ABSTRACT

Title of dissertation: ESSAYS ON PREVENTING SUDDEN STOPS

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Capital markets have witnessed a rash of ‘Sudden Stops’ during the last decade. Policy proposals to prevent these crises include creating indexed bond markets and providing price guarantees for emerging market assets. Chapter 1 explores the macroeconomic implications of indexed bonds with a return indexed to the key variables driving emerging market economies such as terms of trade or productivity. We employ a quantitative model of a small open economy in which Sudden Stops are driven by the financial frictions inherent to world capital markets. While indexed bonds provide a hedge to income fluctuations and can undo the effects of financial frictions, they lead to interest rate fluctuations. Due to this tradeoff, there exists a non-monotonic relation between the “degree of indexation” (i.e., the percentage of the shock reflected in the return) and the overall effects of these bonds on macroeconomic fluctuations. Therefore, indexation can improve macroeconomic conditions only if the degree of indexation is less than a critical value. When the degree of indexation is higher than this threshold, it strengthens the precautionary savings motive, increases consumption volatility and impact effect of Sudden Stops. The

threshold degree of indexation depends on the volatility and persistence of income shocks as well as the relative openness of the economy.

Chapter 2 explores the implications of asset price guarantees provided by an international financial organization on the emerging market assets. This policy is motivated by the globalization hazard hypothesis, which suggest that Sudden Stops caused by global financial frictions could be prevented by offering foreign investors price guarantees on emerging markets assets. These guarantees create a tradeoff, however, because they weaken globalization hazard while creating international moral hazard. We study this tradeoff using a quantitative, equilibrium asset-pricing model. Without guarantees, margin calls and trading costs cause Sudden Stops driven by a Fisherian deflation. Price guarantees prevent this deflation by propping up foreign demand for assets. The effectiveness of price guarantees, their distortions on asset markets, and their welfare implications depend critically on whether the guarantees are contingent on debt levels and on the price elasticity of foreign demand for domestic assets.

ESSAYS ON PREVENTING SUDDEN STOPS

by

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DEDICATION

To my wife, Emine, my parents and my brother.

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Chapter 1

Are Indexed Bonds a Remedy for Sudden Stops?

1.1 Introduction

Liability dollarization[1] and frictions in world capital markets have played a key role in the emerging market crises or Sudden Stops of the last decade. Typically, these crises are triggered by sudden reversals of capital inflows that result in sharp real exchange rate depreciations and collapses in consumption. Figures 1, 2, and Table 4 document the Sudden Stops observed in Argentina, Chile, Mexico, and Turkey in the last decade. For example in 1994, Turkey experienced a Sudden Stop characterized by: 10% current account-GDP reversal, 10% consumption and GDP drops relative to their trends, and 31% real exchange rate depreciation.[2]

In an effort to remedy Sudden Stops, Caballero (2002, 2003) and Borensztein and Mauro (2004) propose the issuance of state contingent debt instruments by emerging market economies. Caballero's proposal relies on the premise that crises in some emerging economies are driven by external shocks (e.g., terms of trade shocks), and that contrary to their developed counterparts, these economies have difficulty absorbing these shocks due to imperfections in world capital markets. Most emerging

[1] Liability dollarization refers to the denomination of debt in units of tradables (i.e., hard currencies). Liability dollarization is common in emerging markets, where debt is denominated in units of tradables but partially leveraged on large non-tradables sectors.

[2] See Figures 1 and 2, Table 4 for further documentation of these empirical regularities (see Calvo et al. (2003) and Calvo and Reinhart (1999) for a more detailed empirical analysis).

countries could reduce aggregate volatility in their economies and cut precautionary savings if they possessed debt instruments for which returns are contingent on the external shocks that trigger crises.[3] He suggests creating an indexed bonds market in which bonds' returns are contingent on terms of trade shocks or commodity prices.[4] Borensztein and Mauro (2004) argue that GDP-indexed bonds could reduce the aggregate volatility and the likelihood of unsustainable debt-to-GDP levels in emerging economies. Hence, they argue that these bonds can help these countries avoid pro-cyclical fiscal policies.

This chapter introduces indexed bonds into a quantitative general equilibrium model of a small open economy with financial frictions in order to analyze the implications of these bonds for macroeconomic fluctuations and Sudden Stops. The model incorporates financial frictions proposed in the Sudden Stops literature (Calvo (1998), Mendoza (2002), Mendoza and Smith (2005), Caballero and Krishnamurthy (2001), among others). In particular, the economy suffers from liability dollarization, international debt markets impose a borrowing constraint in the small open economy. This constraint limits debt to a fraction of the economy's total income valued at tradable goods prices. As established in Mendoza (2002), when the only available instruments are non-indexed bonds, an exogenous shock to productivity or to the terms of trade that renders the borrowing constraint binding triggers a Fisherian debt-deflation mechanism.[5] A binding borrowing constraint leads to a decline in

[3]Precautionary savings refers to extra savings caused by financial markets being incomplete. Caballero (2002) points out that precautionary savings in emerging countries arise as excessive accumulation of foreign reserves.

