rules or policy functions) for aggregate borrowing ($B = G_B^n(B, \varepsilon^T)$), aggregate employment ($H = G_H^n(B, \varepsilon_T)$), and the relative price of the non-tradable good basket ($P^N = G_{P^N}^n(B, \varepsilon_T)$), and for government transfers ($T = G_T^n(B, \varepsilon_T)$) that satisfy the Bellman equation above. Note that while the value function depends on both individual and aggregate borrowing, the decision rules for all other endogenous variables only depend on aggregate borrowing.

To solve for the social planning equilibium we set up a dynamic programming problem. The programming problem is written as a optimization of the value function subject only to the resources constraints and the borrowing constraint. Thus, the planner chooses all quantities directly. Specifically the problem can be written as:

$$v(B, \epsilon) = \max_{c_T, c_N, h, p, B'} \left\{ \frac{1}{1-\rho} \left(\left(\omega c_T^{\kappa} + (1-\omega) c_N^{\kappa} \right)^{\frac{1}{\kappa}} - h^{\delta} \right)^{1-\rho} + \beta E_{\epsilon'} \left[v(B', \epsilon') \,|\epsilon \right] \right\}$$

subject to

$$\begin{aligned} c_T &= (1+r) B + \epsilon - B' \\ c_N &= Ah \\ B' &\geq -\frac{1-\varphi}{\varphi} (\epsilon + pAh) \\ p &= \frac{1-\omega}{\omega} \left(\frac{c_N}{c_T} \right)^{\kappa - 1}. \end{aligned}$$

We compute a solution to this problem numerically. The shock is discretized into a Markov Chain with 11 states as in Floden (2008). The methods to solve the programming problem are standard (e.g. Johnson et al 1993). In particular, we use cubic splines to approximate the value function and we then solve the maximization problem using a feasible sequential quadratic programming routine.

5 Quantifying overborrowing

In this section we discuss the basic properties of the competitive equilibrium allocation and we compare it with the social planner one to quantify overborrowing. We conduct this comparison under alternative model specifications and assumptions for key parameter values.

5.1 Competitive equilibrium

The properties of the competitive equilibrium are more fully explained in Benigno et al (2009). Here we review it only briefly. The policy function for B_t is plotted in Figure 1. In this figure, each solid line depicts the policy function for B_t conditional on a particular state of the tradable shock. This line is drawn assuming the same shock is received in each period. For illustrative purposes, we report the decision rule for the worst state (State 1), and progressively better ones, together with the 45 degree line (dashed line). If the first state is received perpetually then the policy function will meet the 45-degree line right at the point where the constraint becomes binding. The economy remains at this point thereafter. At this point the multiplier is still zero. If the economy is currently at the intersection between the decision rule for one of the better states and the 45-degree line and receives a worse shock, the constraint can bind strictly on impact as the economy jumps to the corresponding new decision rule. For example, if we are at the point where state 3 intersects the 45-degree line and we receive a worse shock we move up directly to a point where the constraint binds strictly (with positive multiplier). So the point on the support of the decision rule in which the constraint starts to bind strictly, depends on the particular exogenous state at which we evaluate the rule as well as the value of the endogenous state variable B_t.

Figure 2 contains the policy functions for other variables of the model as a function of the endogenous state, B_t. The policy functions are drawn for the continued realization of the worst shock. All variables ($C_{T,t}$, P_t^N, $C_{N,t}$, and H_t) follow a similar pattern. Before the constraint binds (before the kink in these rules) the economy behaves in a seemingly linear manner as this shock continues to realize. Far from the constraint, the continued realization of this shock leads to a decrease in both tradable and non-tradable consumption and an increase in debt (not reported in Figure 2) as agents will smooth the impact of the shock by borrowing more from abroad. Once the constraint is reached, however, the decision rules are driven by the need to meet it. Agents cannot longer borrow the desired amount and their borrowing capacity decreases. When the constraints bind, consumption of tradables goods decreases lowering the relative price of non-tradable goods. A falling relative price of non tradable goods has two effects. The first one is to reduce the borrowing capacity by lowering the collateral value of non-tradable income generating an amplification mechanism similar to the debt-deflation spiral (see also Mendoza, 200? on this). This effect amplifies the fall in tradable consumption. The second effect comes from the production side of the economy. Indeed as the price of non-tradable goods falls, the wage in units of tradables declines inducing a reduction in labor supply despite the fact that, as the constraint binds, the marginal utility of supplying one more unit of labor is higher. This second channel, combined with the amplified response of tradable consumption and the relative price of non-tradable, produces a fall in employment and non-tradable production/consumption.

The foreign debt distribution in the stochastic steady state of the model illustrates the working of the borrowing constraint more intuitively. In Figure 3, we compare the ergodic distribution of foreign debt for two economies, one with and one without the occasionally binding borrowing constraint.[16] As we can see, the foreign debt distribution of the economy with the constraint is shifted to the far right of that of the unconstrained economy and it is truncated. That is, agents would like to borrow much more than they can in the constrained economy, and are aware of the state-contingent borrowing limit as well as the possibility to run into a sudden stop because of that. Precautionary saving motive by private agents would then imply that the amount that is borrowed is on average lower than in the uncostrained economy. In the stochastic steady state of the economy, which averages over all possible equilibrium outcomes, there therefore will be an endogenous debt limit beyond which agents do not want to go. The ergodic distribution of borrowing will be truncated at that point. Note however that this is not necessarily the point at which the borrowing constraint binds strictly for any particular time or state of the economy.

The welfare gains of removing the constraint are large by the standards of the business cycle literature, at about 2 percent of consumption at every date and state. As we shall see, however, the overall welfare costs of the constrained inefficiencies imposed by the presence of the borrowing constraint, across different model specifications or parameter values, are much smaller and almost trivial. This is because the main differences in the behavior of these economies arise at the sudden stop, which in turn occurs only infrequently.[17] In fact the welfare cost of the constrained inefficiencies imposed by the borrowing constraint at the

[16] To compute the ergodic distribution of the unconstrained economy we need a stationary model. To achieve stationarity we use an elastic discount factor in both the constrained and the unconstrained economy. However, the elastic discount factor is not present in the model with the constraint that we use to produce all other results.

[17] As shown by Menoza (2002), the second moments of an economy with and without such constraints are quite similar.

sudden stop are quite large, and can account for more than 25 percent of the welfare gain from removing the constraint altogether.

5.2 Comparing to the social planner equilibrium

We now compare the allocations in the competitive equilibrium (CE) with those chosen by the social planner (i.e., SP for brevity), under alternative model specifications and parameter assumptions.

Figure 4 plots the decision rule for B_t for the worst possible state of the exogenous state ε_t in our baseline model with endogenous labor supply. This Figure shows that there is a small underborrowing when the constraint is not binding in the baseline model and a much larger one when the constraint is binding (i.e., for each value of the endogenous state B_t, B_{t+1} is significantly smaller in the CE than in the SP throughout the support of the decision rule). Thus suggesting that, in the benchmark economy there is theoretical scope for both ex ante and ex post policy interventions.

