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ABSTRACT

Financial Crisis and Macro-Prudential Policies*

Stochastic general equilibrium models of small open economies with occasionally binding financial frictions are capable of mimicking both the business cycles and the crisis events associated with the sudden stop in access to credit markets (Mendoza, 2010). In this paper we study the inefficiencies associated with borrowing decisions in a two-sector small open production economy. We find that this economy is much more likely to display "under-borrowing" rather than "over-borrowing" in normal times. As a result, macro-prudential policies (i.e. Tobin taxes or economy-wide controls on capital inflows) are costly in welfare terms in our economy. Moreover, we show that macro-prudential policies aimed at minimizing the probability of the crisis event might be welfare-reducing. Our analysis shows that there is a much larger scope for welfare gains from policy interventions during financial crises. That is to say that, within our modelling approach, ex post or crisis-management policies dominate ex ante or macro-prudential ones.

JEL Classification: E52, F37 and F41
Keywords: bailouts, capital controls, crises, financial frictions, macro prudential policies and overborrowing

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1 Introduction

The great recession of 2007-2009 vividly illustrated the importance of financial market imperfections for emerging and advanced economies alike. For emerging markets this fact is old news as financial imperfections have long been recognized as an important source of business cycle fluctuations and crises in these countries. The great recession of 2007-2009 and the long series of crises in emerging markets beforehand have shown that financial market imperfections result in periods in which capital market access is curtailed and expenditure plans have to be adjusted suddenly. These periods—labelled in the literature credit crunches and sudden stops—are associated with large declines in consumption, output, relative prices, and asset prices.

Macroeconomic models with occasionally binding financial frictions have proven to be capable to describe both the regular business cycle (i.e., normal times when market access is unconstrained) and crisis events (when the market access is curtailed) (e.g., Mendoza, 2010). The distinctive feature of these models is the fact that the underlying financial friction binds only occasionally and the crisis is an endogenous event.

The contribution of this paper is to analyzes the normative implications of this class of models and discuss what broad set of policies will best mitigate the consequences of these financial frictions. To do so we focus on a two-sector small open economy model as in Mendoza (2002) taking as given that it is a useful lens through which to understand the economics of sudden stops.[1]

The scope for policy intervention in this class of models follows from a price externality (or a pecuniary or credit externality) that arises because agents do not internalize the effect of their individual decisions on a key market price entering the specification of the financial friction—see Arnott, Greenwald, and Stiglitz (1994) for a discussion. Because of this externality, it has been shown that in models like the one we analyze there is the potential for inefficient borrowing to occur (e.g. Fernandez-Arias and Lombardo 1998, Uribe 2007, and Lorenzoni 2008). This inefficiency is measured and quantified by comparing the amount that individual agents borrow in the competitive equilibrium (CE) of the economy with the amount that a social planner would choose in an economy subject to the same occasionally binding credit constraint (SP).

By considering the role of the credit externality in a multi-sector production economy, we first show that the direction of inefficient borrowing is ambiguous (i.e. production economies might display over or under borrowing). In our benchmark economy, however,

[1] Both Mendoza (2002) and Benigno Chen, Otrok, Rebucci and Young (2009) provide a detailed discussion of the model. Bianchi (2010) uses an endowment version of this model.

underborrowing is a robust feature of the competitive equilibrium allocation. From a policy perspective, the claim that macro-prudential policies in the form of a tax on borrowing or capital controls can restore efficiency is not robust at best. In our benchmark economy, imposing on the competitive equilibrium allocation a one percent tax on borrowing in tranquil times is welfare-reducing. Despite reducing the probability of a crisis event to zero, macro-prudential policies are costly as they reduce the average consumption level. Second, we also document that the welfare gap between the social planner and the competitive allocation is larger when the crisis occurs (i.e. when the constraint is binding) suggesting that policy interventions during crisis times (such as bailouts or lending of last resort) are more relevant (in welfare terms) than ex-ante ones. The policy implication is that models that eliminate this potential source of ex post inefficiency bias upward the calculation of the welfare gains from ex ante intervention policies.

The mechanisms behind our main findings depend on the interaction between the credit externality and the consumption and labor decisions by agents. In general agents will try to insure against the crisis event (i.e. the possibility that the constraint becomes binding). While in an endowment economy agents self-insure by saving more, in a production economy self-insurance occurs also through labor supply choices. The presence of the credit externality creates a gap between the way competitive agents value consumption and production decisions (private value) versus the way decisions are valued by the social planner (social value) determining the possibility of inefficient behavior.

The general equilibrium interaction between consumption and labor supply decisions can be summarized in three separate effects arising from the presence of the externality: an "intertemporal effect," a "production effect," and an "intrasectoral allocation effect." The intertemporal effect of the externality is well known: because of the credit constraint the marginal social value of saving (the marginal value in the social planner allocation) is higher than the private value (in the competitive equilibrium allocation). Thus, the intertemporal effect of the externality implies that private agents overborrow in the competitive equilibrium allocation and overconsume tradable goods (see Bianchi, 2010). But, while in endowment economies there is no other effect from the externality, in multi-sector production economies the intertemporal allocation of consumption influences labor supply and production decisions via relative price changes. As a result, in our model, the externality also affects the total labor supply and its sector composition or allocation.

Specifically, all else being equal, via changes in relative prices, the relatively lower private value of saving induced by the credit externality can generate a lower private value of supplying additional labor compared to the social one. Lower private production and consumption of domestically produced goods (both tradable and non-tradable goods) can then lead to lower borrowing relative to what is socially desirable, and thus generate the possibility of underborrowing. In addition, while total labor supply tends to be lower than socially desirable, in our multi-sector production economy, the externality also influences the intrasectoral allocation of labor and production. In our benchmark economy, for given total labor supply, the planner will allocate more resources towards the tradable sector than private agents. As a result, the planner will produce and consume less non-tradable goods than private agents, implying lower tradable consumption and higher saving in the social planner allocation relative to the competitive equilibrium. The relative tilt in the socially desirable allocation of labor towards tradable production will then tend to reinforce overborrowing in the competitive equilibrium of the model.

The net result of these three effects determine whether in equilibrium the model economy displays over- or underborrowing. In our baseline calibration, the sum of these three contrasting forces results in underborrowing in equilibrium. More generally though, this general equilibrium interactions suggest that the relative strength of these effects create ambiguity in the direction of the inefficient borrowing. In our analysis, these mechanisms on the production side of the economy are robust to a variety of model specifications, in which the collateral constraint is specified in terms of asset prices rather than relative price of nontradables or the presence of working capital constraint.

Our welfare analysis shows the importance of focusing on the effects of credit externality in production economies. Differently from the endowment case, the planner can affect the value of the collateral by altering the production mix and the relative prices: this creates a gap between the competitive and the planner allocation also in crisis times. Given an overall welfare gain of moving from the CE to the SP allocation, which is about 0.12 percent of permanent consumption, we find that these gains increase by about 25 percent to 0.15 percent if we focus only on the crisis states. Thus, while our "underborrowing" result implies that borrowing should be subsidized rather than taxed in both good and bad times, our welfare analysis shows that intervening in crisis times is more important than in normal times. More generally, our result implies that the welfare gains of policy intervention during a crisis is greater than outside those periods, suggesting that ex-post policies are likely to be more important than ex-ante ones in this class of models.

A set of related studies has examined the policy implications of the same credit externality we focus on in this paper. Korinek (2010) and Bianchi (2010) use endowment versions of the economy we study and find that individual agents in the CE borrow more than in the SP (i.e., they overborrow) and advocate the use of macro-prudential policies (or more generally ex-ante intervention policies) in the form of a tax on international borrowing or economy-wide capital controls as a way to restore efficiency. Jeanne and Korinek (2010) and

Bianchi and Mendoza (2010) analyze models in which the price externality arises because agents fail to internalize the effect of their decisions on an asset price rather than the relative price of non-tradable goods like in our model. Their analysis and policy conclusions are similar to those of Korinek (2010) and Bianchi (2010). All these model economies exhibit overborrowing and an ex ante intervention policy is the proper tool to restore efficiency. In addition, these models are such that ex post intervention policies such as bailouts or any lending of last resort have no scope. This is because, by assumption, in crisis periods, the CE and SP allocations cannot differ when the credit constraint binds in these models.[2]

The model that we use in this paper is standard, except for the occasionally binding credit constraint. The occasionally binding credit constraint is embedded in a 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). The asset menu is restricted to a one period risk-free bond paying off the exogenously given foreign interest rate. In addition to asset market incompleteness, we assume that access to foreign financing is constrained to a fraction of households' total income.

The rest of the paper is organized as follows. Section 2 describes the two-sector production model we use and explains the working of the credit externality in this set up. Section 3 discusses its solution, parametrization and performance. Section 4 compares the CE and the SP equilibria of the baseline model economy we study, discusses the robustness of the main findings of the numerical analysis, and quantifies the welfare gains or costs of tobin taxes in this model set up. Section 5 concludes.

2 Model

The model that we use is a simple two-sector (tradable and non-tradable) small open economy, in which financial markets are not only incomplete but also imperfect like in Mendoza (2010), and in which production occurs in both sectors.

2.1 Households

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

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

[2]See Benigno, Chen, Otrok, Rebucci, and Young (2010) for a more detailed discussion of the related literature and a quantitative comparison between production and endowment economies.

with C_j denoting the individual consumption basket and H_j the individual supply of labor for the tradeable and non-tradeable sectors ($H_j = H_j^T + H_j^N$). The assumption of perfect substitutability between labor services in the two sectors insures that there is a unique labor market. For simplicity we omit the j subscript for the remainder of this section, but 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 (GHH, 1988). In the context of a one-good economy this specification eliminates the wealth effect from the labor supply choice. Here it is important to emphasize that in a 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 tradable goods in the consumption basket. 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 net foreign asset position 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 a balance sheet effect (e.g., Krugman (1999) and Aghion, Bacchetta and Banerjee (2004)) since foreign borrowing is denominated in units of tradables while the income that can be pledged as collateral is generated also in the non-tradable sector. The value of the collateral is endogenous in this model 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 contract between lenders and borrowers. However, we can interpret this constraint as the outcome of an interaction between lenders and borrowers in which the lenders is not willing to permit borrowing beyond a certain limit.[3] This limit depends on the parameter ϕ that measures the tightness of the borrowing constraint and it depends on current income that could be used as a proxy of future income.[4]

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

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

where μ_t is the multiplier on the period budget constraint and λ_t is the multiplier on the international borrowing constraint. When the credit constraint is binding ($\lambda_t > 0$), the Euler equation (7) incorporates an effect that can be interpreted as arising from a country-

[3] As emphasized by Arellano and Mendoza (2003), 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.

[4] 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 need to avoid for tractability since future consumption choices affect current borrowing decisions.

specific risk premium on external financing. In this framework, even if the constraint is not binding at time t, there is an intertemporal effect coming from the possibility that the constraint might be binding in the future. This effect is embedded in the term $E_t\left[\mu_{t+1}\right]$, which implies that current consumption of tradeable goods would be lower compared to an economy in which access to foreign borrowing is unconstrained.

From the previous conditions, we can combine (5) and (6) to obtain the intratemporal allocation of consumption and (5) with (8) to obtain the labor supply schedule, respectively:

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

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

Note here that

$$\left(\frac{\omega C}{C^T}\right)^{\frac{1}{\kappa}} = (\omega)^{\frac{1}{\kappa-1}}\left(1+\left(\frac{1-\omega}{\omega}\right)\left(P_t^N\right)^{1-\kappa}\right)^{\frac{1}{\kappa-1}}.$$

If we were in a one good economy model, there would be no effect coming from the marginal utility of consumption on the labour supply choice because of the GHH preference specification. In a two-sector model, however, a decrease in P_N increases $\left(\frac{\omega C}{C^T}\right)^{\frac{1}{\kappa}}$, and the labor supply curve becomes steeper as P_N falls.[5] Note also that, when the constraint is binding ($\lambda_t > 0$), the marginal utility of supplying one more unit of labor is higher, and this helps to relax the constraint: when $\lambda_t > 0$, the labor supply becomes steeper and agents substitute leisure with labor to increase the value of their collateral for given wages and prices. Given that P_N falls when the constraint is binding, these two effects imply an increase in labor supply for given wages in the constrained region.

Importantly, the labor supply is also affected by the possibility that the constraint may be binding in the future. If in period t the constraint is not binding but it may bind in period $t+1$, we have

$$\left(C_{j,t}-\frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho}\left(H_{j,t}^{\delta-1}\right) = \mu_t W_t$$

and

$$\mu_t = \beta\left(1+i\right)E_t\left[\lambda_{t+1}+\beta\left(1+i\right)E_t\left[\mu_{t+2}\right]\right],$$

so that the marginal benefit of supplying one more unit of labor today is higher, the higher

[5] In what follows, we refer to the labor supply curve in a diagram in which labor is on the vertical axis and the wage rate on the horizontal one.

is the probability that the constraint will be binding in the future. This effect will induce agents to supply more labor for any given wage, and again the labor supply curve will be steeper relative to the case in which there is no credit constraint. For given wages then, this effect tend to increase the level of non-tradable production and consumption and affects tradable consumption depending on the substitutability between tradable and non-tradable goods. When goods are complements, the increases in nontradable consumption is associated with an increase in tradable consumption that reduces the amount agents save in the competitive equilibrium. The opposite would occur if goods were substitute.