[4]Caballero (2002) argues, for example, that Chile could index to copper prices, and that Mexico and Venezuela could index to oil prices.

[5]See Mendoza and Smith (2005), and Mendoza (2005) for further analysis on Fisherian debt-

tradables consumption relative to non-tradables consumption, inducing a fall in the relative price of non-tradables as well as a depreciation of the real exchange rate (RER). The decline in RER makes the constraint even more binding, creating a feedback mechanism that induces collapses in consumption and the RER, as well as a reversal in capital inflows.

Our analysis consists of two steps. The first step is to consider a one-sector economy in which agents receive persistent endowment shocks, credit markets are perfect but insurance markets are incomplete (henceforth frictionless one-sector model). Second, we analyze a two sector model with financial frictions that can produce Sudden Stops endogenously through the mechanism explained in the previous paragraph. The motivation for the first step is to simplify the model as much as possible in order to understand how the dynamics of the model with indexed bonds differ from those of the one with non-indexed bonds.[6] In this frictionless one-sector model, when the available instruments are only non-indexed bonds with a constant exogenous return, agents try to insure away income fluctuations with trade balance adjustments. Since insurance markets are incomplete, agents are not able to attain full-consumption smoothing, consumption is volatile, and correlation of consumption with income is positive. Furthermore, agents try to self-insure by engaging in precautionary savings. If the returns of the bonds are indexed to the exogenous income shock only, the insurance markets are only "partially complete." In order to have complete markets, either full set of state contingent assets such as Arrow

deflation.

[6]This case can also be used to examine the role of indexed bonds in small open developed economies such as Australia and Sweden, which have relatively large tradables sectors and better access to international capital markets than most emerging market economies.

securities should be available (i.e., there are as many assets as the states of nature) or the returns should be state contingent (i.e., contingent on both the exogenous shock and the debt levels, see Section 1.3.1 for further discussion). Although indexed bonds partially complete the market, the hedge provided by these bonds are imperfect because they introduce interest rate fluctuations. Assessing whether the benefits (due to hedging) offset the costs (due to interest rate fluctuations) induced by indexed bonds requires quantitative analysis.

Our quantitative analysis of the frictionless one-sector model establishes that there exists a non-monotonic relation between the "degree of indexation" of the bonds (i.e., the percentage of the shock that is passed on to the bonds' return) and the overall effects of these bonds on macroeconomic variables. Therefore, indexed bonds can reduce precautionary savings, volatility of consumption and correlation of consumption with income only if the degree of indexation is lower than a critical value. If it is higher than this threshold (as with full indexation), indexed bonds worsen these macroeconomic variables.

The changes in precautionary savings are driven by the changes in "catastrophic level of income." Risk averse agents have strong incentives to avoid attaining levels of debt that the economy cannot support when the income is at catastrophic level.[7] Because, otherwise agents would attain non-positive consumption levels which in turn leads to infinitely negative utility if such income levels realize. The degree of indexation has a significant effect on determining the state of nature

[7]The largest debt that the economy can support to guarantee non-negative consumption in the event that income is almost surely at its catastrophic level is referred as natural debt limit.

that defines catastrophic levels of income and whether these income levels are higher or lower than what they would be without indexation. With higher degrees of indexation, these income levels can be determined at a positive shock, because, for example, if agents receive positive income shocks forever, they will receive higher endowment income but will also pay higher interest rates. Our analysis shows that for higher values of the degree of indexation, the latter effect is stronger, leading to lower catastrophic income levels. This in turn creates stronger incentives for agents to build up buffer stock savings.

The effect of indexation on consumption volatility can be analyzed by decomposing the variance of consumption. (Consider the budget constraint of such an economy $c_t = (1 + \varepsilon_t)y - b_{t+1} + (1 + r + \varepsilon_t)b_t$.[8] Using this budget constraint, $var(c_t) = var(y_t) + var(tb_t) - 2cov(tb_t, y_t))$. On one hand, for a given income volatility, indexation increases the covariance of trade balance with income (since in good (bad) times indexation commands higher (lower) repayments to the rest of the world), which lowers the volatility of consumption. On the other hand, indexation increases the volatility of trade balance (due to introduction of interest rate fluctuations), which increases the volatility of consumption. Our analysis suggests that at high levels of indexation, increase in the variance of trade balance dominates the increase in the covariance of trade balance with income, which in turn increases consumption volatility.