Figure 5 compares the behavior of the other endogenous variables for the worst value of the exogenous state ε_t, like in Figure 2. Consistent with Figure 4, there is a gap in the policy functions in the CE allocation and the SP one: the gap is more significant when the constraint binds. When the constraint does not bind, we observe a modest underborrowing. As we noticed earlier there are two opposite forces at work: on one hand the social planner would like to reduce current consumption of tradables bacause it keeps into account the amplification effects caused by the price externality ythat might occur in the future when the constraint binds. At the same time, the increase in marginal utility of tradables causes an increase in the marginal utility of non-tradables and as such an increase in labor supply and non-tradable production/consumption. When goods are complement this effect could dominate the first one causing tradables consumption to increase and saving to be lower that in the CE allocation. If that happens the equilibrium relative price of non-tradables is going to be higher in the SP compared to the CE. A policy intervention geared toward moving the CE closer to the SP would therefore have to induce more borrowing in normal times.

When the constraint binds the differences are even more marked. There are two key differences: first, the relative price of non-tradable increases in the SP, while it collapses in the CE (Figure 5), as the economy goes deeper into debt. Secondly in the SP allocation we observe lower labor and non-tradables consumption than in the CE. These differences arise depending on the way agents react to the constraint in the two equilibria. The planner limits the deflationary implications of the borrowing constraint by increasing the value of the collateral through prices (i.e. by increasing P^N) rather than quantities (i.e. it reduces Y^N). As we discussed in Section 3, when goods are complement, there is marginal benefit in supplying one less unit of labor. The value of the collateral would be higher than otherwise because, when goods are complement the relative price of nontradables will increase and offset the negative impact of lower non-tradables production/consumption. The overall implications of the planner's mechanism is to allow for higher borrowing capacity and as a consequence higher tradable consumption. [18]

In the CE, when the constraint is binding, all else equal, agents supply more labor to relax the constraint by increasing their non-tradable labor income. However, they don't internalize the effect that higher labor supply has, all else equal, on the equilibrium relative price. Indeed a lower relative price will tighten the constraint even more and induce a lower level of tradable consumption. As a result tradable consumption falls much more and much faster than in the SP.

Figure 6, compares the ergodic distributions of borrowing in the two allocations. It shows that the two allocations have a similar ergodic distribution of debt despite the differences in the decision rules conditional on the worst possible state.[19] Nonetheless, the mean debt-to-GDP of this distribution is slightly smaller in the CE than in the SP, as one would expect consistent with the plot in Figure 5. As Table 2 reports, the average level of debt as a ratio to annual GDP is -10.20 and -10.22 percent in the CE and the SP, respectively (a small but statistically significant difference).

The probability of having the constraint binding strictly is higher in the SP than in the CE (Table 2). It is 2.3 percent of the simulated quarters in the SP and only 2.06 percent in the CE (or 9.2 and 8.2 percent per year, respectively). This difference can be interpreted in terms of precautionary saving behavior, and the decision rules we discussed above illustrate how the latter comes about. The sudden stop is more costly in the CE than in the SP equilibrium in terms of total consumption in units of tradable goods, with a welfare gain from removing the constrained inefficiency imposed by it on the CE of 0.4 percent of consumption. Agents therefore try to borrow less and to face a sudden stop less frequently in the CE than the SP.

Consistent with the small differences in average debt and the probability of sudden stop we reported, the overall welfare gains of moving from the CE to the SP equilibrium is a mere 0.015 percent of average lifetime consumption (compared to about the 2 percent that can be obtained by removing the constraint altogether). This suggests that while there is

[18] As we shall see below, internalizing the consequence of the distortion introduced by the binding credit constraint in the labor margin (equation 8) is key to this result.

[19] The reason is that the decision rules for the better states are much closer to each others when the constraint does not bind and the economy spends little time in the worst state.

theoretical scope for policy action, second best policy interventions have an overall limited ability to affect welfare significantly. Thus, this stresses the importance of first best policy actions geared toward the complete removal of the financial friction at the root of the problem.[20]

Consider now the same economy under an alternative calibration in which agents are more impatient (i.e., the discount factor is lower at 0.91) and the shocks are larger. Figure 7 reports the same decision rules as Figure 5, while Figure 8 compares the ergodic distributions of B_t in the two allocations. As we can see from Figure 7, with more impatient agents and larger shocks, we now generate overborrowing relative to the SP equilibrium when the constraint does not bind. Being more impatient implies that agents have relatively higher current consumption of tradables good: since marginal utility of current consumption is now smaller than in the previous case the increase in current consumption (away from the constraint) dominates the negative effect of lower current consumption of tradables induced by the labor supply mechanism in the SP allocations. In equilibrium, as goods are complement, we observe higher consumption of tradables, higher consumption of nontradables and higher relative price of non-tradables. Instead, when the constraint is binding, the decision rules for the CE behave in a similar manner as in the benchmark economy, relative to those of the SP.

This economy's behavior thus differs not only quantitatively but also qualitatively compared to the benchmark economy. The important policy implication is that this economy would require an ex ante policy intervention of opposite sign to that in the benchmark model to close the gap between the CE and the SP. However, when the constraint binds (after the kink in the decision rules), the difference compared to the benchmark calibration is only quantitative. This suggests that the sign of an ex post policy intervention would be the same in the two economies, although the intensity of that intervention would possibly be different because of different parameter values.

As Table 2 reports, average debt in the stochastic steady state of this economy is smaller than in the benchmark model, and larger in the CE than in the SP (i.e., there is overborrowing as we noted already). Average debt is smaller than in the benchmark economy because here the sudden stops are more costly with a welfare gain of moving from the CE to the SP at the sudden stop of 0.6 percent of permanent consumption (although the overall welfare differences between these two economies are trivial), and hence private agents self insure more. This also leads to a significantly smaller probability of sudden stop in the CE in this case (1.53 percent per quarter). In contrast, the planner, faces sudden

[20] The intuition for this is that welfare is state dependent in these economies. And given that all economies spend most of their time outside the sudden stop state, the overall welfare difference is very small.

stops with about the same probability as in the benchmark economy (2.2 percent of the quarters). Yet, here, the constrained efficient level the borrowing is lower than in the benchmark economy.

Consider now an endowment economy under the baseline and the alternative calibration. Figure 9, compares the decision rule and the ergodic distribution for foreign borrowing in the CE and the SP when labor supply is exogenous, i.e., in a endowment economy, for two sets of parameter values that are the same as in the production economies discusse above, to the extent possible. As we can see from Panel A, for the baseline parameter values and the worst realization of the shock, once we shut off endogenous labor supply, there is essentially no difference in the decision rule for foreign borrowing between the CE and the SP allocation, either before or after the constraint binds. This implies that the differences between CE and SP allocations documented above stem from the distortion introduced by the credit constrain in the labor margin of the households (equation 8). Nonetheless, we can see that in the ergodic distribution (which averages over all possible realizations of the shocks and points on the support of the decision rules) we find a small overborrowing. This suggests that the distortion introduced by the credit constraint in the intertemporal margin leads households to undervalue current marginal utility of tradable consumption relative to future one.