2.2 Firms

Firms produce tradables and non-tradables goods with a variable labor input and decreasing return to scale technologies

$$\begin{aligned} Y_t^N &= A_t^N H_t^{1-\alpha^N}, \\ Y_t^T &= A_t^T H_t^{1-\alpha^T}, \end{aligned}$$

where A^N and A^T are the productivity levels that are assumed to be random variables in the non-tradables and tradables sector respectively. The firm's problem is static and current-period profits (π_t) are:

$$\pi_t = A_t^T \left(H_t^T\right)^{1-\alpha^T} + P_t^N A_t^N \left(H_t^N\right)^{1-\alpha^N} - W_t H_t.$$

The first order conditions for labor demand in the two sectors are given by:

$$W_t = \left(1-\alpha^N\right) P_t^N A_t^N \left(H_t^N\right)^{-\alpha^N}, \tag{11}$$

$$W_t = \left(1-\alpha^T\right) A_t^T \left(H_t^T\right)^{-\alpha^T}, \tag{12}$$

so that the value of the marginal product of labor equals the wage in units of tradable goods (W_t). By taking the ratio of (11) over (12) we obtain:

$$P_t^N = \frac{\left(1-\alpha^T\right) A_t^T \left(H_t^T\right)^{-\alpha^T}}{\left(1-\alpha^N\right) A_t^N \left(H_t^N\right)^{-\alpha^N}}, \tag{13}$$

from which we note that the relative price of non-tradable goods determines the allocation of labor between the two sectors. For given productivity levels, a fall in P_t^N drives down the marginal product of non-tradable and induces a shift of labor toward the tradable sector.

2.3 Aggregation and equilibrium

2.3.1 Labor Market Equilibrium in a two-sector production economy

The distinguishing and novel feature of our two-sector production economy is the implication of sector labor allocation for precautionary saving behavior.

To analyze our mechanism, we characterize the labor market equilibrium and the sector labor allocation in terms of three equilibrium conditions. We can express the labor supply schedule as

$$\left(H_t^{\delta-1}\right) = \left(1 + \left(\frac{1-\omega}{\omega}\right)\left(P_t^N\right)^{1-\kappa}\right)^{\frac{1}{\kappa-1}} W_t \left(1 + \frac{1-\phi}{\phi}\frac{\lambda_t}{\mu_t}\right),$$

where W_t is determined by (12), and note that the wage rate falls when tradable labor input increases:

$$\left(H_t^{\delta-1}\right) = \left(1 + \left(\frac{1-\omega}{\omega}\right)\left(P_t^N\right)^{1-\kappa}\right)^{\frac{1}{\kappa-1}} \left(1-\alpha^T\right) A_t^T \left(H_t^T\right)^{-\alpha^T} \left(1 + \frac{1-\phi}{\phi}\frac{\lambda_t}{\mu_t}\right). \tag{14}$$

We then combine (13) with (9) to obtain the sector allocation of labor:

$$P_t^N = \frac{\left(1-\alpha^T\right) A_t^T \left(H_t^T\right)^{-\alpha^T}}{\left(1-\alpha^N\right) A_t^N \left(H_t^N\right)^{-\alpha^N}} \tag{15}$$

$$P_t^N = \frac{(1-\omega)^{\frac{1}{\kappa}} \left(A_t^N \left(H_t^N\right)^{1-\alpha^N}\right)^{-\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}} \left(C_t^T\right)^{-\frac{1}{\kappa}}} \tag{16}$$

with $H = H^T + H^N$. The system of equations (14)-(16) determines H_t, P_t^N, H_t^N for given consumption of tradables C_t^T, productivity levels in the two sector (i.e. A_t^N and A_t^T), and the possibility that the constraint is binding, λ_t.[6] When the constraint is not binding (i.e., $\lambda_t = 0$), (14), (15) and (16) determine the labor market equilibrium along with the relative prices, while changes in equilibrium C_t^T capture the effect of the possibility that the constraint might be binding in the future.[7]

The general equilibrium interaction of labor market equilibrium, relative price of non-tradable goods, and precautionary saving is complex in our two-sector production economy. This interaction can generate, in equilibrium, stronger precautionary saving than a one

[6] In the appendix we determine the sign of the response to total labor supply, the demand of non-tradable and tradable labor and the relative price of non-tradable for a given change in C^T.

[7] As we explained above, when $\lambda_t = 0$ agents will save more compared to the unconstrained economy as they take into account the possibility that the constraint might bind in the future.

sector production economy or endowment economies.

As in the two-sector endowment economy, lower tradable consumption for precautionary saving reason leads to a decline in the relative price of non-tradable. For given wages, the decline in the relative price of non-tradable will induce changes in labor supply and production decisions that eventually have implications for the saving behavior. While total labor supply always increases, because of the income effect generated by the relative price change, the associated sector reallocation of labor implies a decline in non-tradable labor that, in equilibrium, tends to increase the relative price of non-tradable goods. If goods are complements, as we assume in the model calibration, the ensuing decline in non-tradable consumption might induce agents to save even more compared to the endowment economy, and hence amplify the precautionary saving effect coming from the possibility of a binding borrowing constraint in the future.

The magnification of the precautionary saving effect of a possibly binding borrowing constraint is a property of a two-sector production economy and does not depend on the way the borrowing constraint is specified. In a one-sector production economy with endogenous labor supply, the first order condition for labor supply would be equal to $\left(H_t^{\delta-1}\right) = U_C(C_t)W_t$ and the labor supply schedule would be affected by consumption choices. [8]

The mechanism induced by the two-sector production structure is also robust to the way the collateral constraint is specified. If we add land to the model and express the collateral constraint in terms of land price (like in Jeanne and Korinek (2009) or Bianchi and Mendoza (2010)) the labor supply and intrasectoral reallocation effects would still operate. This mechanism would also survive in the context in which there is a working capital constraint like in Bianchi and Mendoza (2010): as long as the constraint is not binding, the labor market equilibrium conditions would be identical to the one proposed here ((14), (15) and (16) (with $\lambda_t = 0$)).

2.3.2 Goods Market Equilibrium Conditions

To determine the good market equilibrium, combine the household budget constraint and the firm's profits with the equilibrium condition in the nontradable good market to obtain the current account equation of our small open economy:

$$C_t^T = A_t^T H_t^{1-\alpha^T} - B_{t+1} + (1+i)\,B_t. \tag{17}$$

[8] Only if we had GHH preferences, the same condition would become $\left(H_t^{\delta-1}\right) = W_t$ and labor supply would be independent of the consumption choices.

Nontradable good market equilibrium condition implies that

$$C_t^N = Y_t^N = A_t^N \left(H_t^N\right)^{1-\alpha^N}. \tag{18}$$

Finally, 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:

$$B_{t+1} \geq -\frac{1-\phi}{\phi}\left[Y_t^T + P_t^N Y_t^N\right], \tag{19}$$

so that (17) and (19) determines the evolution of the foreign borrowing.

2.4 Social Planner Problem

We now focus on the social planner's problem. The planner maximizes (1) subject to the resource constraints (17) and (18), the international borrowing constraint from an aggregate perspective (19), and the pricing rule of the competitive equilibrium allocation. By constraining the social planner problem to the pricing *rule* of the competitive equilibrium allocation we follow Kehoe and Levine (2003) in the characterization of the constrained efficient outcome. Another possibility would be to use the concept of conditional efficiency in which the planner problem is constrained by the competitive equilibrium pricing *function* in which P_t^N would be a function of state variables as in the competitive equilibrium allocation (i.e. $P_t^N = f(B_t, A_t^N, A_t^T)$. Here in the constrained efficient case we note that the relative price is determined by the competitive rule (9, so that we can rewrite (19) as:

$$B_{t+1} \geqslant -\frac{1-\phi}{\phi}\left[A_t^T \left(H_t^T\right)^{1-\alpha^T} + \frac{(1-\omega)^{\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}} \left(C_t^T\right)^{-\frac{1}{\kappa}}}\left(A_t^N \left(H_t^N\right)^{1-\alpha^N}\right)^{1-\frac{1}{\kappa}}\right]. \tag{20}$$

In particular, the planner chooses the optimal path of $C_t^T, C_t^N, B_{t+1}, H_t^T$ and H_t^N, and the first order conditions for its problem are given by:

$$C_T : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} \left(\frac{\omega C}{C^T}\right)^{\frac{1}{\kappa}} = \mu_{1,t} + \tag{21}$$

$$-\frac{\lambda_t}{\kappa}\frac{1-\phi}{\phi}\frac{(1-\omega)}{\omega}\left(\frac{(1-\omega)\left(C_t^T\right)}{\omega}\right)^{\frac{1-\kappa}{\kappa}}\left(A_t^N \left(H_t^N\right)^{1-\alpha^N}\right)^{\frac{\kappa-1}{\kappa}},$$

$$C_N : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} (1-\omega)^{\frac{1}{\kappa}} \left(C_t^N\right)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_{2,t}, \tag{22}$$

$$B_{t+1}:\mu_{1,t}=\lambda_t+\beta\left(1+i\right)E_t\left[\mu_{1,t+1}\right], \tag{23}$$

and

$$H_t^T:\left(C_t-\frac{H_t^\delta}{\delta}\right)^{-\rho}\left(H_t^{\delta-1}\right)=\left(1-\alpha^T\right)\mu_{1,t}A_t^T H_t^{-\alpha^T}+\frac{1-\phi}{\phi}\lambda_t\left(1-\alpha^T\right)\mu_{1,t}A_t^T H_t^{-\alpha^T}. \tag{24}$$

$$\begin{aligned}H_t^N:\left(C_t-\frac{H_t^\delta}{\delta}\right)^{-\rho}\left(H_t^{\delta-1}\right)&=\left(1-\alpha^N\right)\mu_{2,t}A_t\left(H_t^N\right)^{-\alpha^N} \\ +\frac{1-\phi}{\phi}\lambda_t\frac{\left(1-\omega\right)^{\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}}\left(C_t^T\right)^{-\frac{1}{\kappa}}}\frac{\kappa-1}{\kappa}&\left(1-\alpha^N\right)\left(A_t^N\right)^{\frac{\kappa-1}{\kappa}}\left(H_t^N\right)^{\left(1-\alpha^N\right)\frac{\kappa-1}{\kappa}-1}.\end{aligned} \tag{25}$$

where $\mu_{1,t}$ is the Lagrange multiplier on (17), $\mu_{2,t}$ is the Lagrange multiplier on (18) and λ_t is the multiplier on (20).

There are two main differences between the competitive equilibrium first order conditions and those of the planner's problem introduced by the presence of the occasionally binding borrowing constraint. First, equation (21) shows that, in choosing tradable consumption, the planner takes into account the effects that a change in tradable consumption has on the value of the collateral (see also Korinek, 2010 and Bianchi, 2009). This is what is usually referred as the "pecuniary externality" in the related literature and it occurs when the constraint is binding (i.e. $\lambda_t > 0$). As we noted above, however, even if the constraint is not binding today, the possibility that it might bind in the future can affect the marginal value of tradable consumption today (i.e. the marginal value of saving). The Euler equation from the planner perspective becomes

$$\mu_{1,t}=\beta\left(1+i\right)E_t\left[\lambda_{t+1}+\beta\left(1+i\right)E_t\left[\mu_{1,t+2}\right]\right]$$

where $E_t\left[\mu_{1,t+2}\right]$ is given by (21) and takes into account the future effect of the pecuniary externality. This crucially implies that, at the same allocation, the marginal social value of saving (the marginal value in the SP allocation), through this effect, will be higher than the private value (in the CE allocation). Thus, the decentralized equilibrium might display overborrowing. This effect of the price externality is common in economies in which the collateral constraint is expressed in terms of a relative price (see Benigno et al. (2010)).

A different effect would arise in an economy in which the price externality is modelled through the presence of an asset price in the credit constraint (e.g., when the value of an asset serves as a collateral rather than income). Because of the forward looking nature of asset prices, the planner takes also into account the effect of its consumption choices on asset prices through their effects on the stochastic discount factor. This effect might induce a higher increase in tradable consumption in the social planner allocation and go in the opposite direction of the price externality one.

In the production economy that we study, the presence of the occasionally binding borrowing constraint generate an additional mechanism. To see this, we can rewrite the first order conditions for the labor allocation in the tradable sector as

$$H_t^T : \left(C_t - \frac{H_t^\delta}{\delta}\right)^{-\rho} \left(H_t^{\delta-1}\right) = \left(1-\alpha^T\right)\mu_{1,t} A_t^T H_t^{-\alpha^T} \left(1 + \frac{1-\phi}{\phi}\frac{\lambda_t}{\mu_{1,t}}\right),$$

and rewrite the non tradable labor supply equation by using (22) and the equilibrium condition in the non-tradable good market as

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

These expression shows that, when the constraint is binding, the social marginal utility of supplying one extra unit of tradable labor is always positive, while the social marginal value of supplying one extra unit of non-tradables labor depends on the degree of substitutability between tradable and non-tradable goods. When goods are substitutes and the borrowing constraint is binding, the planner always supplies one more unit of non-tradable labor for given marginal product of labor, as that helps in relaxing the constraint. However, when goods are complements, the planner decreases the amount of non-tradable labor supplied at the margin.