This tradeoff is also preserved in the two sector model with financial frictions.

[8]Here, b is bond holdings, r is risk free net interest rate, y is endowment income, ε_t is the income shock, and c is consumption.

In addition, in this model, the interaction of the indexed bonds with the financial frictions leads to additional benefits *and* costs. Specifically, when indexed bonds are in place, negative shocks can result in a relatively small decline in tradable consumption; as a result, the initial capital outflow is milder and the RER depreciation is weaker compared to a case with non-indexed bonds. The cushioning in the RER can help to contain the Fisherian debt-deflation process. While these bonds help relax the borrowing constraint in case of negative shocks, this time, an increase in debt repayment following a *positive* shock can lead to a larger need for borrowing, which can make the borrowing constraint suddenly binding, triggering a debt-deflation. Quantitative analysis of this model suggests, once again, that the degree of indexation needs to be lower than a critical value in order to smooth Sudden Stops. With indexation higher than this critical value, the latter effect dominates the former, hence lead to more detrimental effects of Sudden Stops. We also find that the degree of indexation that minimizes macroeconomic fluctuations and impact effect of Sudden Stops depends on the persistence and volatility of the exogenous shock triggering Sudden Stops, as well as the size of the non-tradables sector relative to its tradables sector; suggesting that the indexation level that maximizes benefit of indexed bonds needs to be country specific. Because an indexation level that is appropriate for one country in terms of its effectiveness at preventing Sudden Stops may not be effective for another and may even expose to higher risk of facing Sudden Stops.

Debt instruments indexed to real variables (i.e., GDP, commodity prices, etc.)

have not been widely employed in international capital markets.[9] As Table 1.3 shows, only a few countries issued these types of instruments in the past. In the early 1990s, Bosnia and Herzegovina, Bulgaria, and Costa Rica issued bonds containing an element of indexation to GDP; at the same time, Mexico and Venezuela issued bonds indexed to oil. Since the late 1990s, Bulgaria has already swapped a portion of its debt with non-indexed bonds. France issued gold-indexed bonds in the early 1970s, but due to depreciation of the French Franc in subsequent years, the French government bore significant losses and halted issuance.[10] Although problems on the demand side have been emphasized in the literature as the primary reason for the limited issuance of indexed bonds, the supply of such bonds has always been thin, as countries have exhibited little interest in issuing them. Our results may also help to understand why it has been the case: countries may have been reluctant due to the imperfect hedge that these bonds provide.

Several studies have explored the costs and benefits of indexed debt instruments in the context of public finance and optimal debt management.[11] As mentioned above, Borensztein and Mauro (2004) and Caballero (2003) drew attention to these instruments as possible vehicles to provide insurance benefits to emerging countries. Moreover, Caballero and Panageas (2003) quantified the potential welfare effects of credit lines offered to emerging countries. They modelled a one-sector model with collateral constraints where Sudden Stops are exogenous. They used

[9] In terms of hedging perspective CPI-indexed bonds may not provide a hedge against income risks, since inflation is pro-cyclical.

[10] The French government paid 393 francs in interest payments for each bond issued, far more than the 70 francs originally planned (Atta-Mensah (2004)).

[11] See, for instance, Barro (1995), Calvo(1988), Fischer (1975), Magil and Quinzii (1005), among others

this setup to explore the benefits of these credit lines in terms of smoothing Sudden Stops, interpreting them as akin to indexed bonds. This chapter contributes to this literature by modelling indexed bonds explicitly in a dynamic stochastic general equilibrium model where Sudden Stops are endogenous. Endogenizing Sudden Stops reveals that the efficacy of indexed bonds in terms of preventing these crises depends on whether the benefits due to hedging outweigh the imperfections introduced by these bonds. Depending on the structure of indexation, we show that they can potentially amplify the effects of Sudden Stops.[12]

This chapter is related to studies in several strands of macro and international finance literature. The model has several features common to the literature on precautionary saving and macroeconomic fluctuations (e.g., Aiyagari (1994), Hugget (1993)). The chapter is also related to studies exploring business cycle fluctuations in small open economies (e.g., Mendoza (1991), Neumeyer and Perri (2005), Kose (2002), Oviedo (2005), Uribe and Yue (2005)) from the perspective of analyzing how interest rate fluctuations affect macroeconomic variables. In addition to the papers in the Sudden Stops literature, this chapter is also related to follow up studies to this literature, including Calvo (2002), Durdu and Mendoza (2005), and Caballero and Panageas (2003), which investigate the role of relevant policies in terms of preventing Sudden Stops. Durdu and Mendoza (2005) explore the quantitative implications of price guarantees offered by international financial organizations on emerging market assets. They find that these guarantees may induce moral hazard among global