Average annual borrowing is 7.4 and 7.1 percent in this case, while the probabilities of sudden stops are 13.0 percent in the CE and 1.7 percent per quarter in the SP. In the CE, in this case, the probability of sudden stop is much higher because households cannot rely on the labor margin to supply more collateral when the constraint binds or is expected to bind in the future and the cost of the sudden stop relative to the constrained efficient allocation is small. In fact, the gain of moving from the CE to the SP is of two orders of magnitude smaller than in the production economies above, at 0.002 percent of permanent consumption. So agents in this economy are willing to meet it more frequently despite the fact that they borrow less on average compared to the benchmark economy. The social planner also borrows less on average than in the benchmark economy with production, but its probability of meeting the constraint is much smaller than in the CE, and not too far away for the one found in the benchmark economy.

In an endowment economy with more impatient agents and larger shocks overborrowing is larger. This is evident from Panel B of Figure 9 and is consistent with the comparison between the two production economies we discussed above. In this case, the decision rule for B_t for the worst possible state also shows clearer evidence of over-borrowing in the intermediate region of the state space. In this endowment economy, both the average level of borrowing an the probability of sudden stop are comparable to those in the benchmark production economy (10.25 and 2.36 percent, respectively). Interestingly, however, the social planner faces a sudden stop with a much lower probability than in all other cases in this endowment economy (0.23 percent) despite a similar level of average borrowing as in the CE.[21] The gain of moving from the CE to the SP is one order of magnitude larger than in the endowment economy with baseline calibration, but still much smaller than in the production economies above, at 0.02 percent of permanent consumption.

The important policy implication of the comparison between production and endowment economies is that, by construction, in the latter, there is no scope for ex post policy intervention in this environment. It is therefore not possible to analyze the relative merits of the two intervention strategies. As tradable consumption is pinned down by the constraint when this binds, in an endowment economy, neither private agents nor the planner can manipulate the collateral value of non-trable income to relax the borrowing constraint and hence seek to achieve a better allocation.

6 Policy Implications

The quantitative analysis in the previous section has important policy implications. A recent literature reviewed in section 2 has focused on the theoretical and quantitative possibility of overborrowing, unambiguously recommending ex ante type of intervetions such as a Tobin tax or other prudential controls on international capital inflows, to curtail it.

While consistent with a theoretical second best view of the world, this clear cut policy prescription in practice warrants several qualifications. First, overborrowing is clearly a quantitative matter, and there is no solid basis to conclude that overborrowing is a key and general feature of emerging economies. As we saw in the quantitative analysis conducted in the previous section, it is sufficient to move from a calibration to the "Argentina" economy to a calibration to the "Mexican" economy to find a small underborrowing rather then overborrowing if the model has endogenous labor supply. By the well established standards of the DSGE methodology, such lack of robustness is sufficient to require a more cautious approach to prudential controls on capital inflows, especially in light of the (mixed at best) historical experience with such policy tools. By the standards of the DSGE methodology, the pros and cons of alternative policy regimes should be evaluated quantitatively in models that fit the data well, as it is now the case for standard monetary and fiscal stabilization policy issues. But rich models with occasionally binding financial frictions are not easily

[21] This is possibly because of our definition of sudden stop (as the event in which the constraint binds strictly) does not allow for the possibility to be close to (and hence negatively affected by) but not yet at the constraint.

amenable to be analyzed quantitatively with the same ease with which the standard new Keynesian model has been investigated in the monetary literature. So there is a need to recognize that these models are in their infancy and not yet ready to provide clear cut policy recommendations. One important implication is that capital controls alone as recommended in the literature (as recently implemented by Brazil) may not achieve constrained efficiency in more richly specified and parametrized economies.

Second, such interventions are distortionary and may hamper economic efficiency if inappropriately imposed. As Nikolov (2009) has pointed out, for instance, in this kind of model environment, there is a trade off between the higher volatility associated with looser borrowing constraints (i.e., a higher leverage ratio in his model) and the lower average growth associated with imposing prudential controls (i.e., lower leverage ratios in his model). So mandating lower regulatory leverage ratios on prudential grounds may impose significant efficiency costs in terms of lower average growth. This point is largely absent from the current policy debate, in part because it is difficult to evaluate such trade off quantitatively in the models available. Nonetheless, Nikolov's (2009) analysis clearly highlights the risk involved, consistent with the traditional debate in the literature on capital controls.

Third, even when they are the appropriate policy regime from a second-best welfare perspective, ex-ante policies do not eliminate sudden stops and finacial crises completely. They just mitigate their severity, and possibly their likelihood as our analysis highlights. So even with prudential policies in place, we would still need to design policies that can be implemented in response to sudden stops. This is brought out clearly by our analysis of the two production economies considered in which there are wedges between the CE and the SP allocations both before and after the constraint binds. A combination of ex post and ex ante interventions, as allowed for in Beningno et al (2009), seems preferable on these grounds. In Benigno at al (2009), we study optimal policy for intervening on the exchange rate before and after a possible sudden stop. The instrument is a distortionary tax instrument that can be interpreted as an intervention in the foreign exchange market that affect both static and intertemporal margins. The optimal policy problem we set up explicitly allows for both ex-ante and ex-post intervention, as we search for an optimal policy rule for all states of the world. The analysis in that work finds that ex-post policies are more important than ex-ante.

Fourth, while a comparison among alternative second best policy regime is useful in practice, one should not loose sight of first best outcomes, especially in the long run. As we saw in fact overall welfare differences between CE and SP allocations are only a tiny fraction of the welfare gain of removing the constraint altogether. A more difficult, but safer, direction to orient policy action is to try to address the underlying sources of financial frictions.

In the specific case of our model, this means strengthening domestic policies (e.g., more sustainable fiscal and external positions and higher official reserve cushions) and domestic and international institutions to allow foreign creditors to impose looser debt constraints and have stronger incentive to stay in markets buffeted by external shocks. But the details of the micro fundations may matter for the policy conclusions. In particular, there are no moral hazard concerns in our set up. Using these models for positive purposes, to describe the cycle or the crisis, or both, the micorfundations of financial friction matter less. For policy analysis, they can make a difference. For instance, moral hazard considerations may surface in a microfunded specification of our constraint. Once moral hazard of ex post policies is considered, the implication may be reversed and ex ante policies may become more clearly preferable. For instance, if one considers two-sided commitment problems in models of default, such as in Cavallo, Chang, and Velasco (2009), the recommendation would be to adopt policies that facilitate creditors' commitment to borrowers to alleviate the consequences of the credit friction. In practice, this means policies that facilitate the smooth functioning of international capital markets such as the defunct sovereign debt restructuring mechnaism, the collective action cluses, and the international corporate debt restructuring mechanism that we should be talking about in light of the recent experaince. That is, policy should be geared toward improving the stability of the of international markets, rather the climate in the receiving country. Both set of policies should therefore be pursued at the same time. Indeed, studying overborrowing with fully micro-funded finacial frictios is an important area of future research.