Note here that there is an effect on labor supply also when the constraint is not binding ($\lambda_t = 0$). To see this, note that the labor market equilibrium is determined by the following three equations. The first is

$$H_t^T : \left(H_t^{\delta-1}\right) = \left(1-\alpha^T\right)\left(\frac{\omega C}{C^T}\right)^{\frac{1}{\kappa}} A_t^T \left(H_t^T\right)^{-\alpha^T}. \tag{26}$$

We can then rewrite the non tradable labor supply equation by using (22) and the equilibrium condition in the non-tradable good market to obtain:

$$H_t^N : \left(H_t^{\delta-1}\right) = \left(1-\alpha^N\right)\left(\frac{(1-\omega) C}{C^N}\right)^{\frac{1}{\kappa}} A_t^N \left(H_t^N\right)^{-\alpha^N}. \tag{27}$$

where total labor supply is defined as

$$H = H^T + H^N. \tag{28}$$

The system of equations given by (26), (27) and (28) determines total labor supply and the sectoral allocation of labor for given C^T, A_t^T and A_t^N.

There are two effects in our production economy coming from the possibility that the constraint might bind in the future. The first one is on total labor supply, while the second is on the substitution between tradable and non-tradable labor (intratemporal labor reallocation effect). Both effects are induced by the fact that, in the social planner allocation, current marginal utility of tradable consumption is higher compared to the competitive equilibrium allocation. Higher current marginal utility of tradable consumption increases the marginal utility of supplying one unit of labor today. As a result, in the social planner allocation, labor supply is higher compared to the CE even when the constraint is not binding. This effect alone can cause underborrowing in equilibrium.

The second effect depends on the intrasectoral labor allocation**.** Higher current marginal utility of tradable consumption (i.e. $\mu_{1,t}$) in the SP implies that, for given total labor supply, the planner will shift resources towards the tradable sector. This shift will reduce the production and the consumption of non-tradable goods. When goods are complement this reduction in the consumption of non-tradable consumption will also imply a reduction in tradable consumption, and hence increasing the amount agents save in the SP allocation relative to the CE allocation. The shift of labor towards tradable production then will tend to strengthen overborrowing in the competitive allocation compared to the social planner one.[9] When goods are substitutes, the decline in non-tradable consumption leads to an

[9] It is possible to see the effect on total labor supply by combining (25) and (24) when the constraint is not binding to get

$$2\left(C_t - \frac{H_t^\delta}{\delta}\right)^{-\rho}\left(H_t^{\delta-1}\right) = \left(1-\alpha^T\right)\mu_{1,t}A_t^T H_t^{-\alpha^T}\left(1 + \frac{\left(1-\alpha^N\right)A_t^N\left(H_t^N\right)^{-\alpha^N}}{\left(1-\alpha^T\right)A_t^T H_t^{-\alpha^T}}\frac{\mu_{2,t}}{\mu_{1,t}}\right)$$

and note that when the constraint is not binding

$$\frac{\mu_{2,t}}{\mu_{1,t}} = \left(\frac{\left(1-\alpha^N\right)A_t^N\left(H_t^N\right)^{-\alpha^N}}{\left(1-\alpha^T\right)A_t^T H_t^{-\alpha^T}}\right)^{-1}$$

so that

$$\left(C_t - \frac{H_t^\delta}{\delta}\right)^{-\rho}\left(H_t^{\delta-1}\right) = \left(1-\alpha^T\right)\mu_{1,t}A_t^T H_t^{-\alpha^T}.$$

increase in tradable consumption and as such to a decrease in the amount agents save in the SP allocation compared to the CE allocation. Under substitutability sectoral allocation of labor might induce underborrowing in the competitive equilibrium allocation. Note finally that, in equilibrium, sector re-allocation will have a further feedback effect on total labor supply by affecting wages in units of tradable.

In contrast to what we discussed for the competitive equilibrium, the specification of the borrowing constraint has implications for the characterization of the social planner allocation. While the production/labor supply choice are independent from the way the constraint is specified (equations (26), (27) and (28) will remain the same), the intertemporal consumption pattern is affected by the way the planner manipulates the stochastic discount factor when the borrowing constraint is specified in terms of asset prices.[10] Consider the following experiment in which the planner decreases future consumption while increasing current consumption: by doing so, the planner increases the pricing kernel and inflate asset prices. When the incentive of the planner to manipulate the intertemporal consumption pattern dominates, marginal utility of tradable consumption today is lower than in the competitive equilibrium the possibility of underborrowing arises.

In the papers by Bianchi and Mendoza (2010) and Korinek and Jeanne (2010) this effect is not present despite the fact that they consider economies in which the borrowing constraint depend on a key asset price. Bianchi and Mendoza (2010) don't have this effect because to solve for the social planner problem they use the concept of conditional efficiency (i.e. they assume that the asset price is determined by the asset price function that links current asset price to the exogenous and endogenous state variables). By construction then the planner cannot influence the intertemporal path of consumption. [11]

3 Solution methods, parameter values, and model evaluation

In this section we describe the global solution methods that we use to compute the competitive and the social planner equilibrium of the model. We then discuss the parameter values chosen and the model's ability to fit the data for a typical emerging market economy

[10] The following reasoning is based on characterizing the constrained efficient social planner problem as in Kehoe and Levine (1993) so that the equilibrium condition that determines asset prices in the competitive allocation is taken as a constraint of the social planner problem.

[11] Using the concept of conditional efficiency has implications also for the behavior of the economy in the binding region. When the amount of borrowing is constrained, conditional efficiency eliminates the possibility that the planner manipulate asset prices forcing the social planner allocation to be closer to the competitive one.

like Mexico.

3.1 Solution methods

The competitive equilibrium problem is given by equations (4), (5), (6), (7), (8), (11), (12), (17) and (18) above. The algorithm for the solution of the competitive equilibrium of the model is derived from Baxter (1990) and Coleman (1989), and involves iterating on the functional equations that characterize a recursive competitive equilibrium in the states $\left(B, A^T\right)$. The key step is the transformation of the complementary slackness conditions on the borrowing constraint into a set of nonlinear equations that can be solved using standard solvers (in particular, a modified Powell's method). The key steps are to replace the Lagrange multiplier, λ_t, with the expression $\max\left\{\lambda_t^*, 0\right\}^2$ and to replace the complementary slackness conditions:

$$\lambda_t \geq 0,$$
$$B_{t+1} + \frac{1-\varphi}{\varphi}\left(A_t^T\left(H_t^T\right)^{1-\alpha_T} + P_t^N A\left(H_t^N\right)^{1-\alpha_N}\right) \geq 0,$$
$$\lambda_t\left(B_{t+1} + \frac{1-\varphi}{\varphi}\left(A_t^T\left(H_t^T\right)^{1-\alpha_T} + P_t^N A\left(H_t^N\right)^{1-\alpha_N}\right)\right) = 0,$$

with the single nonlinear equation

$$\max\left\{-\lambda_t^*, 0\right\}^2 = B_{t+1} + \frac{1-\varphi}{\varphi}\left(A_t^T\left(H_t^T\right)^{1-\alpha_T} + P_t^N A^N\left(H_t^N\right)^{1-\alpha_N}\right).$$

We then guess a function $\eta_{t+1} = G_\eta\left(B_t, A_t^T\right)$ and solve for $\left\{\lambda_t^*, \eta_t, B_{t+1}, C_t^T, C_t^N, H_t^T, H_t^N, P_t^N\right\}$ at each value for $\left(B_t, A_t^T\right)$. This solution is used to update the G_η function to convergence. Note that if the constraint binds, $\lambda_t^* > 0$ so that $\max\left\{-\lambda_t^*, 0\right\}^2 = 0$.[12]

Given the solution for the equilibrium decision rules, we can compute the equilibrium value of lifetime utility by solving the functional equation

$$V\left(B_t, A_t^T\right) = \frac{1}{1-\rho}\left(\left(\omega^{\frac{1}{\kappa}}\left(C_t^T\right)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}}\left(C_t^N\right)^{\frac{\kappa-1}{\kappa}}\right)^{\frac{\kappa}{\kappa-1}} - \frac{1}{\delta}\left(H_t^T + H_t^N\right)^{\delta}\right)^{1-\rho} +$$
$$+\beta E\left[V\left(B_{t+1}, A_{t+1}^T\right)|A_t^T\right],$$

which defines a contraction mapping and thus has a unique solution.[13]

[12] Note also that $\lambda_t = \max\left\{\lambda_t^*, 0\right\}^2 \geq 0$, $\max\left\{-\lambda_t^*, 0\right\}^2 \geq 0$, and $\max\left\{\lambda_t^*, 0\right\}^2 \max\left\{-\lambda_t^*, 0\right\}^2 = 0$ so the complementary slackness conditions are satisfied.

[13] This functional equation gives us lifetime utility only in equilibrium. To obtain lifetime utility outside

To solve for the social planning equilibrium we set up a standard dynamic programming problem:

$$V^{SP}\left(B_t, A_t^T\right) = \max_{C_t^T, C_t^N, H_t^T, H_t^N, B_{t+1}} \frac{1}{1-\rho}\left(\left(\omega^{\frac{1}{\kappa}}\left(C_t^T\right)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}}\left(C_t^N\right)^{\frac{\kappa-1}{\kappa}}\right)^{\frac{\kappa}{\kappa-1}} - \frac{1}{\delta}\left(H_t^T + H_t^N\right)^{\delta}\right)^{1-\rho} +$$

$$+\beta E\left[V^{SP}\left(B_{t+1}, A_{t+1}^T\right) | A_t^T\right]$$

subject to the resource constraints, the borrowing constraint, and the marginal condition that determines P^N:

$$C_t^T = (1+r) B_t + A_t^T \left(H_t^T\right)^{1-\alpha_T} - B_{t+1}$$
$$C_t^N = A^N \left(H_t^N\right)^{1-\alpha_N}$$
$$B_{t+1} \geq -\frac{1-\varphi}{\varphi}\left(A_t^T \left(H_t^T\right)^{1-\alpha_T} + P_t^N A^N \left(H_t^N\right)^{1-\alpha_N}\right)$$
$$P_t^N = \left(\frac{1-\omega}{\omega}\right)^{\frac{1}{\kappa}}\left(\frac{C_t^N}{C_t^T}\right)^{-\frac{1}{\kappa}}.$$

We approximate the function V^{SP} using cubic splines, and solve the maximization using feasible sequential quadratic programming.

Welfare gain and losses are computed as a percent of tradable consumption.[14] Let $V^{SP}\left(B_t, A_t^T\right)$ denote lifetime utility in the social planning allocation. We first solve the dynamic functional equation

$$v\left(B_t, A_t^T; \chi\right) = \frac{1}{1-\rho}\left(\left(\omega^{\frac{1}{\kappa}}\left((1+\chi)C_t^T\right)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}}\left(C_t^N\right)^{\frac{\kappa-1}{\kappa}}\right)^{\frac{\kappa}{\kappa-1}} - \frac{1}{\delta}(H)^{\delta}\right)^{1-\rho}$$

$$+\beta E\left[v\left(B_{t+1}, \left(A_{t+1}^T\right), \eta\right) | A_t^T\right]$$

where $v\left(B_t, A_t^T; \chi\right)$ is the lifetime utility experienced using the competitive equilibrium decision rules with an extra χ percent of tradable consumption given freely to the representative household. This functional equation defines a contraction mapping, so it has a unique solution. From the solution of this problem, we can compute the solution to the nonlinear equation

$$V\left(B_t, A_t^T\right) = v\left(B_t, A_t^T; \chi\left(B_t, A_t^T\right)\right),$$

equilibrium, we would need to solve the household problem separating individual debt b from aggregate debt B.

[14] The rank among allocation would not change if we express the welfare gain and losses as a percent of overall consumption.

which yields the percent increase in tradable consumption that renders the representative agent indifferent between the competitive equilibrium and the social planning allocation state-by-state.

Note that the algorithm to solve the competitive equilibrium of the model can in principle be implemented with more exogenous or endogenous states in the competitive equilibrium. However, the algorithm to compute the SP limits our analysis to one endogenous state. To solve the dynamic program in the SP we need to preserve the shape of V^{SP}, and this is only possible in one dimension. As the main purpose of the analysis is comparing the two allocations, this constrains the degree of complexity of the model we can analyze.

3.2 Parameter values

The model is calibrated at quarterly frequency on Mexico data. There are several reasons to focus on Mexico. First Mexico is a representative emerging market economy whose experience is particularly relevant for the main issue addressed in the paper. Mexico experienced three major episodes of international capital flows reversals since 1980 that are unambiguously regarded as typical examples of sudden stops: the first one leading to the 1982 debt crisis; the second one, the well known "Tequila crisis" in 1994-1995; and the third one in 2008-09 during the global financial crisis that led Mexico to seek (or accept) IMF financial assistance. Second, Mexico is a well functioning, relatively large, market-based economy in which production in both the tradable and non-tradable sectors of the economy goes well beyond the extraction of natural resources such as oil or other commodities. Third, there is a substantial body of previous quantitative work on Mexico, starting from Mendoza (1991), which greatly facilitates the choice of the parameter values of the model. In particular, we choose model parameters following the work of Mendoza (2002, 2010) and Kehoe and Ruhl (2008) to the extent possible, and use available data where necessary to complement or update this previous work.

The specific set of parameter values that we use in our baseline calibration are reported in Table 1. The elasticity of intertemporal substitution is set to standard value of $\rho = 2$, like in Mendoza (2002, 2010). We set then the world interest rate to $i = 0.01587$, which yields an annual real rate of interest of about 6.5 percent like in Mendoza (2002): a value that is between the 5 percent of Kehoe and Ruhl (2008) and the 8.6 percent of Mendoza (2010).