[12]Krugman (1998) and Froot et al. (1989) emphasize moral hazard problems that GDP indexation can introduce. Here, we point out other adverse effects that indexation can cause even in the absence of moral hazard.

investors, and conclude that the effectiveness of price guarantees depends on the elasticity of investors' demand as well as whether the guarantees are contingent on debt levels. Similarly, in this chapter, we explore the potential imperfections that can be introduced by the issuance of indexed bonds, and derive the conditions under which such a policy could be effective in preventing Sudden Stops.

Our findings are closely related to those of Magill and Quinzii (1995). They compare the welfare effects of introduction of inflation indexed bonds and point out that while these bonds can eliminate the fluctuations in purchasing power, they introduce another risk that arise from relative price fluctuations; suggesting that economies might actually be worse off with introduction of inflation indexed bonds.

Earlier seminal studies that in financial innovation literature such as Shiller (1993) and Allen and Gale (1994) analyze how creation of new class of "macro markets" can help to manage economic risks such as real estate bubbles, inflation, recessions, etc. and discusses what sorts of frictions can prevent the creation of these markets. This chapter emphasizes possible imperfections in global markets, and points out under which conditions issuance of indexed bonds may not improve macroeconomic conditions for a given emerging market.

The rest of the chapter proceeds as follows. The next section describes the full model environment. Section 1.3 presents the quantitative results of the frictionless one-sector model, and the two-sector model with financial frictions. We conclude and offer extensions in Section 1.4.

1.2 Model

In this section, we describe the general setup of the two sector model with financial frictions. The model with non-indexed bonds is similar to Mendoza (2002). Foreign debt is denominated in units of tradables and imperfect credit markets impose a borrowing constraint that limits external debt to a share of the value of total income in units of tradables (which therefore reflects changes in the relative price of non-tradables that is the model's RER).

Representative households receive a stochastic endowment of tradables and non-stochastic endowment of non-tradables, which are denoted $(1+\varepsilon_t)y^T$ and y^N, respectively. ε_t is a shock to the world value of the mean tradables endowment that could represent a productivity shock or a terms-of-trade shock. In our model, $\varepsilon \in \mathcal{E} = [\varepsilon_1 < ... < \varepsilon_m]$ (where $\varepsilon_1 = -\varepsilon_m$) evolves according to an m-state symmetric Markov chain with transition matrix $\mathcal{P}$. Households derive utility from aggregate consumption (c), and maximize Epstein's (1983) stationary cardinal utility function:

$$U = E_0 \left\{ \sum_{t=0}^{\infty} \exp\left[-\sum_{\tau=0}^{t-1} \gamma \log(1+c_t) \right] u(c_t) \right\}. \tag{1.1}$$

Functional forms are given by:

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}, \tag{1.2}$$

$$c_t(c_t^T, c_t^N) = \left[\omega (c_t^T)^{-\mu} + (1-\omega)(c_t^N)^{-\mu} \right]^{-\frac{1}{\mu}}. \tag{1.3}$$

The instantaneous utility function (1.2) is in constant relative risk aversion (CRRA) form with an inter-temporal elasticity of substitution $1/\sigma$. The consumption aggregator is represented in constant elasticity of substitution (CES) form, where $1/(1+\mu)$ is the elasticity of substitution between consumption of tradables and non-tradables and where ω is the CES weighing factor. $\exp\left[-\sum_{\tau=0}^{t-1}\gamma\log(1+c_t)\right]$ is an endogenous discount factor that is introduced to induce stationarity in consumption and asset dynamics. γ is the elasticity of the subjective discount factor with respect to consumption. Mendoza (1991) introduced preferences with endogenous discounting to quantitative small open economy models, and such preferences have since been widely used.[13]

The households' budget constraint is:

$$c_t^T + p_t^N c_t^N = (1+\varepsilon_t)y^T + p_t^N y^N - b_{t+1} + (1+r+\phi\varepsilon_t)b_t \tag{1.4}$$

where b_t is current bond holdings, $(1+r+\phi\varepsilon_t)$ is the gross return on bonds, and p_t^N is relative price of non-tradables. The indexation of the debt works as follows. Consider a case in which there are high and low states for tradables income. The return on the indexed bonds is low in the bad state and high in the good one, but the mean of the return remains unchanged and equal to R.[14] When households'

[13] As explained in Schmitt-Grohé and Uribe (2003), preferences with constant discounting, where rate of time preference is equal to real interest rate, introduces non-stationarity in consumption and asset holdings. Schmitt-Grohé and Uribe (2003) compares the quantitative implications of the specifications used in the literature to resolve this problem. Kim and Kose (2003) also compares quantitative implications of endogenous discounting with that of constant discounting.