7 Conclusions

In this paper we study overborrowing quantitatively in production and endowment small open economies subject to a borrowing constraint that occasionally gives rise to sudden stops, endogenously. In this environment, there is a well known pecuniary externality that creates theoretical scope for policy intervention. We found that while the competitive equilibrium of these economies is never constrained efficient, differences in allocations with respect to a socially planned equilibrium are both qualitative and quantitative matter. Differences between the two allocations can arise both when the constraint is binding and when it is not in a production environment. But they arise only when the constraint is not binding in an endowment economy. Moreover, within production economies, whether or not there is overborrowing depends on the value of specific parameters. In the endowment economies we considered there is always overborrowing, but its quantitative relevance does depend heavily on parameter values. In particular, significant differences when the constraint does not bind can arise only for economies with relatively impatient agents and large shocks compared to the typical emerging market economy. As we discuss in the paper, this finding has important policy implications and suggests that both ex ante and ex post policy interventions are likely to be welfare improving, but the largest pay offs are likely to stem from actions geared toward addressing the underlying sources of financial friction.

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Table 1. Model Parameters

Structural parameters	**Values**
Elasticity of substitution between tradable and non-tradable goods	$\kappa = 0.760$
Intertemporal substitution and risk aversion	$\rho = 1$
Labor supply elasticity	$\delta = 2$
Credit constraint parameter	$\phi = 0.7$
Labor share in production	$\alpha = 1$
Relative weight of tradable and non-tradable goods	$\omega = 0.48568$
Discount factor	$\beta = 0.98$

Exogenous variables	**Values**
Tax rate on non-tradable consumption	$\tau = 0.00$
World real interest rate	$i = 0.0159$
Steady State Relative Price of Non-tradable	$P_N = 1$

Productivity process	
Persistence	$\rho_{\varepsilon^T} = 0.55^4$
Volatility	$\sigma_{\varepsilon^T} = 0.59^4$

Table 2. Average foreign borrowing and probability of a sudden stop

Annual average debt in ergodic distribution (Percent per year)	**CE**	**SP**
Production, benchmark parameters	-10.20	-10.22
Production, alternative parameters	-7.31	-6.90
Endowment, benchmark parameters	-7.40	-7.10
Endowment, alternative parameters	-10.25	-10.14
Quarterly sudden stop probabilities (Percent per quarter)		
Production, benchmark parameters	2.06	2.30
Production, alternative parameters	1.53	2.20
Endowment, benchmark parameters	13.66	1.70
Endowment, alternative parameters	2.36	0.23

Welfare gains of moving from CE to SP at the sudden stop

Production, benchmark parameters: 0.4 percent of permanent consumption

Production, alternative parameters: 0.6 percent of permanent consumption

Endowment, benchmark parameters: 0.002 percent of permanent consumption

Endowment, alternative parameters: 0.02 percent of permanent consumption

Figure 1: Decision Rule For Foreign Borrowing (Competitive Equilibrium)

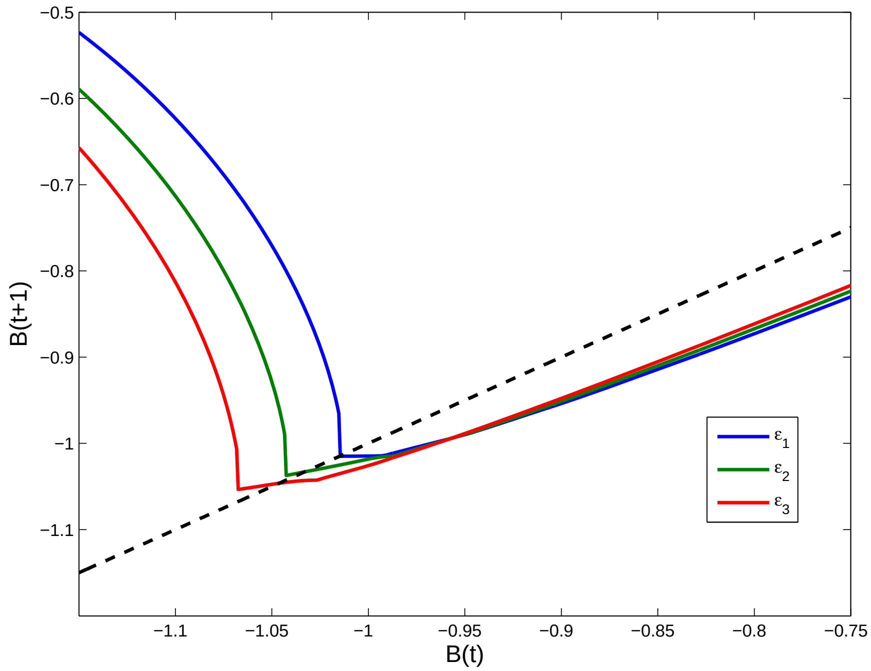


Figure 2: Decision Rules For Relative Price, Consumption, and Labor (Competitive Equilibrium)