The elasticity of intratemporal substitution in consumption between tradables and non-tradables is an important parameter in the analysis as we discussed in the previous section. But there is a good degree of consensus in the literature on its value. We follow Ostry and Reinhart (1992), who estimates a value of $\kappa = 0.760$ for developing countries. This is a conservative assumption compared to the value of 0.5 used by Kehoe and Ruhl (2008) closer to the one assumed for an advanced, more closed economy like the United States.

Estimates of the wage elasticity of labor supply in Mexico are uncertain at best (Mendoza, 2002 and 2010). We set the value of $\delta = 2$, as in Mendoza (2002), close to the value of 1.84 adopted by Mendoza (2010).

The labor share of income, $(1-\alpha^T)$ and $(1-\alpha^N)$ is set to 0.66 in both tradable and non tradable sectors: a standard value, close to that used by Mendoza (2002), and consistent with empirical evidence on the aggregate share of labor income in GDP in household survey of Garcia-Verdu (2005).

The shock to tradable total factor productivity specified as

$$\log\left(A_t^T\right) = \rho_A \log\left(A_{t-1}^T\right) + \varepsilon_t,$$

where ε_t is an iid $\mathrm{N}(0, \sigma_A^2)$ innovation. The parameters of this process are set to $\rho_A = 0.537$ and $\sigma_A = 0.0134$ which are the first autocorrelation and the standard deviation of aggregate total factor productivity reported by Mendoza (2010). Both the average value of A^T and the constant A^N are set to one.

The remaining three model parameters—the share of tradable consumption in the consumption basket (ω), the credit constraint parameter (ϕ), and the discount factor (β)—are set by iterating on a routine that minimizes the sum of squared differences between the moments in the ergodic distribution of the competitive equilibrium of the model and three data targets. The data targets are a C^N/C^T ratio of 1.643, a 35 percent debt-to-GDP ratio, and an unconditional probability of sudden stop of 2 percent per quarter. This C^N/C^T ratio is the value implied by the following ratios estimated by Mendoza (2002): Y^T/Y^N =0.648, C^T/Y^T =0.665, and C^N/Y^N =0.708 as in Mendoza (2002).[15] The debt-to-GDP target is Mexico's average net foreign asset to annual GDP ratio, from 1970 to 2008, in the updated version of the Lane and Milesi-Ferretti (2006) data set.

The target for the unconditional probability of sudden stop is more difficult to pin down. Despite a significant body of empirical work on identifying sudden stops in emerging markets to describe the macroeconomic dynamics around these events, there is no consensus in the literature on how to define sudden stops empirically, and hence no accepted measure of the unconditional probability of these events. By focusing on Mexico, we can pin down this target simply and unambiguously, measuring it as the relative frequency, on a quarterly

[15] Ratios computed with updated data are essentially the same. As we evaluate the model's ability to replicate the 1995 Tequila crisis we use the exact values reported by Mendoza (2002).

basis, of Mexico's sudden stops years over the period 1975-2010. This assumes that, as generally accepted, 1982, 1995, and 2009 were sudden stop years for Mexico. The resulting 2 percent is very close to the 1.9 percent implied by the empirical analysis of Jeanne and Ranciere (2010) over the period 1975-2003, who use an "absolute" definition of sudden stops as current account reversals larger than 5 percent of GDP. Our number is also similar to the 2.2 percent value implied by Calvo, Izquierdo, and Mejia (2008) for the period 1990-2004, based on a "relative" definition of sudden stops as current account reversals larger than two standard deviations. The two percent value, however, is at the low-end of the range of values estimated in these studies by pooling data for the whole sample of emerging markets considered.

In order to contrast Mexico data with model outcomes during sudden stop episodes, consistent with both the model and the empirical literature above, we define a sudden stop in the model as an event in which: (a) $\lambda_t > 0$ (i.e. the international borrowing constraint is binding) and (b) $(B_{t+1} - B_t) > 2\sigma(B_{t+1} - B_t)$ (i.e. the current account or changes in the net foreign asset position in a given period exceed two times its standard deviation). The first criterion is a purely model based definition sudden stop. The second criterion allows us to consider only model events in which there are large current account reversals, in line with the aforementioned empirical literature.[16] [17]

With the targets above we obtain $\omega = 0.3526$, $\beta = 0.9717$, and $\phi = 0.415$. The implied value of ω is slightly higher than in Mendoza (2002) and slightly lower than targeted by Kehoe and Ruhl (2008). The implied annual value of β is yield an annual discount factor of 0.8915, only slightly lower than in Kehoe and Ruhl (2008).[18] The implied value of ϕ is lower than in Mendoza (2002), who however calibrates it to the deterministic steady state of the model, and there are no standard benchmarks for this model parameter in the literature.

[16] The definition of sudden stop typically used in the empirical literature focuses on large capital flows reversals because some smaller ones may be due to terms of trade changes or other factors Jeanne and Ranciere (forthcoming), for instance, excludes commodity importers and oil producers, while Calvo et al. (DATE) add other criteria to the second one we use above.

[17] Note that national accounts data typically have a trend, and hence the empirical literature focuses changes in the current account, or the first difference of the capital flows. As our model has no trend growth and the data are in percent deviation from HP filter, we focus on the current account rather than its change. We obtain similar results when we define the sudden stop with respect to changes in the current acocunt.

[18] This value is not comparable to the one assumed by Mendoza (2002) as he uses an endogenous discount factor specification. In our model, the presence of the borrowing constraint removes the necessity to introduce any device to induce a stationary ergodic distribution of foreign borrowing.

3.3 Model evaluation

The class of models we study is potentially capable of describing well both the cycle and the crisis periods of an emerging market economy like Mexico (Mendoza, 2010). However, in our implementation of the model, we shut down a number of shocks used in other work and focus on the mechanisms driving our policy results. With our one shock we clearly cannot match all the moments of the data that this class of models is capable of replicating. Nonetheless, it is useful to see how well our one shock model does do in describing both the business cycle and the dynamics around a typical sudden stop event, as the first exercise is standard and helps to understand the findings in the second one.

To conduct this comparison we use the variable as defined in Table 2. All data variables are reported in percent deviations from HP filtered trend (over the 1993Q1-2007Q4 period) except the current account, which is reported as a share of GDP. All model variables are reported in percent deviation from ergodic mean except the current account that is reported, as in the data, as a share of GDP. To calculate model moments we simulate the model for 1,000,000 time periods, and retain the final 10,000 simulation periods to calculate moments and identify sudden stop events.

Table 3 reports data and simulated second moments. Despite its simplicity, the model describes the data reasonably well except for the behavior of the tradable GDP that is counterfactual because of the behavior of labor supply when the constraint is binding in our model economy. As we can see, once we normalize all standard deviations relative to GDP in units of tradable goods (as in Bianchi, 2010), the model roughly matches the ranking of the data volatilities consistent with the results in Mendoza (2002), despite the fact that the model has only one shock. In particular, the model generates consumption volatility that is almost as high as GDP volatility and a current account that is less volatile that aggregate GDP or its components. The model however produces higher relative price volatility and too low tradable GDP volatility relative to the data (i.e. relative to GDP volatility).[19] Like in the data, all model variables are similarly persistent, but less than in the data (especially for the relative price on non-tradable goods and tradable GDP). All correlations with GDP except the relative price one are also all roughly consistent with the data. The correlation between CA and GDP is positive contrary to what we observe in the data. This is because, as calibrated to Mexican data, the constraint does not alter consumption smoothing enough in the ergodic distribution of our model to generate such negative correlation.[20] Note in addition that, the correlation between CA and net income

[19]Note that, using data up to 2007, as we do, the absolute value of consumption volatility in the data is much lower than reported by Mendoza (2002), and hence much closer to GDP volatility.

[20]For instance, Bianchi (2010) obtain a negative correlation calibrating the model to Argentine data with

(defined as GDP minus investment and government expenditure, and hence closer to our model definition) may be either slightly positive or zero in the average emerging market economy (Luo, Nie, and Young, 2010). Indeed, as it is well known (Backus, Kehoe, and Kydland, 1994), a model with investment would generate a negative correlation.

Similar strengths and weaknesses emerge by comparing the macroeconomic dynamics around a typical sudden stop event. For this comparison, we focus on the 1995 Tequila crisis, the same episode studied by Kehoe and Ruhl (2008) and Mendoza (2010). Specifically, Figure 1 compares the model and the Mexican data for key variables four quarters before and after 1995Q1, where the model variables are average across the identified sudden stop episodes, four periods before and four periods after our sudden stop definition is initially met.[21]

As we can see from Figure 1, the model qualitatively reproduces the large declines in expenditure on consumption and output (both expressed in units of tradable goods), and the relative price of tradable during the 1995 Tequila crisis in Mexico. However in the model this relative price decline is less persistent than in the data. Similarly, qualitatively, non tradable output and expenditure on non-tradable consumption measured in units of tradables are described relatively well by the model. The same lack of persistence characterizes all model variables that generally recover much faster than in the data. We note also that consumption expenditure falls much more than output in our model economy since, in the model, tradable output increases in sudden stop. Consistent with the data, tradable GDP also starts to fall sharply before the sudden stops, but it increases during the sudden stop period, counterfactually. As a result, tradable consumption falls much less than non-tradable consumption, while in the data the opposite occurs.

Quantitatively, however, the model produces a sudden stop dynamics of amplitude roughly one-order of magnitude smaller than in the data. This occurs for two reasons. First, as we noted above, the model is too simple to provide an accurate quantitative account of the data: in particular we limit ourselves to only one shock in tradable productivity while other shocks (for example foreign interest rate shocks) might have contributed in amplifying the dynamic of the economy during sudden stop. Second, and more importantly, the model counterfactually predicts an increase in total employment at the sudden stop, driven by a sharp increase in labor supply and fall in the real wage (not reported).

As Kehoe and Ruhl (2008) discuss there are three ways to generate a falling employ-

very high shock variance and low discount factor.

[21] As it is evident in the capital flow data (not reported), while capital flows into Mexico started to revert in the fourth quarter of 1994, they were initially accommodated by a very large decrease in official reserves that eventually lead to collapse of the fixed exchange rate regime in December 1994. As a result, the current account started to revert only in 1995Q1.

ment in the model: a friction in the labor mobility across sectors, variable capital utilization, and a working capital constraint, but none produces satisfactory account of labor market dynamics during the Tequila crisis in their model. In addition, in our model they pose additional complications. Imperfect labor mobility and variable capital utilization introduce an additional state variable. But, as we noted earlier, the comparison between the competitive and the social planner allocation that is the focus of the paper constrains the number of endogenous state variable that can feature in our model. A working capital constraint could produce falling output, but would complicates the specification of the borrowing constraint. In addition a working capital constraint would generate output falling at the sudden stop, but would not alter the underlying mechanism at work in the region in which we examine inefficient borrowing (i.e. during tranquil times) so that our discussion on the role of macro-prudential policies would be robust to this change. For these reasons, at first pass, we prefer to keep the model simple.

4 Inefficient borrowing and macro-prudential policies

In this section we report and discuss a comparison between the competitive equilibrium allocation and the social planner one based on a full numerical solution of our two-sector, production model. In this section, we also discuss the robustness of the analysis to changes in key parameter values and its policy implications for the debate on macro-prudential policies.[22]

4.1 Comparing CE and SP allocations

The policy function for foreign borrowing, B_{t+1}, is plotted in Figure 2, conditional on a particular state of the tradable shock. The decision rules are drawn assuming this shock is received in each period. The continuos line refers to the competitive equilibrium (CE) allocation while the dotted line refers to the social planner one (SP). The Figure shows that there is a small underborrowing when the constraint is not binding and a much larger one when the constraint binds—i.e., for each value of the endogenous state B_t, B_{t+1} is smaller in the CE than in the SP throughout the support of the decision rule. This result shows that, in our model, in which there is scope for both ex ante and ex post inefficiencies, the latter are quantitatively much larger than the former.

These findings are in sharp contrast with those in the related literature—Bianchi (2010),

[22] The properties of the competitive equilibrium of this economy are well known (see for instance Mendoza, 2002), and are fully discussed in Benigno et al (2009 and 2010).

Bianchi and Mendoza (2010) and Korinek and Jeanne (2010). The literature, has focused only on ex ante inefficiencies (i.e., when the constraint does not bind) in models in which ex post efficiencies does not arise. In contrast, Figure 2 shows that in a model in which both ex ante and ex post efficiencies can arise, the ex ante inefficiency found is not only smaller than the ex post one, but it also goes in the opposite direction. Note that the borrowing inefficiency that we document in our benchmark economy calls for both ex ante and ex post policy intervention geared toward inducing more rather than less borrowing than private agents choose to take on, both before and after the constraint binds.