[14] Although return is indexed to terms of trade shock, our modeling approach potentially sheds light on the implications of RER indexation, as well. In our model, the aggregate price index (i.e., the RER) is an increasing function of the relative price of non-tradables (p^N), which is determined at equilibrium in response to endowment shocks.

current bond holdings are negative, (i.e., when households are debtors) they pay less (more) in the event of a negative (positive) endowment shock. The standard assumption on modelling bonds' return is to assume that indexation is one-to-one; i.e., the return of indexed bonds is $1+r+\varepsilon_t$ (see for example Borensztein and Mauro (2004)). Here, we consider a more flexible setup by assuming a flexible degree of indexation by introducing a parameter $\phi \in [0,1]$, which measures the degree of indexation of the bonds. In particular, the limiting case $\phi = 0$ yields the benchmark case with non-indexed bonds, while $\phi = 1$ is the full-indexation case. Notice that ϕ affects the variance of the bonds' return (since $var(1 + r + \phi\varepsilon_t) = \phi^2 var(\varepsilon_t)$). As ϕ increases, the bonds provide a better hedge against negative income shocks, but at the same time it introduces additional volatility by increasing the return's variance. As explained below, there is a critical degree of indexation beyond which the distortions due to the increased volatility of returns outweigh the benefits that indexed bonds introduce. In our quantitative experiments, we will characterize the value of ϕ; at which, the bonds' benefits are maximized.

To simplify notation, we denote bond holdings as b_t regardless of whether bonds are non-indexed or indexed. As mentioned above, when ϕ is equal to zero, the bond boils down to a non-indexed bond with a fixed gross return $R = 1 + r$. This return is exogenous and equal to the world interest rate. When ϕ is greater than zero, it is an indexed bond with a state contingent return; i.e., it (imperfectly) hedges income fluctuations.

In addition to the budget constraint, foreign creditors impose the following borrowing constraint, which limits debt issuance as a share of total income at period

t not to exceed κ:

$$b_{t+1} \geq -\kappa \left[(1+\varepsilon_t)y^T + p_t^N y^N\right]. \tag{1.5}$$

The borrowing constraint takes a similar form as those used in the Sudden Stops literature in order to mimic the tightening of the available credit to emerging countries (see for example, Caballero and Krishnamurthy (2001), Mendoza (2002), Mendoza and Smith (2005), Caballero and Panageas (2003)). As Mendoza and Smith (2005) explain, although these types of borrowing constraints are not based upon a contracting problem between lenders and borrowers, they are realistic in the sense that they resemble the risk management tools used in international capital markets, such as Value-at-Risk models employed by investment banks.

The optimality conditions of the problem facing households are standard and can be reduced to the following equations:

$$U_c(t)\left(1-\frac{\nu_t}{\lambda_t}\right) = \exp\left[-\gamma \log(1+c_t)\right] E_t \left\{ \frac{(1+r+\phi\varepsilon_t)p_t^c}{p_{t+1}^c} U_c(t+1) \right\} \tag{1.6}$$

$$\frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{1+\mu} = p_t^N \tag{1.7}$$

along with the budget constraint (1.4), the borrowing constraint (1.5), and the standard Kuhn-Tucker conditions. ν and λ are the Lagrange multipliers of the borrowing constraint and the budget constraint, respectively. U_c is the derivative of lifetime utility with respect to aggregate consumption. p_t^c is the CES price index of aggregate consumption in units of tradable consumption, which equals $\left[\omega^{\frac{1}{\mu+1}} + (1-\omega)^{\frac{1}{\mu+1}}(p^N)^{\frac{\mu}{\mu+1}}\right]^{\frac{1+\mu}{\mu}}$. Equation (1.6) is the standard Euler Equation equating marginal utility at date t to that of date $t+1$. Equation (1.7) equates the marginal rate of substitution between tradabales consumption and non-tradables consumption to the relative price of non-tradables.

1.3 Quantitative Analysis

We explore the model's dynamics in two steps. First, we examine the role that indexed bonds play in a standard one-sector model in which the problem of liability dollarization is excluded and there is no borrowing constraint. Then we introduce the two frictions back as in the complete model described above in order to examine the role that indexed bonds can play in reducing the adverse effects of liability dollarization and preventing Sudden Stops.