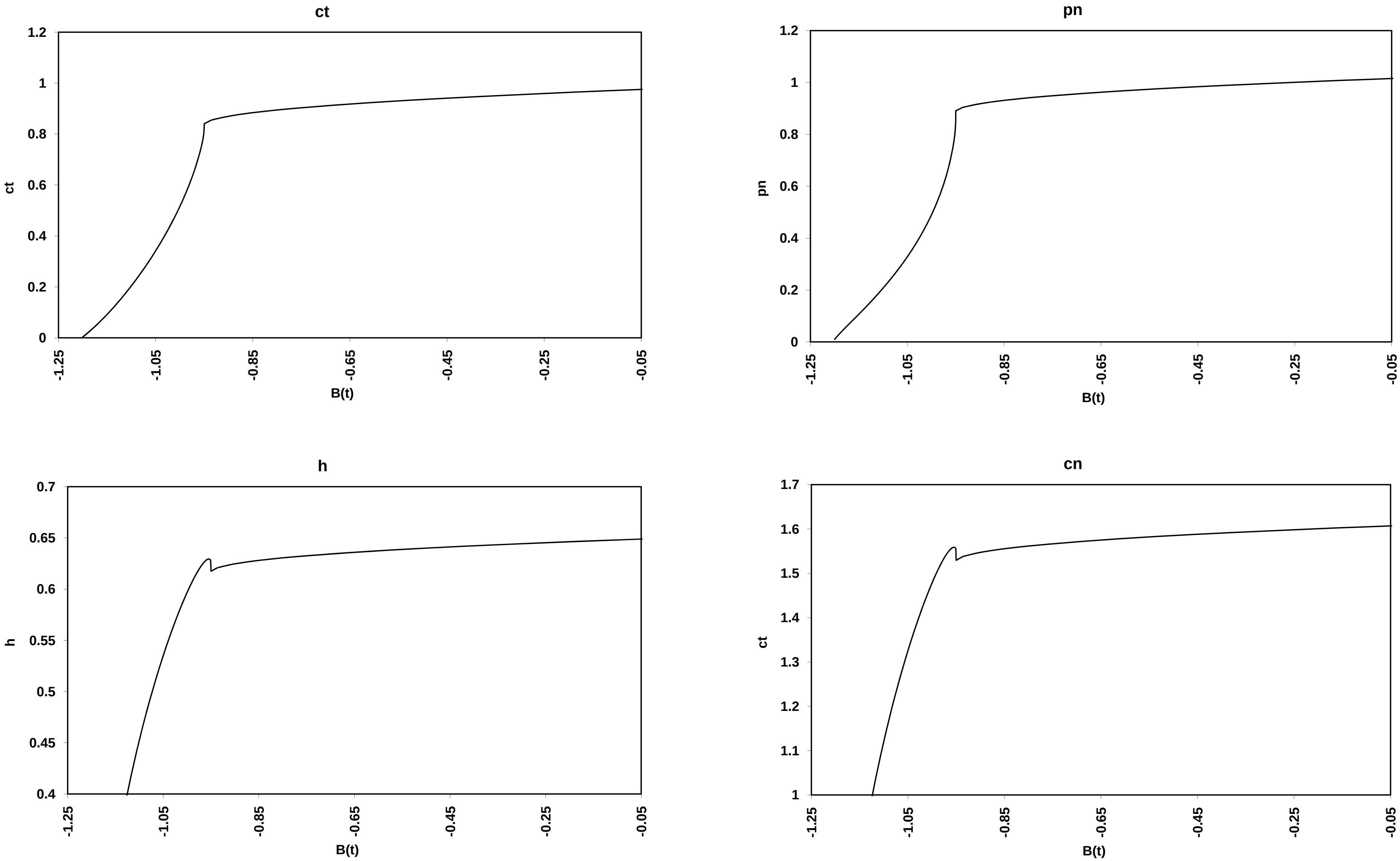


Figure 3. Ergodic Distribution For Foreign Borrowing

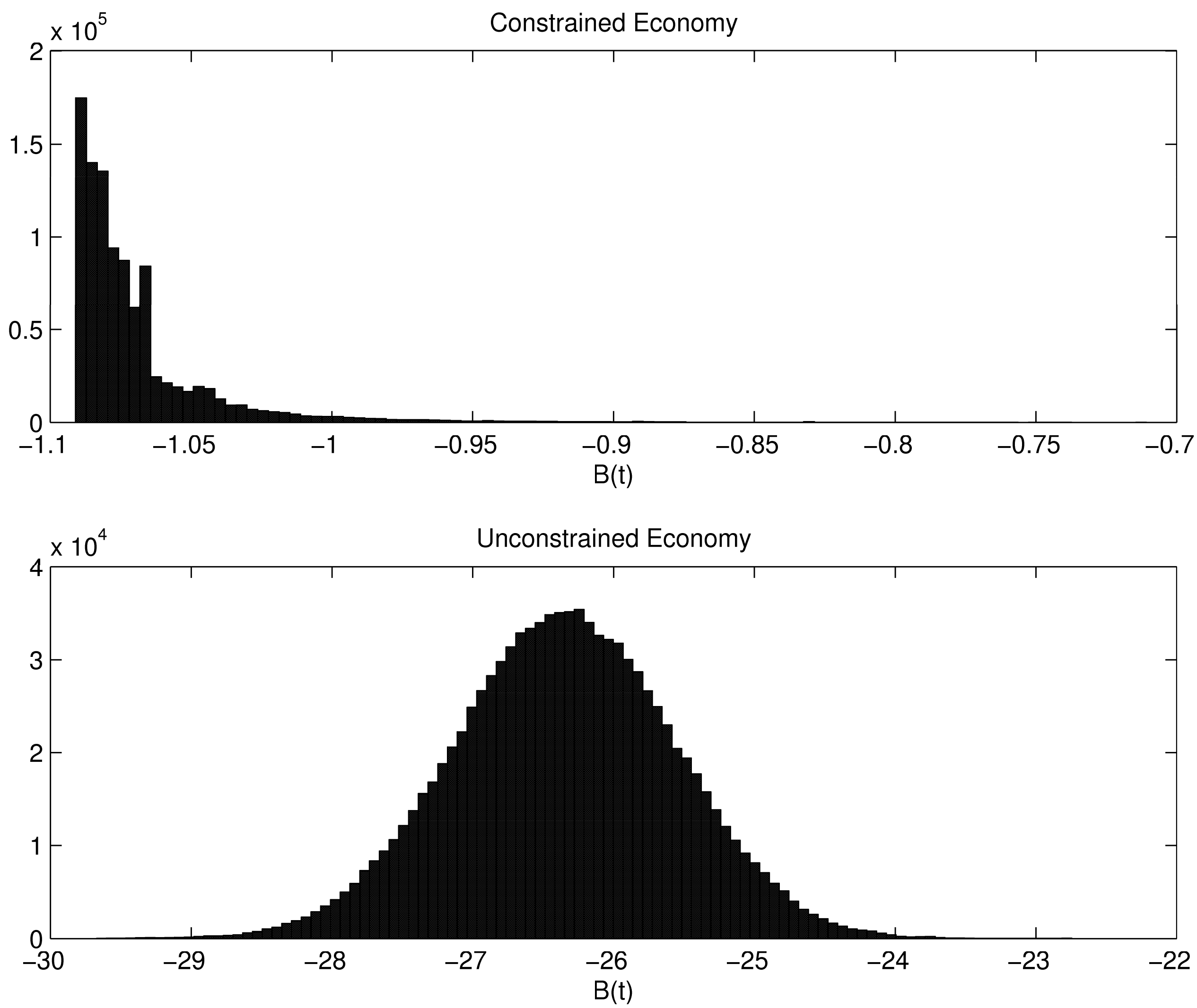


Figure 4: Decision Rule For Foreign Borrowing (Competitive Equilibrium and Social Planner)