Figures 3 and 4 report the policy functions for the other key variables of the model as a function of the endogenous state, B_t. The policy functions are drawn for the continued realization of the same shock. All variables (P_t^N, W_t, H_t^T, $H_t^N$and H_t, C_t^T, $C_t^N$and C_t) follow a similar pattern in both allocations displaying a kink in correspondence of the state in which the constraint becomes binding.[23] As the economy moves toward the binding region, agents (and the planner) increase the amount they want to borrow and reduce their tradable and non-tradable consumption (Figure 4). In this transition, before the constraint binds, the relative price of non-tradable falls in both the competitive and the social planner allocation. Note though, that the relative price of non-tradable goods in the SP allocation is higher compared to the CE allocation in the non-binding region as the social planner consumes relatively more of tradable (i.e. borrows more in equilibrium) in normal times. As we discussed above, in our two-sector production economy, there is an additional effect coming from the intrasectoral labor allocation on precautionary saving when goods are complement so that in our competitive allocation consumption of tradable goods is further reduced in normal times. Since the relative price of non-tradables is lower in the CE allocation compared to the SP one, the sector allocation of labor (see equation (13)) is such that in the CE there is overproduction of tradables and under-production of non-tradables relative to the SP (Figure 4).

Once the constraint binds we observe two important differences between the CE allocation and the SP one. First, as already noted, the differences between the decision rules of the CE and the SP are much larger than in "normal times". Second, the SP engineers an increase in P_t^N accompanied with a decrease in non-tradable production, while in the CE allocation the relative price decreases and non-tradable production rises.

These differences arises because of the way the planner deals with the constraint compared to how private agents do. In our production economy, increasing the value of the

[23] Note that the kink of the decision rules in the SP occurs at a higher level of B_t than in the CE because the SP borrow more on average than the CE. As we shall see below, however, this does not mean that the SP is more constrained than the CE since the lower bound on debt is determined by the intersection between the policy functions for each state with the 45 degree line at different.

collateral in units of tradable could occur by increasing the production of tradables and/or by increasing the value of non-tradable production. As the social planner takes into account the impact of its consumption and production decisions on the relative price of non-tradable goods, it increases the value of collateral by increasing this price (and hence the value of non-tradable production in units of tradable goods) rather than by increasing the amount of non-tradable goods produced. In the SP allocation, a combination of relatively higher consumption of tradables (i.e. more borrowing) and lower consumption of non-tradables (i.e. by reducing the production of non-tradables) leads to an increase in the relative price. The SP also increases the production of tradable goods but less so than in the CE allocation so that total labor supply rises but less than in the CE allocation. Private agents on the other hand tend to increase their borrowing capacity by producing more of both tradables and non-tradables. In doing so they do not internalize the effects of their production decisions on the relative price of non-tradable goods, and in equilibrium we observe a lower relative prices that tends to further tighten the constraint.

Figure 5, compares the ergodic distributions of foreign borrowing in the CE and the SP allocation. The Figure shows the under-borrowing that characterizes our benchmark economy, as the CE distribution is located to the right of the SP one. Nonetheless, the mean debt-to-GDP ration of these two distributions is the same (i.e., 35 percent), with only slightly smaller average debt in the CE than in the SP (-0.914 and -0.941 in the CE and the SP, respectively).[24]

Despite having the same mean, the shape of these two distributions is very different. The shape of the borrowing distribution depends on the location of the intersection of the policy function at different values of the exogenous state with the 45 degree line (not reported), which in turn depends on the shape of policy function itself. In the SP, these intersections occur on a more dispersed portion of the distribution's support. As a result, the distribution does not display truncation and appears "unconstrained". However, in CE, the intersection between the policy functions for different values of the exogenous state and the 45 degree line is concentrated to the left, and the distribution of the CE appears truncated.

The probability of running into a crisis episode reflects this difference in the shape of the ergodic distribution. In the benchmark CE allocation, the unconditional probability of a crisis is 2 percent on a quarterly basis. In the SP allocation, this probability is 1.2 percent, despite the same average level of foreign borrowing as a share of GDP. The intuition is that, by allocating productive resources differently, the social planner increases the value of the collateral through an increase in relative prices and permits more borrowing in response to

[24] GDP is higher in the SP (0.6674) than in the CE allocation (0.6486).

negative shocks without increasing its probability to meeting the constraint.

The overall differences in the CE and SP allocations are reflected in the calculation of the welfare gains of moving from the CE to the SP allocation. Despite the same average borrowing, the SP achieves not only a lower probability of a crisis, but also higher welfare. The welfare cost of inefficient borrowing in our baseline production economy is 0.12 percent of permanent tradable consumption (Table 5). And the welfare gain of moving from the CE to the SP equilibrium in states of the worlds in which the constraint binds is about 25 percent higher than the overall cost (at 0.15 percent of permanent tradable consumption (Table 5).[25]

The intuition for this result is that welfare is state dependent in this class of models (see for instance Figure 5 for a selected number of endogenous and exogenous states). The largest differences in the behavior of these economies arise in the states in which the constraint is binding. And given that the economy spends most of its time outside these states, the overall welfare difference between the two allocations is smaller than the welfare difference in those states. It follows that the welfare difference between the CE and the SP in normal times is even smaller than the overall difference (which includes the sudden stop).

4.2 Robustness

In this subsection we explore the extent to which the underborrowing result found in our benchmark economy is robust to changes in parameter values. We change the parameters that could be critical in determining the sign of the inefficient borrowing (see Benigno at al. 2010). We focus on three key parameters: the elasticity of intratemporal substitution that determines the sign of the sector allocation effect, the discount factor that determines the strength of the intertemporal effect, and the variance of the shocks. Figure 7 reports the decision rule and the ergodic distribution of $B(t+1)$. Table 4 and 5 report the average borrowing as a share of GDP and the probability of sudden stop, along with the welfare gains, respectively for the benchmark case and these three other cases.[26]

Figure 7 (second row of panels) shows that the results are qualitatively unchanged when we set the elasticity of substitution between tradable and non-tradable to 1.25 (i.e., assuming substitutability rather than complementarity), even though the underborrowing is quantitatively smaller. This is evidenced by a smaller differences between the CE and the SP for the same endogenous and exogenous state and an ergodic distribution of CE

[25] See section 3 for details on the definitions and computations of these welfare gains and losses.

[26] In each case, the parameter is changed as reported in Table 4 and 5, without recalibrating the model.

borrowing that remains to the right of SP one. A change in the elasticity of substitution does not affect the marginal utility of tradable consumption, but it has an impact on labor choices through the non-tradable relative price. When the elasticity of substitution increases the change in the relative price in both the CE and SP allocation is smaller for a given change in tradable consumption, and the smaller change in relative prices reduces the labor supply effect in both the CE and SP allocation. Also the decrease in non-tradable production and consumption that follows from labor market equilibrium (see Appendix A) is now accompanied by an increase in tradable consumption so that the initial precautionary saving impact on tradable consumption is dampened. With our calibration, the net outcome of these effects is such that underborrowing is smaller compared to the benchmark case in which goods are complement, but is not eliminated.

Table 5 also shows that, in this case, the probability of sudden stop is higher than in the benchmark case in the CE (2.6 percent) and a much lower in the SP (0.35 percent): on the one hand, higher substitutability implies that the relative price drop less than when goods are complement and that helps in relaxing the constraint. On the other hand, substitutability implies that precautionary saving is reduced and agents borrow more for a given state increasing the probability of hitting the constraint. In the CE allocation, the second effect dominate the first one leading to a higher probability of sudden stop. In the SP allocation, instead, the first effect prevails reducing the probability of sudden stop. The welfare gains in moving to the SP allocation are lower (0.0525 percent, Table 5) since the cost of being in a sudden stop are smaller in this case.

Underborrowing increases significantly with a lower discount factor, as evidenced by the fact that the ergodic distributions are much further apart than in the baseline case (Figure 7, third row of panels). Lowering the discount factor to 0.91 makes agent more impatient and reduces precautionary saving so that agents borrow more in both the CE and SP allocations. Both the CE and the SP meet the constraint more frequently, but in the SP allocation the unconditional probability of sudden stop is higher than in the CE allocation (from 1.2 in the baseline case to 2.2 with higher discount factor, Table 5). This suggests that the social planner does not necessarily need to reduce the probability of a sudden stop relative to the CE. The reason is that the planner reduces the cost of being in the sudden stop so that even if the welfare gain of moving from the CE to the SP remains positive (0.0351 overall, table 5), they are smaller than in the baseline case.

When we triple the variance of the shocks, underborrowing is strengthened compared to the baseline if measured as the gap between the SP and CE ergodic distribution (Figure 7, fourth row of panels). Once we increase the variance of the shock, there is such an increase in the precautionary saving in both the CE and the SP so that the probability of a sudden stop goes to zero in both allocations. Yet, the shape of the two distributions is different. In the case of the CE, the borrowing distribution is truncated. In the SP is seemingly unconstrained for the reasons explained above. In this case, however, the welfare gain of moving from the CE to the SP is very small, as these gains accrue only in normal times.

4.3 Implications for macro-prudential policy

In the numerical analysis we have found that underborrowing is a robust feature of the competitive allocation of our two-sector production model. We found that the welfare gains of moving from the CE to the SP in sudden stop states are much larger than in tranquil times and that, for the same or a higher level of borrowing, efficiency is not necessarily associated with a lower probability of crisis. What are the implications of these results for macro-prudential policies?

First, ex post policies (i.e. policy interventions in crisis states) are more important than ex ante ones (i.e. policy interventions during tranquil times). Indeed, in our analysis, welfare gains are always significantly higher in sudden stop states than in other states. Note here, however, that we are abstracting from moral hazard and time consistency considerations.

Second, these result illustrate that constrained-efficiency can be achieved not only by outright reducing borrowing and the probability of a crisis, as suggested by the existing literature, but also by allocating productive resources more efficiently in both normal and crisis times. In the efficient allocation, relative prices move in such a way that the economy is less vulnerable to the presence of occasionally binding financial frictions. This is because, as we mentioned earlier, our social planner tends to relax the constraint by changing relative prices rather than quantities. Broadly speaking, this would be consistent with the "old adage" that it is how capital is intermediated and allocated that matters, not how much funds come into a small open economy. After all, the very presence of a financial friction suggests that in a first best world these economies would like to borrow more not less.[27]

Another way to restate the point above is to note that crises are not eliminated completely by the social planner, and neither probability of a crisis nor the level of borrowing are good policy objectives. While in general the social planner tends to reduce the unconditional probability of the crisis, there might be cases (for example when agents are impatient) in which the unconditional probability of sudden stop chosen by the social planner is higher than in the competitive equilibrium. More broadly, there is a trade off between volatility and efficiency in this class of models, and minimizing the probability of the crisis is not

[27] See Mendoza (2002) and Benigno et al, (2010) for a quantitative comparison with an unconstrained economy.

necessarily a good criterion to orient policy. In welfare terms, in certain cases, the gains of higher average consumption may outweight the costs of a more volatile consumption because of the more frequent sudden stops. In these cases, a planner that takes this trade off into account may allocate resources in such a way to allow for higher and more volatile consumption to achieve efficiency. It follows that the appropriate policy regime depends on the specific characteristics of the economy.

Third, if the design of ex-ante policies is sensitive to the structure of the economy, the wrong policy regime might impose costs that exceeds its intended benefits. These costs can be easily quantified in our benchmark economy by imposing a small tax on debt (a Tobin tax) equal to 1 percent in tranquil times and zero once the crisis occurs. This simple state-contingent policy rule implements in our model specific proposals in terms of macro-prudential policies in the related literature. Figure 8, reports the results for this experiment (as well as for the case in which the same rule is not state-contingent) and shows that such a rule is not robust to the specification of the model. In this case, as expected, average borrowing as a share of GDP is unchanged and the probability of sudden stop goes to zero. However, the Tobin tax moves the economy further away from the constrained-efficient allocation as evidenced by negative welfare gains in moving from the CE with Tobin tax to that without. The tax forces agents to save more (moving the ergodic distribution of debt to the right of the CE without tax), the probability of a sudden stop goes to zero, but welfare declines. This implies that the distortion introduced by the policy intervention is more costly in welfare terms than the benefit of reducing to zero the probability of the crisis. It follows that from a policymaker's perspective minimizing the probability of the crisis or targeting the level of borrowing are not necessarily welfare-improving criteria.

5 Conclusions

In this paper we compared the competitive and the social planner allocations in a two-sector small open production economy with an occasionally binding borrowing constraint. Our economy belongs to a class of models that can potentially match both normal fluctuations and crisis events. We find that the interaction between saving and production decisions by agents in the competitive equilibrium lead to underborrowing. Moreover, our welfare analysis shows that higher welfare costs arise at crises times. These results suggest that macro-prudential policies aimed at reducing the amount of borrowing or the probability of a crisis might be counterproductive and ex-post policies entails higher welfare gains than ex ante ones. Our analysis suggests that the distortionary costs imposed by macro-prudential policies may be bigger than the benefit of eliminating the probability of crisis events. In our related work (Benigno et al. 2008) we study these policy issues further by discussing the proper choice of the instrument and proposing a Ramsey approach to the optimal policy problem that takes into account interaction between ex ante and ex post policies.