1.3.1 The frictionless one-sector model

In the frictionless one-sector version of the model, indexed bonds with returns indexed to the exogenous shock are not able to complete the market but just partially completes it by providing the agents with the means to hedge against fluctuations in endowment income. If we call $(1 + r + \phi\varepsilon)b_t$ financial income, the underlying goal to complete the market would be to keep the sum of endowment and financial incomes constant and equal to the mean endowment income, i.e., $(1+\varepsilon_t)y^T+(1+r+\phi\varepsilon)b_t = y^T$. Clearly, we can keep this sum constant only if the bonds' return is state contingent (i.e., contingent on both the exogenous shock and the debt stock, which requires $R_t(b, \varepsilon) = -\frac{\varepsilon_t y^T}{b_t}$ or agents can trade Arrow securities (i.e., there are as many assets as the number of state of nature). Hence, indexed bonds introduce a tradeoff: on one hand it hedges income fluctuations but on the other hand it introduces interest rate fluctuations. In order to analyze the overall effect of indexed bonds, we solve the model numerically. The dynamic programming representation (DPP) of the household's problem in this case reduces to:

$$\begin{aligned} V(b,\varepsilon) = \max_{b'} \left\{u(c) + (1+c)^{-\gamma} E\left[V(b',\varepsilon')\right]\right\} \quad s.t. \\ c^T = (1+\varepsilon)y^T - b' + (1+r+\phi\varepsilon)b. \end{aligned} \tag{1.8}$$

Here, the endogenous state space is given by $\mathcal{B} = \{b_1 < ... < b_{NB}\}$, which is constructed using $NB = 1,000$ equidistant grid points. The exogenous Markov process is assumed to have two states for simplicity: $\mathcal{E} = \{\varepsilon_L < \varepsilon_H\}$. Optimal decision rules, $b'(b,\varepsilon) : \mathcal{E} \times \mathcal{B} \rightarrow \mathcal{R}$, are obtained by solving the above DPP via a value function iteration algorithm.

Calibration

The parameter values used to calibrate the model are summarized in Table 1.1. The CRRA parameter σ is set to 2, the mean endowment y^T is normalized to one, and the gross interest rate is set to the quarterly equivalent of 6.5%, following the values used in small open economy RBC literature (see for example Mendoza (1991)). The steady state debt-to-GDP ratio is set to 35%, which is inline with the estimate for the net asset position of Turkey (see Lane and Milesi-Ferretti (1999)). The elasticity of the subjective discount factor follow from euler equation for consumption evaluated at steady-state:

$$(1+\bar{c})^{-\gamma}(1+r) = 1 \Rightarrow \gamma = \log(1+r)/\log(1+\bar{c}). \tag{1.9}$$

The standard deviation of the endowment shock is set to 3.51% and the autocorrelation is set to 0.524, which are the standard deviation and the autocorrelation of tradable output for Turkey given in Table 1.4.

Table 1.1: Parameter Values

σ	2	relative risk aversion	RBC parametrization
y^T	1	tradable endowment	normalization
σ_ε	0.0351	tradable output volatility	Turkish data
ρ_ε	0.524	tradable output autocorrelation	Turkish data
R	1.0159	gross interest rate	RBC parametrization
γ	0.0228	elasticity of discount factor	steady state condition

Using the "simple persistence" rule, we construct a Markovian representation of the time series process of output. The transition probability matrix $\mathcal{P}$ of the shocks follows:

$$\mathcal{P}(i,j) = (1-\rho_\varepsilon)\Pi_i + \rho_\varepsilon \mathcal{I}_{i,j} \tag{1.10}$$

where $i, j = 1, 2$; Π_i is the long-run probability of state i; and $\mathcal{I}_{i,j}$ is an indicator function, which equals 1 if $i = j$ and 0 otherwise, ρ_ε is the first order serial autocorrelation of the shocks.

Simulation Results

We report long run values of the key macroeconomic variables, such as mean bond holdings that is a measure of precautionary savings, volatility of consumption, correlation of consumption with income, which measures to what extend income fluctuations affect consumption fluctuations, and serial autocorrelation of consumption which measures the persistence of consumption, of the model to highlight the effect of indexation on consumption smoothing in Table 1.5. Without indexation ($\phi = 0$), mean bond holdings are higher than the case with perfect foresight (-0.35) (which is an implication of precautionary savings), volatility of consumption is positive, and consumption is correlated with income.