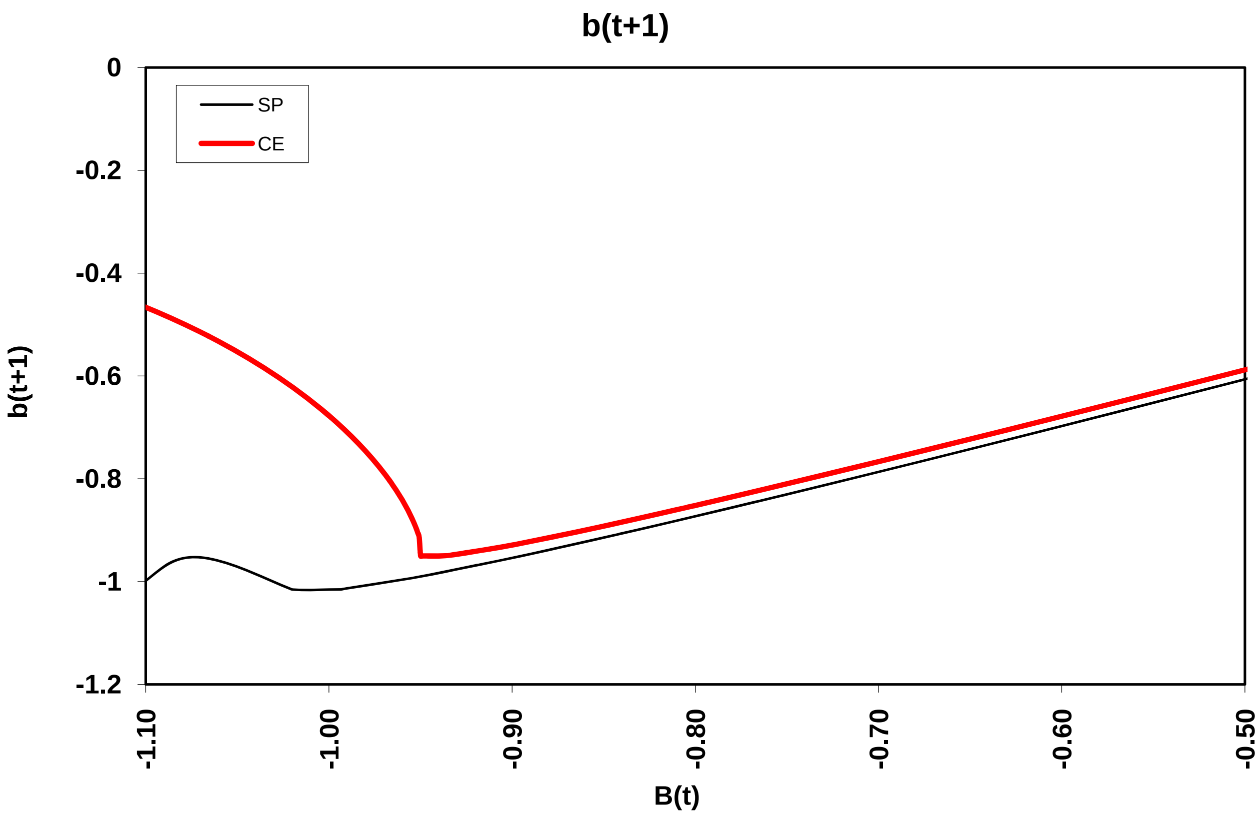


Figure 5: Decision Rules For Relative Prices, Consumption, Labor (Competitive Equilibrium and Social Planner)

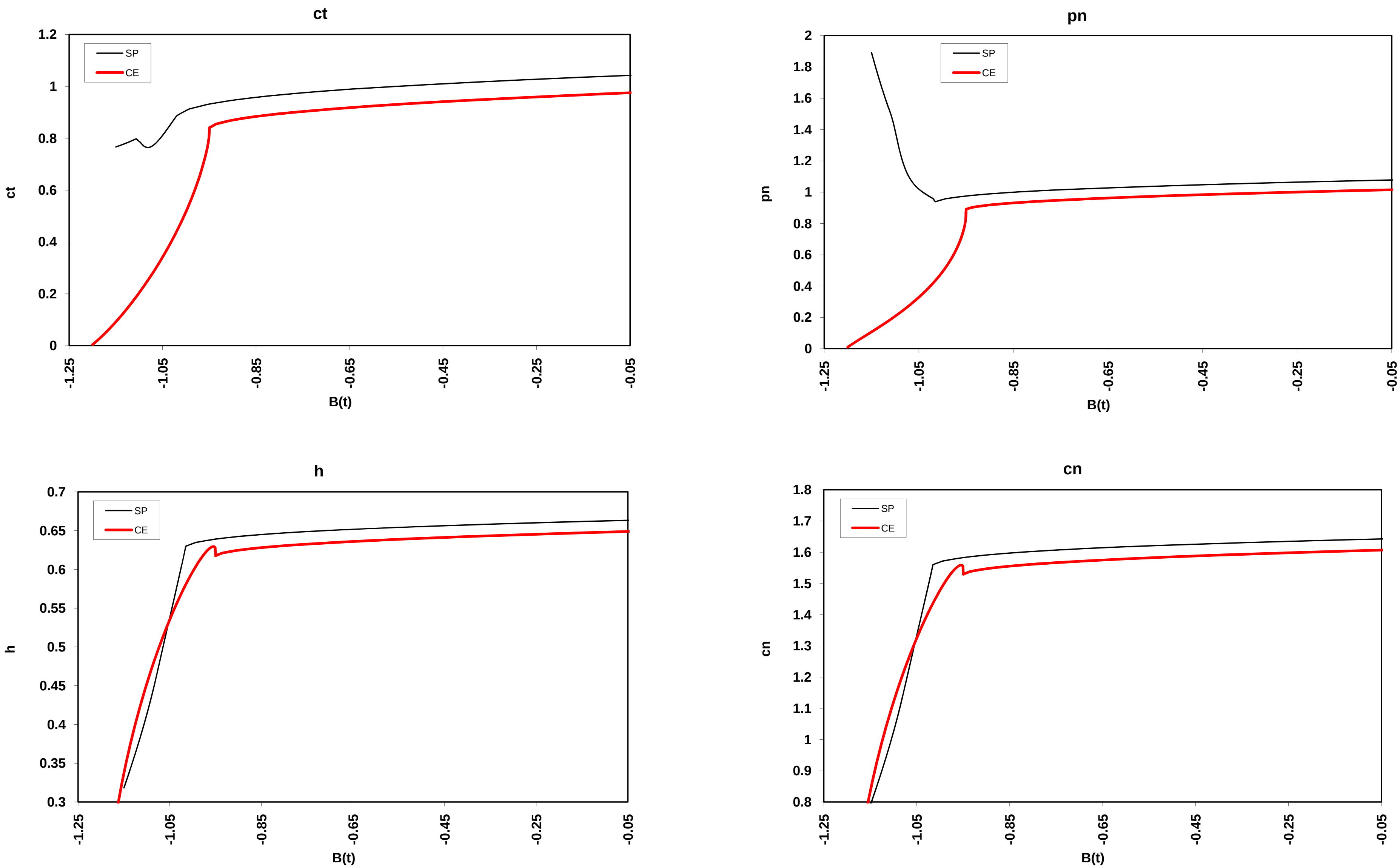


Figure 6: Ergodic Distribution For Foreign Borrowing (Competitive Equilibrium and Social Planner)