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Appendix A: Labor Market Equilibrium in CE allocation

By taking a total differential of the system of equations (14), (15) and (16) we get that

$$sign\left(\frac{dH_t}{dC_t^T}\right) = sign\left(\frac{\alpha^T}{\alpha^N}\frac{1-\alpha^N}{1-\alpha^T} - \frac{Y_t^T}{C_t^T}\right).$$

so that, among other things, the response of total hours worked to a change in precautionary savings depends on labor intensities in the two sector and on whether the country is producing more tradable output than what it consumes during the current period. Moreover it is possible to show that

$$sign\left(\frac{dH^N}{dC^T}\right) = sign\left((\delta-1)\frac{h^T}{\alpha^T} + 1 - \varepsilon_{pn}\right) > 0,$$

where $h^T = \frac{H^T}{H}$ and $h^N = \frac{H^N}{H}$ with

$$\varepsilon_{pn} = \frac{\frac{1-\omega}{\omega}(P^N)^{1-k}}{1+\frac{1-\omega}{\omega}(P^N)^{1-k}} < 1$$

so that unambiguously $dH^N/dC^T > 0$. The response of H^T to a change in precautionary savings can then be found using

$$\frac{dH^T}{H^T}\left((\delta-1)h^T + \alpha^T\left(1-\varepsilon_{pn}\right)\right) = -\frac{dH^N}{H^N}\left((\delta-1)\,h^N + \varepsilon_{pn}\alpha^N\right),$$

which implies that H^T and H^N always move in opposite directions after a change in precautionary savings and so that $dH^T/dC^T < 0$. Finally, $dH^N/dC^T > 0$, $dH^T/dC^T < 0$ implies that $dP^N/dC^T > 0$.

Table 1. Model Parameters

Structural parameters	**Values**
Elasticity of substitution between tradable and non-tradable goods	$\kappa = 0.760$
Intertemporal substitution and risk aversion	$\rho = 2$
Labor supply elasticity	$\delta = 2$
Credit constraint parameter	$\phi = 0.415$
Labor share in production	$1 - \alpha^T = 1 - \alpha^N = 0.66$
Relative weight of tradable and non-tradable goods	$\omega = 0.3526$
Discount factor	$\beta = 0.9717$
Exogenous variables	**Values**
World real interest rate	$i = 0.01587$
Steady state productivity level	$A^N = A^T = 1$
Productivity process	
Persistence	$\rho_{\varepsilon^T} = 0.5370$
Volatility	$\sigma_{\varepsilon^T} = 0.0134$
Average values in the ergodic distribution	
Net foreign assets (or minus foreign borrowing)	$B = -0.9080$
Qaurterly GDP	$Y = 0.6486$
Qaurterly Tradable GDP	$Y^T = 0.2544$
Qaurterly Non-Tradable GDP	$Y^N = 0.3942$

Table 4. Average foreign borrowing and probability of a sudden stop

Annual average debt in the ergodic distribution	**CE**	**SP**
(Percent of annual GDP)		
Benchmark	35.0	35.0
$\kappa = 1.25$	35.0	35.0
$\beta = 0.91$	35.0	35.0
$\sigma_{\varepsilon^T} = 0.04$	32.0	33.0
$\beta = 0.91$ and $\sigma_{\varepsilon^T} = 0.04$	35.0	35.0
Fixed Tobin tax (1 percent)	35.0	na
State-Contingent Tobin tax (1 percent outside sudden stop)	35.0	na

Quarterly unconditional sudden stop probabilities		
(Percent per quarter)		
Benchmark	2.00	1.20
$\kappa = 1.25$	2.60	0.35
$\beta = 0.91$	2.05	2.21
$\sigma_{\varepsilon^T} = 0.04$	0.00	0.00
$\beta = 0.91$ and $\sigma_{\varepsilon^T} = 0.04$	3.60	2.20
Fixed Tobin tax (1 percent)	0.00	na
State-Contingent Tobin tax (1 percent outside sudden stop)	0.00	na

Table 5. Welfare gain of moving from the CE to the SP[28]
(In percent of permanent consumption)

	Overall	**At the sudden stop**
Benchmark	0.1230	0.1500
$\kappa = 1.25$	0.0525	0.0752
$\beta = 0.91$	0.0351	0.0390
$\sigma_{\varepsilon^T} = 0.04$	0.0013	na
$\beta = 0.91$ and $\sigma_{\varepsilon^T} = 0.04$	0.0430	0.0580
Fixed Tobin tax (1 percent)	-0.00049	-0.00061
State-Contingent Tobin tax (1 percent outside sudden stop)	-0.00024	-0.00035

[28]For the last two experiments (fixed Tobin tax and State-contingent Tobin tax) the welfare gain/loss is compared to the benchmark competitive equilibrium allocation.

Table 1. Model Parameters

Structural parameters	**Values**
Elasticity of substitution between tradable and non-tradable goods	$\kappa = 0.760$
Intertemporal substitution and risk aversion	$\rho = 2$
Labor supply elasticity	$\delta = 2$
Credit constraint parameter	$\phi = 0.415$
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Exogenous variables	**Values**
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Productivity process	
Persistence	$\rho_{\varepsilon^T} = 0.5370$
Volatility	$\sigma_{\varepsilon^T} = 0.0134$
Average values in the ergodic distribution	
Net foreign assets (or minus foreign borrowing)	$B = -0.9080$
Qaurterly GDP	$Y = 0.6486$
Qaurterly Tradable GDP	$Y^T = 0.2544$
Qaurterly Non-Tradable GDP	$Y^N = 0.3942$

Table 2. Variable Definitions

Variables	Model	Data 1/
GDP	Y=YT+YN	National Accounts, production accounts, GDP, 2003 prices.
Non-Tradable GDP	YN=PN*HN^0.66	National Accounts, production accounts, GDP, tertiary sectors, 2003 prices.
Tradable GDP	YT=EXP(ESPILON)*HT^0.66	National Accounts, production accounts, GDP, secondary sectors, 2003 prices.
Relative Price of Non-Tradable	PN=((1-omega)/omega)(CN/CT)^(kappa-1)	Consumer price of services relative to consumer price of merchandise, indexes, base 2002Q2.
Consumption Expenditure	C=CT+PN*CN	National Accounts, expenditure accounts, Private Consumption, 1993 prices.
Non-Tradable Consumption	CN=YN	National Accounts, expenditure accounts, Services plus nationally produced non-durable goods, 1993 prices.
Tradable Consumption	CT=(1+i)*B(t)+YT-B(t+1)	National Accounts, expenditure accounts, Imported goods plus nationally produced durable goods, 1993 prices.
Current Account	CA(t)=(B(t+1)-B(t))/Y	Balance of payment statistics, Current account balance to GDP.

1/ Data sources:

National accounts are from INEGI, Banco de Información Económica (BIE), http://dgcnesyp.inegi.org.mx/bdiesi/bdie.html.

Consumer price indexes are from Banco de Mexico (Consulta; series SP68277 and SP56335, respectively), http://www.banxico.org.mx/sitioingles/polmoneinflacion/estadisticas/cpi/cpi.htm .

Current account and GDP in US dollar are from the IDB Latin Macro Watch (LMW), http://www.iadb.org/Research/LatinMacroWatch/lmw.cfm.

Table 3. Model Evaluation: Second Moments of the Data and the Competitive Equilibrium (CE)

	St. Dev.	St. Dev. Realtive to GDP		First Autocorrelation		Correlation with GDP	
	Data	Data	CE	Data	CE	Data	CE
GDP	2.4%	1.0	1.0	0.8	0.5	1.00	1.00
Non-Tradable GDP	2.2%	0.9	0.7	0.8	0.5	0.97	0.97
Tradable GDP	3.4%	1.4	0.4	0.8	0.3	0.96	0.91
Consumption Expenditure	2.6%	1.1	0.9	0.8	0.5	0.91	0.98
Relative Price of Non-Tradable	2.5%	1.0	2.9	0.9	0.5	0.26	0.85
Current Account (In percent of GDP)	2.1%	0.9	0.5	0.8	0.5	-0.61	0.98

Table 4. Average foreign borrowing and probability of a sudden stop

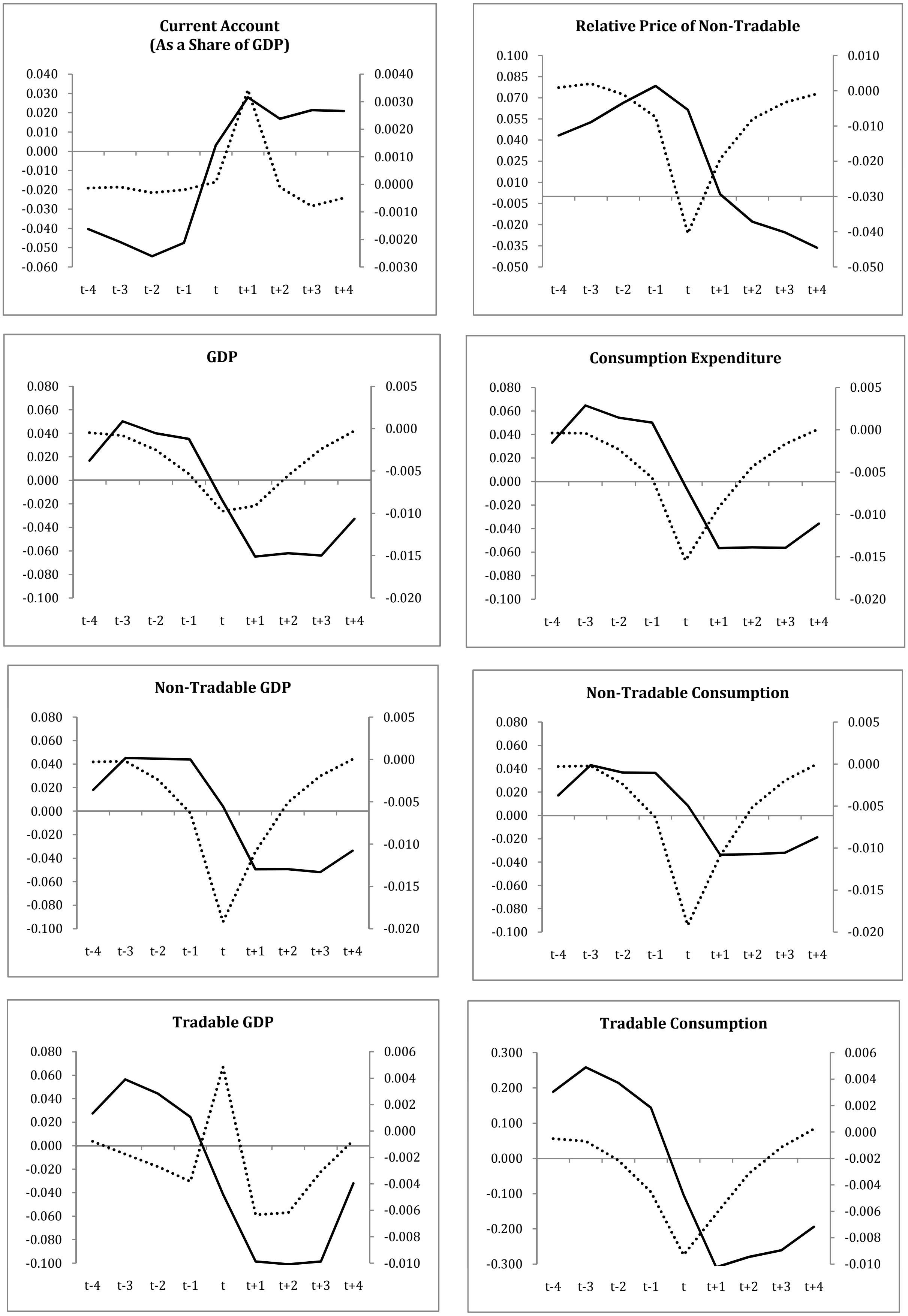
Annual average debt in the ergodic distribution	**CE**	**SP**
(Percent of annual GDP)		
Benchmark	35.0	35.0
$\kappa = 1.25$	35.0	35.0
$\beta = 0.91$	35.0	35.0
$\sigma_{\varepsilon^T} = 0.04$	32.0	33.0
$\beta = 0.91$ and $\sigma_{\varepsilon^T} = 0.04$	35.0	35.0
Fixed Tobin tax (1 percent)	35.0	na
State-Contingent Tobin tax (1 percent outside sudden stop)	35.0	na
Quarterly unconditional sudden stop probabilities		
(Percent per quarter)		
Benchmark	2.00	1.20
$\kappa = 1.25$	2.60	0.35
$\beta = 0.91$	2.05	2.21
$\sigma_{\varepsilon^T} = 0.04$	0.00	0.00
$\beta = 0.91$ and $\sigma_{\varepsilon^T} = 0.04$	3.60	2.20
Fixed Tobin tax (1 percent)	0.00	na
State-Contingent Tobin tax (1 percent outside sudden stop)	0.00	na

Table 5. Welfare gain of moving from the CE to the SP
(In percent of permanent consumption)

	Overall	**At the sudden stop**
Benchmark	0.1230	0.1500
$\kappa = 1.25$	0.0525	0.0752
$\beta = 0.91$	0.0351	0.0390
$\sigma_{\varepsilon^T} = 0.04$	0.0013	na
$\beta = 0.91$ and $\sigma_{\varepsilon^T} = 0.04$	0.0430	0.0580
Fixed Tobin tax (1 percent) 1/	-0.00049	-0.00061
State-Contingent Tobin tax (1 percent outside sudden stop) 1/	-0.00024	-0.00035

1/ Welfare gain/loss is relative to the benchmark CE allocation

Figure 1. Model Evaluation: Sudden Stop Dynamics in the Data and the Competitive Equilibrium 1/



1/ Data (In percent deviation from HP trend unless otherwise noted): Solid line, left axis.
Competitive Equilibrium (In percent deviation from ergodic mean unless otherwise noted): Dotted line, right axis.
See Table 2 for variable definitions and data sources.