Now we analyze how the results change when we index debt repayments to endowment shocks. As Table 1.5 reveals, when the degree of indexation is in the [0.015, 0.25) range, households engage in less precautionary savings (as measured by the long run average of b) and the standard deviation of consumption declines relative to the case in which there is no indexation. Moreover, in this range, correlation of consumption with GDP falls slightly and its serial autocorrelation increases slightly. These results suggests that when the degree of indexation is in this range, indexation improves these macroeconomic variables from the consumption smoothing perspective. However, when the degree of indexation is greater than 0.25, these improvements reverse. In the full-indexation ($\phi = 1$) case, for example, the standard deviation of consumption is 4.8%, four times the standard deviation in the no-indexation case. The persistence of consumption also declines at higher degrees of indexation. The autocorrelation of consumption in the full indexation case is 0.886, compared to 0.978 in the no-indexation case and the high of 0.984 in the case where $\phi = 0.10$. Not surprisingly, the ranking of welfare is in line with the ranking of consumption volatility, as the last row of Table 1.5 reveals. However, the absolute values of the differences in welfare are quite small.[15]

The above changes are driven by the changes in the ability to hedge income fluctuations with indexed bonds. This hedging ability is affected by the degree of indexation because the degree of indexation alter the incentives for precautionary savings. In particular, it has a significant effect on determining the state of nature that defines the "catastrophic" level of income at which household reach their natural debt limits. The natural debt limit (ψ) is the largest debt that the economy can support to guarantee non-negative consumption in the event that income remain at its catastrophic level almost surely, i.e.,

$$\psi = -\frac{(1-\varepsilon)y^T}{r}. \tag{1.11}$$

With non-indexed bonds, catastrophic level of income is realized at state of nature with the negative endowment shock. When the debt approaches to the natural debt limit, consumption approaches zero, which leads to infinitely negative utility. Hence, agents have strong incentives to avoid holding debt levels lower than natural debt limit. In order to guarantee positive consumption almost surely in the event that income remains at its catastrophic level, agents engage in strong precaution-

[15] As pointed out by Lucas (1987), welfare implications of altering consumption fluctuations in these type of models are quite low.

ary savings. An increase (decrease) in this debt limit strengthens (weakens) the incentives to save, since the level of debt that agents would try to avoid would be higher (lower). With indexation, the natural debt limit can be determined at either negative or positive realization of the endowment shock, depending on which yields the lower income (determines the catastrophic level of income). To see this, notice that using the budget constraint, when the shock is negative, we derive:

$$c_t \geq 0 \Rightarrow (1-\varepsilon)y - b_{t+1} + b_t(1+r-\phi\varepsilon) \geq 0 \Rightarrow \psi_L \geq -\frac{(1-\varepsilon)y}{r-\phi\varepsilon},\ if\ r-\phi\varepsilon > 0. \tag{1.12}$$

Notice that for the ranges of values of ϕ where $r - \phi\varepsilon < 0$, Equation 1.12 yields an upper bound for the bond holdings; i.e., $\psi_L \leq -\frac{(1-\varepsilon)y}{r-\phi\varepsilon}$). Hence, in this range, negative shock will not play any role in determining the natural debt limit. Again using the budget constraint, positive endowment shock implies the following natural debt limit:

$$c_t \geq 0 \Rightarrow (1+\varepsilon)y - b_{t+1} + b_t(1+r+\phi\varepsilon) \geq 0 \Rightarrow \psi_H \geq -\frac{(1+\varepsilon)y}{r+\phi\varepsilon}. \tag{1.13}$$

Combining these two equations, we get:

$$\psi = \begin{cases} \max\{-\frac{(1-\varepsilon)y}{r-\phi\varepsilon}, -\frac{(1+\varepsilon)y}{r+\phi\varepsilon}\},\ if\ \phi < r/\varepsilon \\ -\frac{(1+\varepsilon)y}{r+\phi\varepsilon},\ if\ \phi > r/\varepsilon. \end{cases} \tag{1.14}$$

Further algebra suggest that when $\frac{1-\varepsilon}{1+\varepsilon} < \frac{r-\phi\varepsilon}{r+\phi\varepsilon}$ or $\phi < r$, natural debt limit is determined at state of nature with a negative endowment shock and in this case, $\partial\psi/\partial\phi < 0$, i.e., increasing the degree of indexation decreases the natural debt limit or weakens the precautionary savings incentive. However if $\frac{1-\varepsilon}{1+\varepsilon} > \frac{r-\phi\varepsilon}{r+\phi\varepsilon}$ or $\phi > r$, $\partial\psi/\partial\phi > 0$, i.e., increasing the degree of indexation increases the natural debt limit or strengthens the precautionary savings incentive.