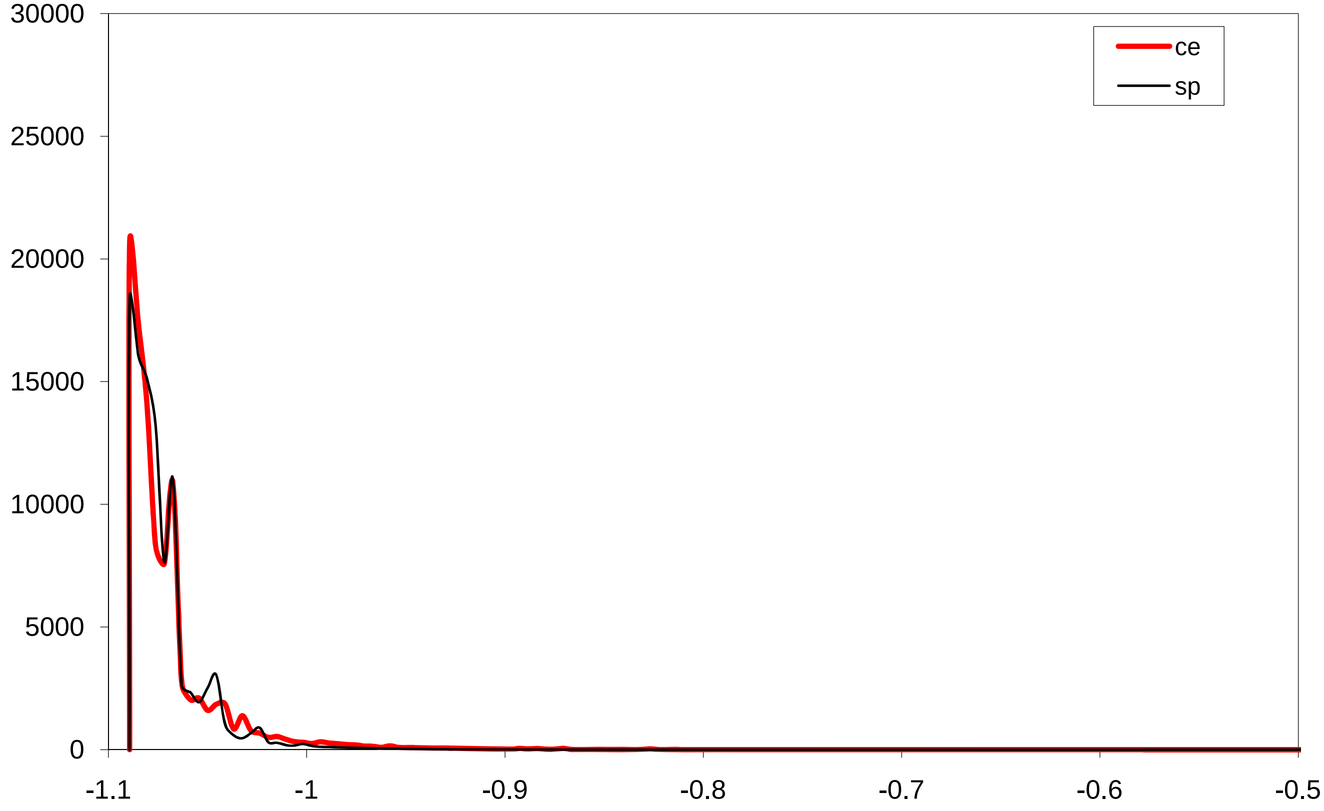


Figure 7: Alternative Calibration (More impatient agents and larger shocks)
Decision Rules For Foreign Borrowing, Relative Price, Tradable Consumption, and Labor (Competitive Equilibrium and Social Planner)

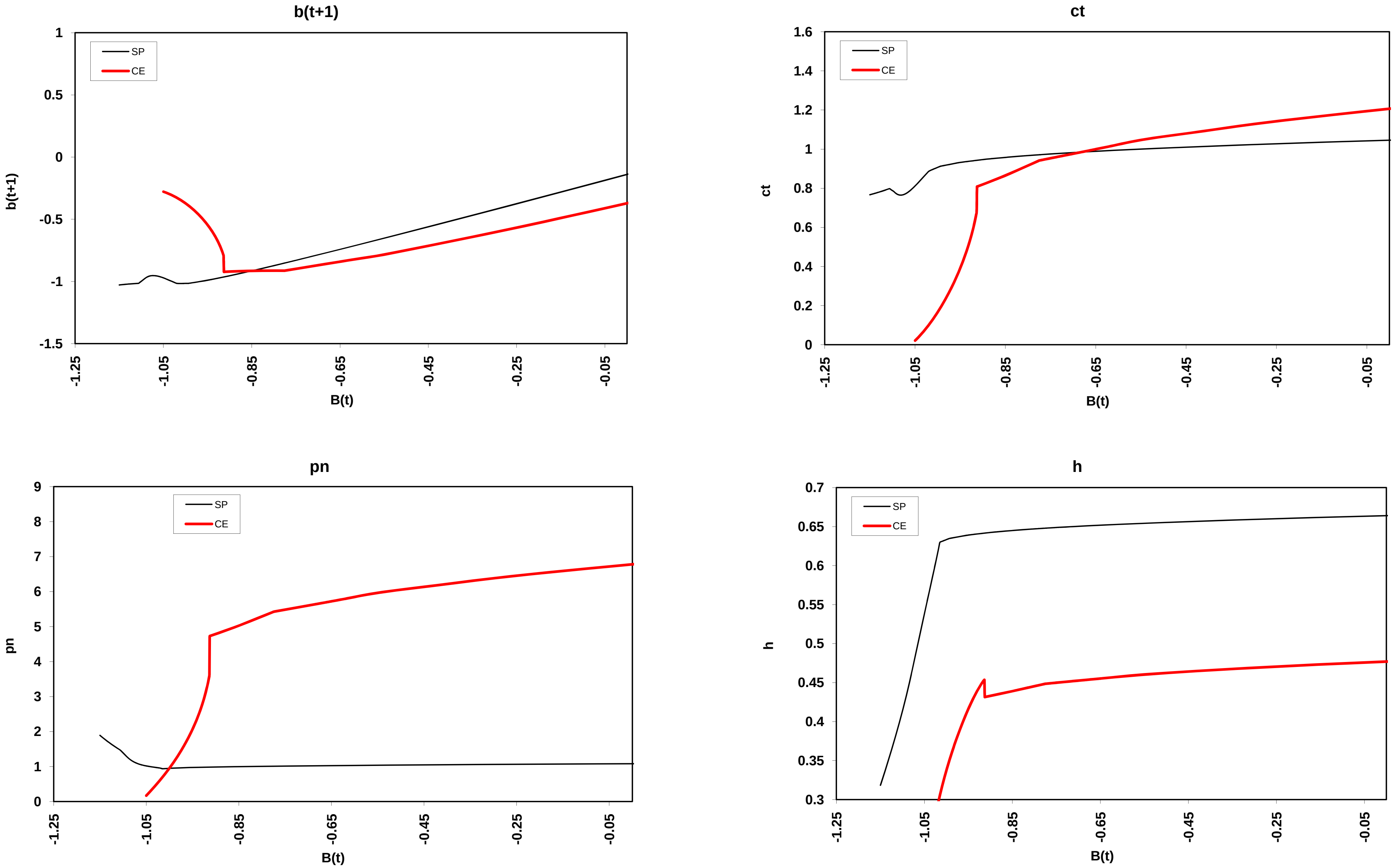


Figure 8: Alternative Calibration (More impatient agents and larger shocks)
Ergodic Distribution For Foreign Borrowing (Competitive Equilibrium and Social Planner)