Figure 2: Decision Rule For Foreign Borrowing

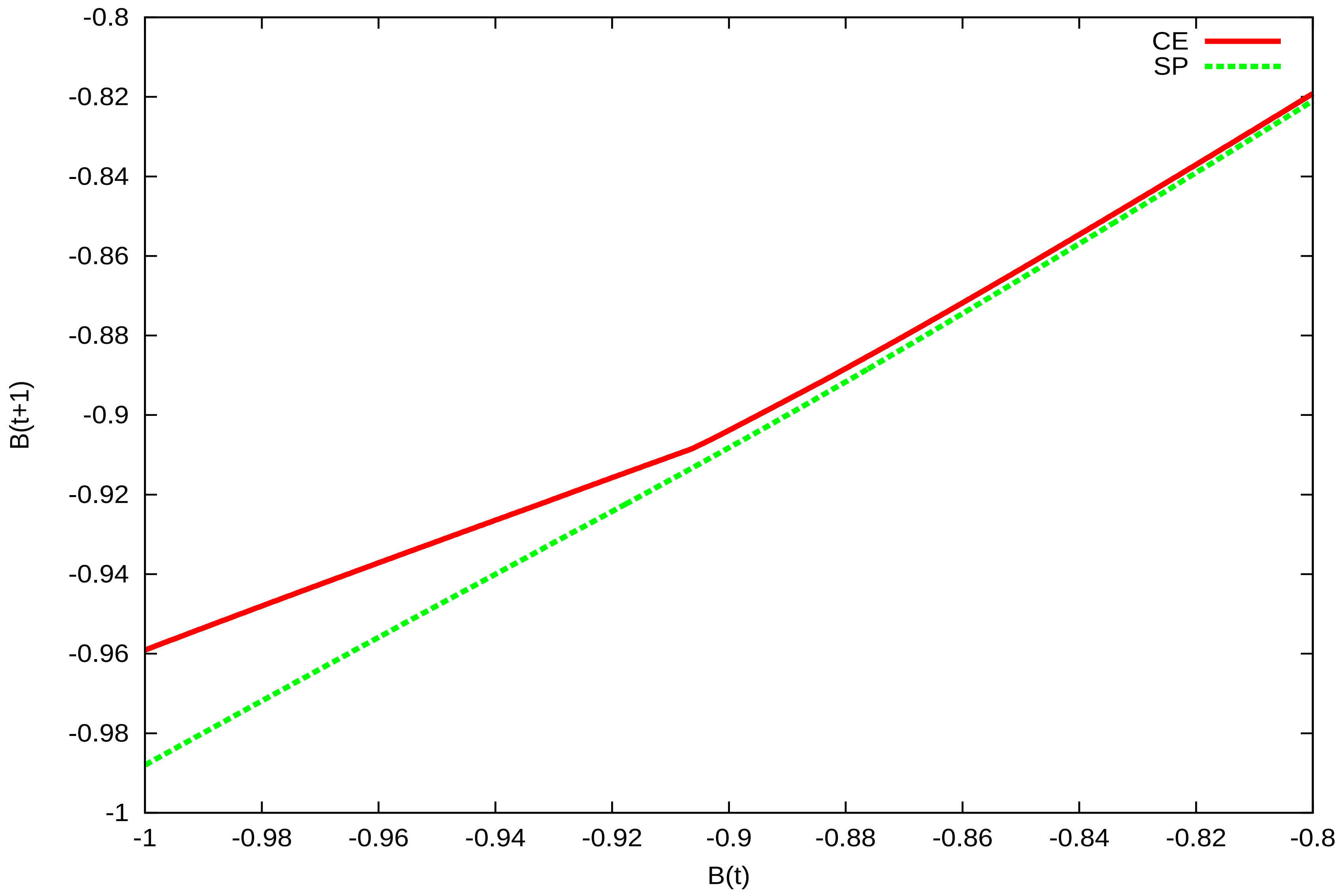


Figure 3: Decision Rules For Relative Price, Consumption, Wages and Labor

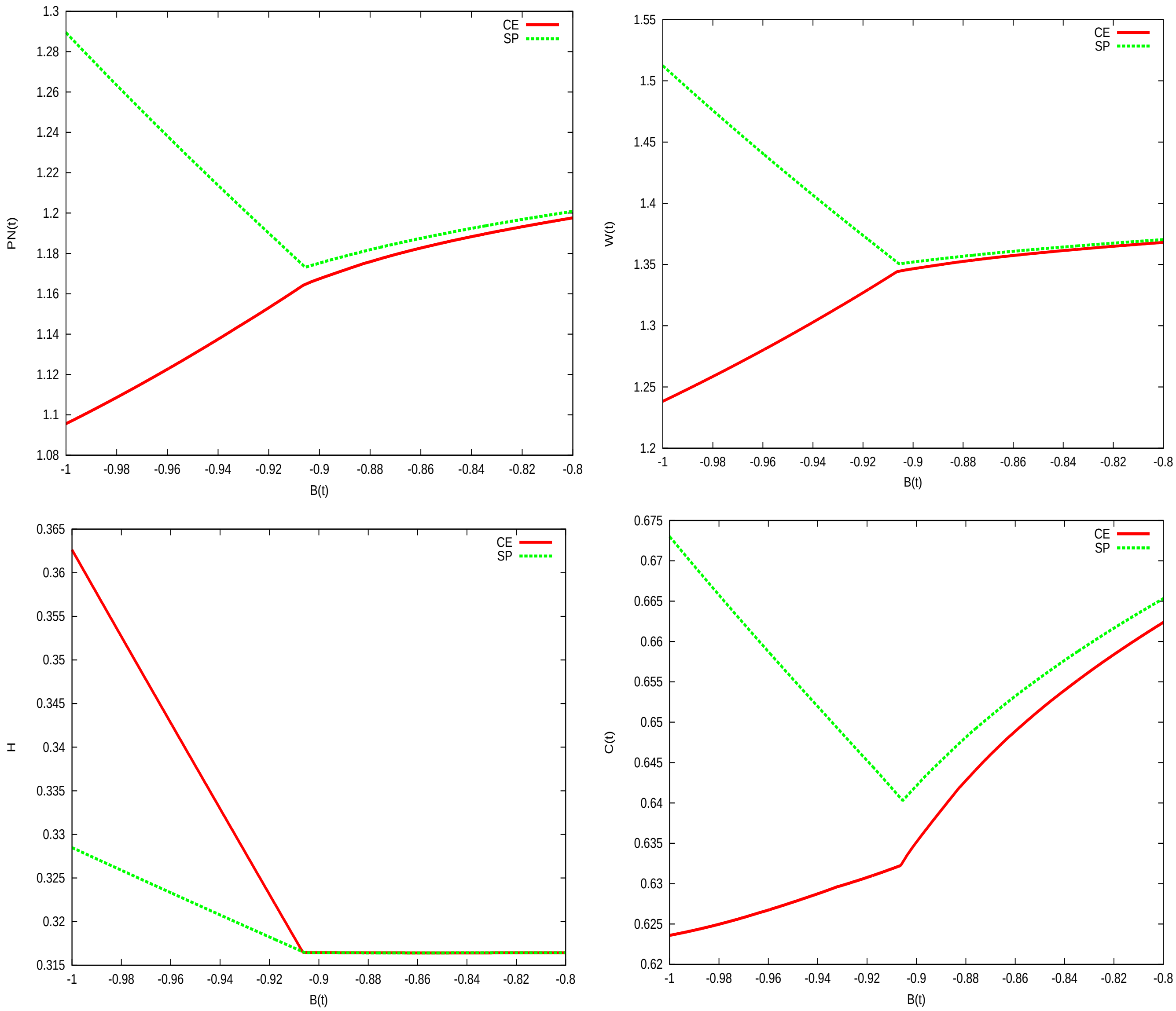


Figure 4: Decision Rules For Traded and Nontraded Consumption and Labor

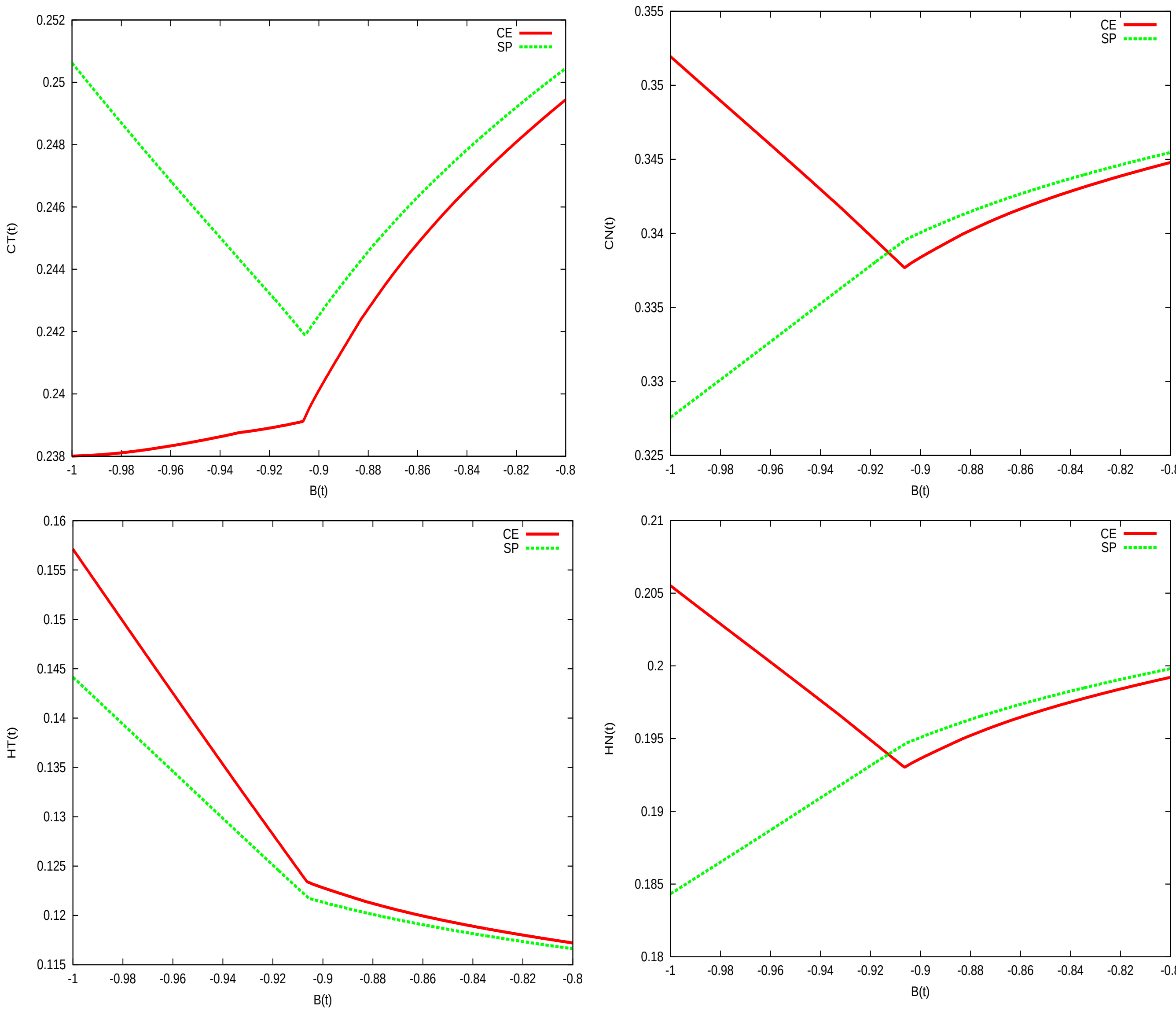


Figure 5: Ergodic Distribution for Foreign Borrowing

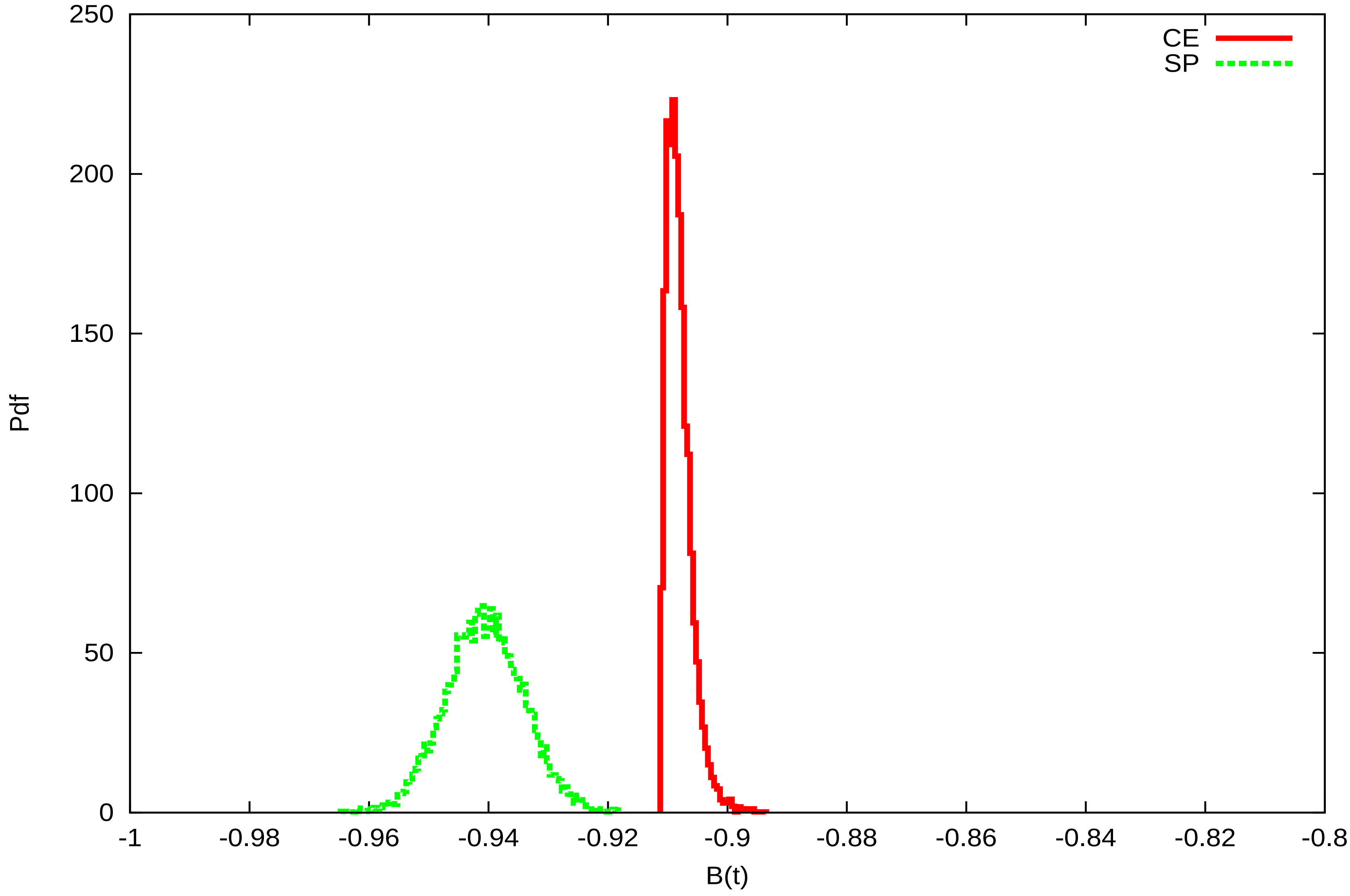


Figure 6: Welfare by State