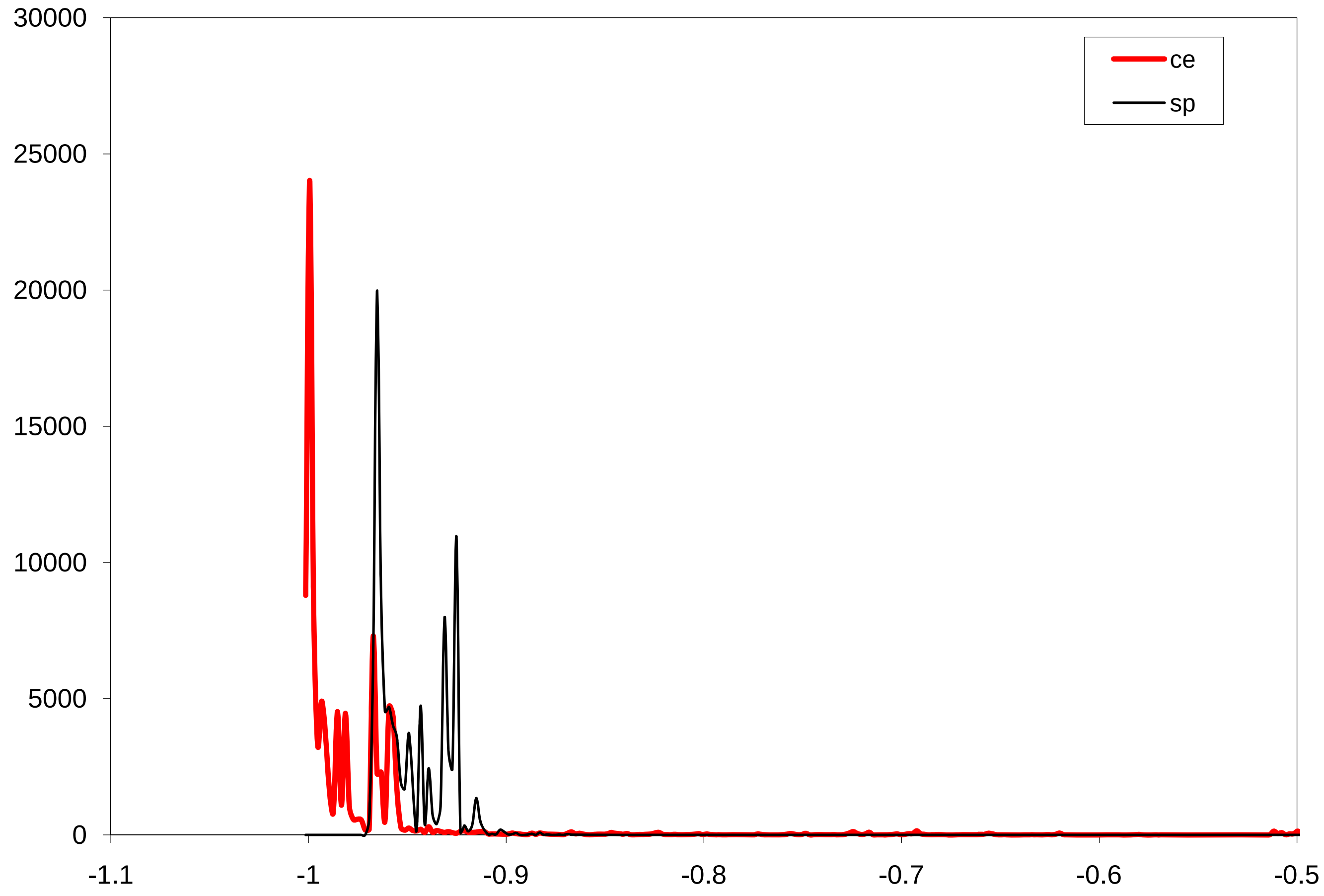
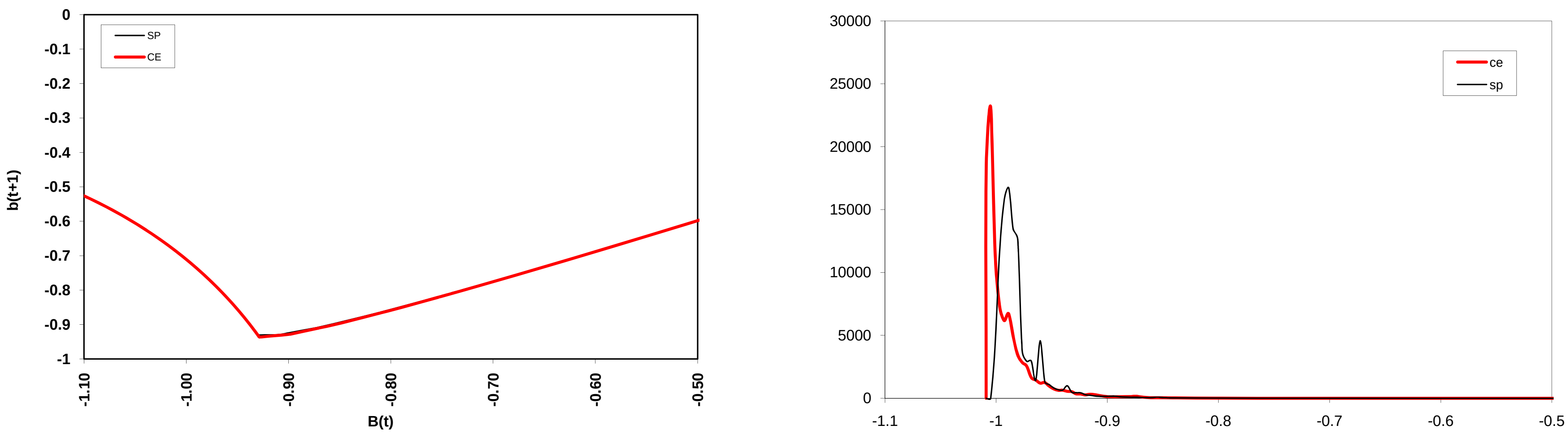


Figure 9: Endowment Economies under Alternative Calibrations (Competitive Equilibium and Social Planner)
Panel A. Baseline calibration



Panel B. Alternative calibration