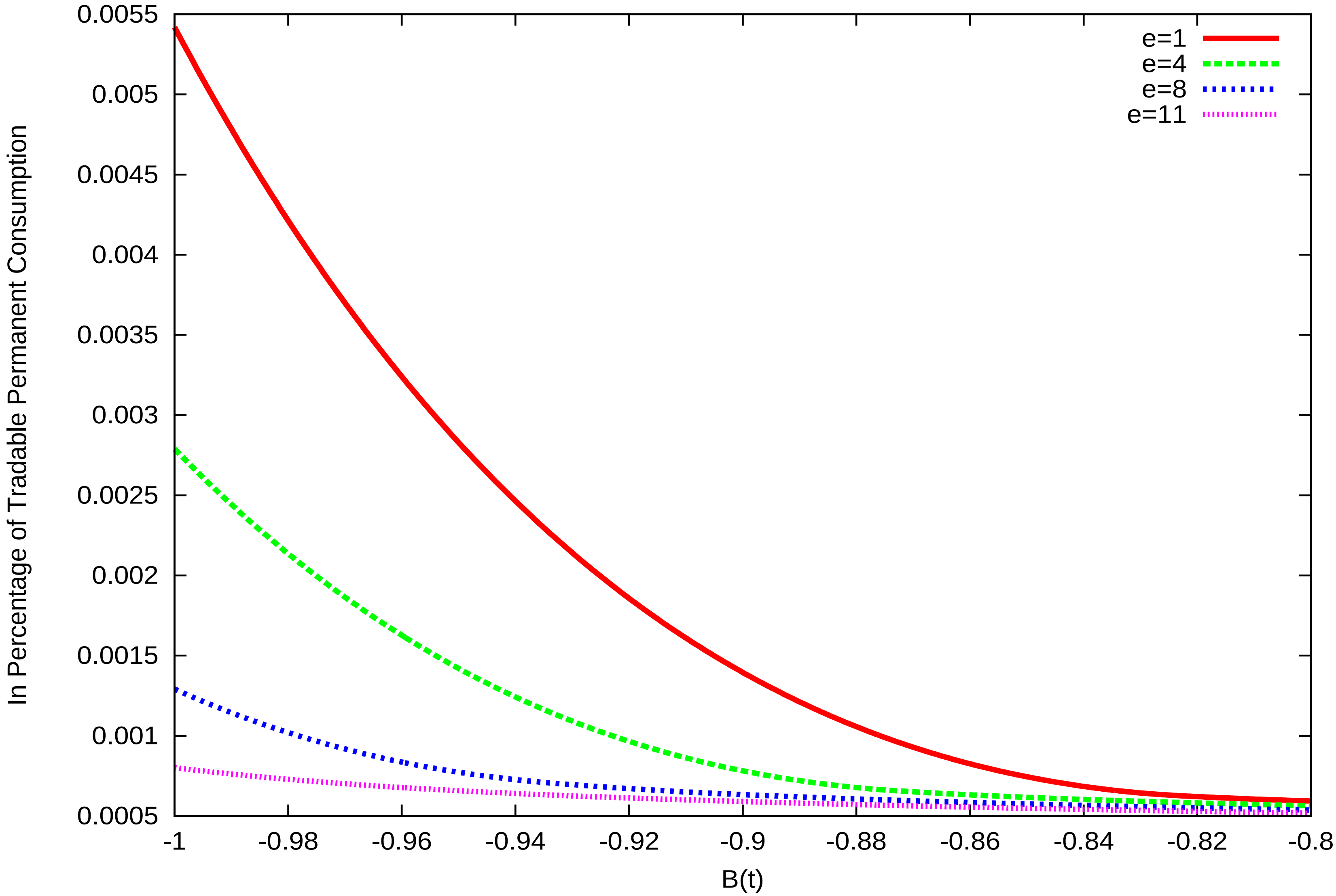
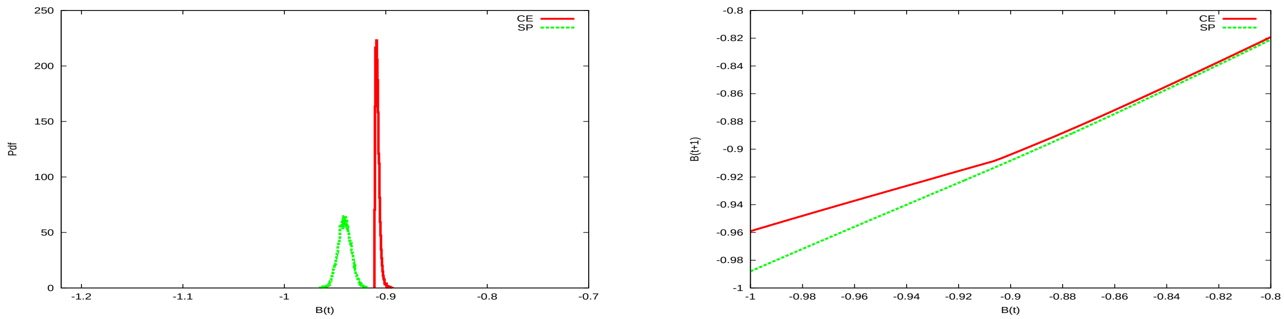
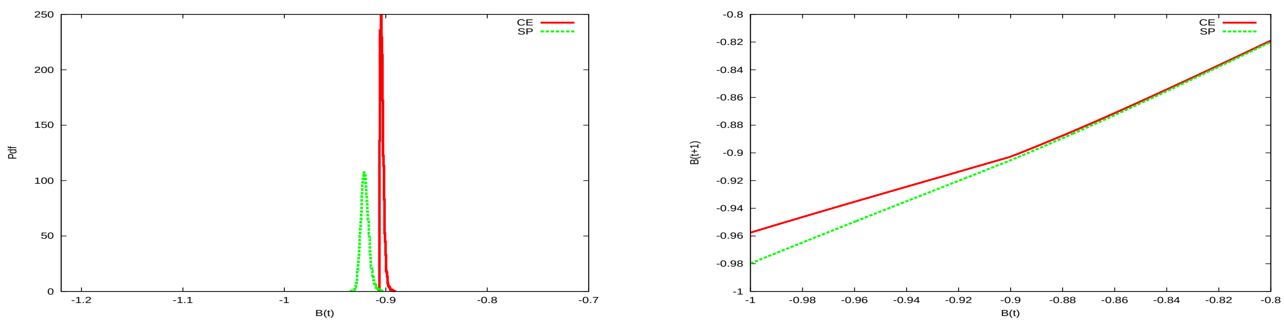


Figure 7: Robustness

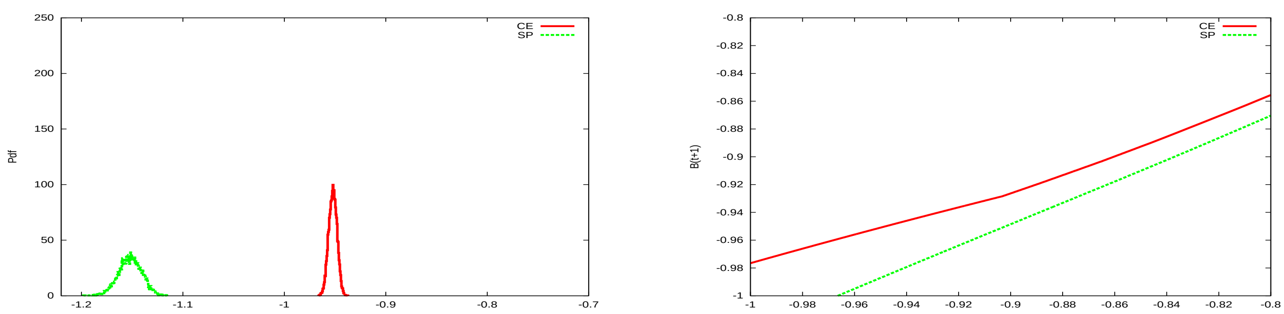
(a) BenchMark



(b) Higher Elasticity



(c) Lower Discount Factor



(d) Higher Variance

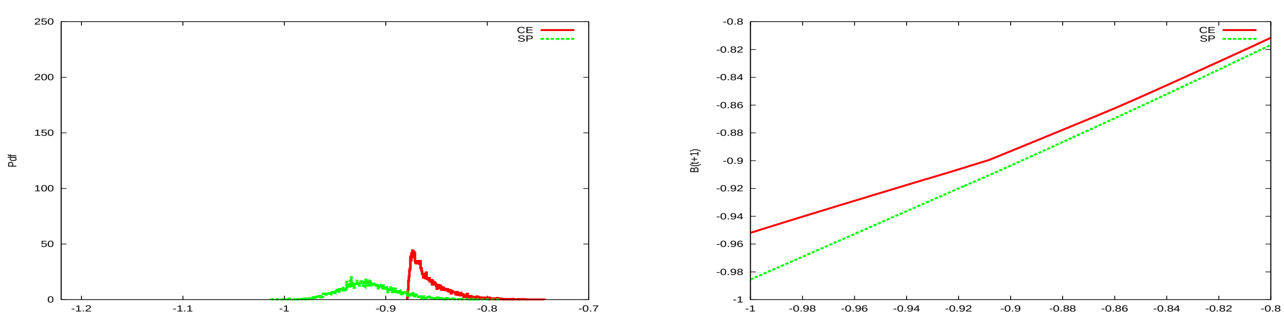
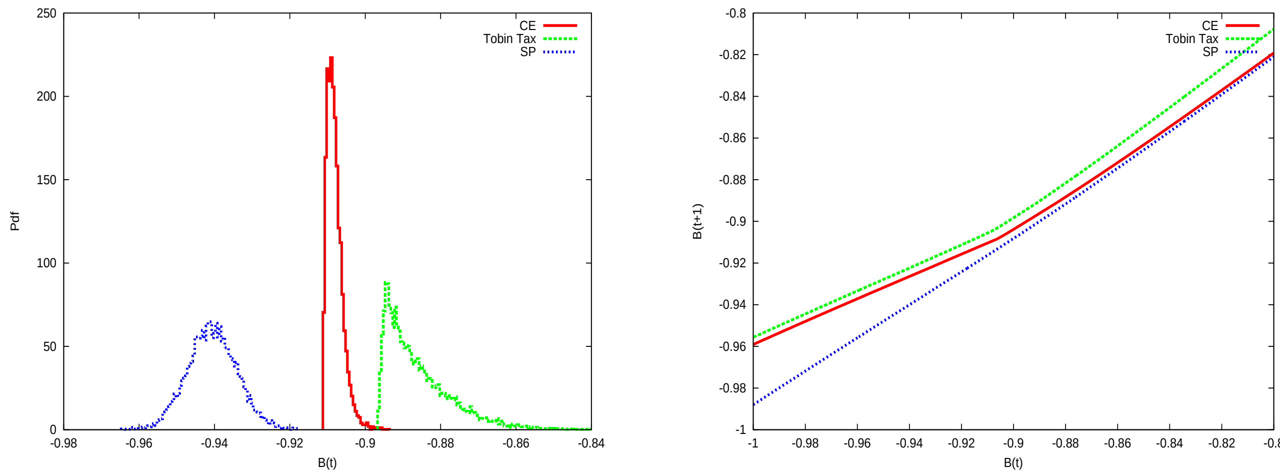


Figure 8: Tobin Tax

(a) Fixed Tax



(b) State Contingent Tax