In Table 1.6, we numerically calculate these natural debt limits as functions of the degrees of indexation, along with the corresponding returns in both states ($R_t^i = 1 + r + \phi\varepsilon_t$) and confirm the analytical results derived above. When the degree of indexation is less than 0.0159, the natural debt limit is determined by the negative shock and decreases (i.e., the debt limit becomes looser) as we increase ϕ. When ϕ is greater than 0.0159, it is determined by the positive shock and increases (i.e., the debt limit becomes tighter) as we increase ϕ (we print the corresponding limits darker in the table). In the full-indexation case, for example, this debt limit is -20.09, whereas the corresponding value is -61.49 in the non-indexed case. In other words, in the full-indexation case, positive endowment shocks decrease the catastrophic level of income to one third of the value in the non-indexed case. This in turn sharply strengthen precautionary savings motive.

In order to understand the role of indexation on volatility of consumption, we perform a variance decomposition analysis. Higher indexation provides a better hedge to income fluctuations by increasing the covariance of the trade balance (tb $=b' - R_t^i$b) with income (since in good (bad) times agents pay more (less) to the rest of the world). However, higher indexation also increases the volatility of the trade balance. In order to pin down the effect of indexation on these variables, we perform a variance decomposition using the following identity:

$$var(c^T) = var(y^T) + var(tb) - 2cov(tb, y^T).$$

In Table 1.7, we present the corresponding values for the last two terms in the above equation for each of the indexation levels.[16] Clearly, both the variance of the trade balance and the covariance of the trade balance with income monotonically increase with the level of indexation. However, the term $var(tb) - 2cov(tb, y^T)$ fluctuates in the same direction as the volatility of consumption, suggesting that at high levels of indexation the rise in the variance of the trade balance offsets the improvement in the co-movement of the trade balance with income, i.e., the effect of increased fluctuation in interest rate dominates the effect of hedging provided by indexation. Hence, consumption becomes more volatile for higher degrees of indexation.

To sum up, when the degree of indexation is higher than a critical value (as with full-indexation), the precautionary savings motive is stronger and the volatility of consumption is higher than in the non-indexed case. These results arise because the natural debt limit is lower at higher levels of indexation and because the increased volatility in the trade balance far outweighs the improvement in the co-movement of the trade balance with income.

These results suggest that in order to improve macroeconomic variables, the indexation level should be low. When ϕ is lower than 0.25, agents can better hedge against fluctuations in endowment income than when ϕ is at higher levels. In this

[16] Since the endowment is not affected by changes in the indexation level, its variance is constant.

case, the precautionary savings motive is weaker, the volatility of consumption is smaller, and consumption is more persistent. When ϕ is in the $[0.10, 0.25]$ range, the correlation of consumption with income approaches zero and the autocorrelation of consumption nears unity. These values resemble the results that could be attained in the full-insurance scenario, and suggest that partial indexation is optimal.

The results using a frictionless one-sector model shed light on the debate about the indexation of public debt. Our findings in this section suggest that the hedge indexed bonds provide is imperfect and that indexation of the debt in a one-to-one fashion may not improve macroeconomic variables. However, partial indexation could prove beneficial by mimicking outcomes that would arise under full insurance.

1.3.2 Two Sector Model with Financial Frictions

When we introduce liability dollarization and a borrowing constraint, the DPP of the household's problem becomes:

$$\begin{aligned} V(b,\varepsilon) &= \max_{b'} \left\{ u(c) + (1+c)^{-\gamma} E\left[V(b',\varepsilon')\right] \right\} \quad s.t. \\ c^T &= (1+\varepsilon)y^T - b' + (1+\phi\varepsilon)Rb \\ c^N &= y^N \\ b' &\geq -\kappa\left[(1+\varepsilon)y^T + p^N y^N\right]. \end{aligned} \tag{1.15}$$

As in the previous one-sector model, the endogenous state space is given by $\mathcal{B} = \{b_1 < ... < b_{NB}\}$, and the exogenous Markov process is assumed to have two states: $\mathcal{E} = \{\varepsilon_L < \varepsilon_H\}$. Optimal decision rules, $b'(b,\varepsilon) : \mathcal{E} \times \mathcal{B} \rightarrow \mathcal{R}$, are obtained by solving the above DPP.

Solving the Model

We solve the stochastic simulations using value function iteration over a discrete state space in the [-2.5, 5.5] interval with 1,000 evenly spaced grid points. We derive this interval by solving the model repeatedly until the solution captures the ergodic distribution of bond holdings. The endowment shock has the same Markov properties described in the previous section. The solution procedure is similar to that in Mendoza (2002). We start with an initial conjecture for the value function and solve the model without imposing the borrowing constraint for each coordinate (b, ε) in the state space, and check whether the implied b' satisfies the borrowing constraint. If so, the solution is found and we calculate the implied value function that is then used as a conjecture for the next iteration. If not, we impose the borrowing constraint with equality and solve a system of non-linear equations defined by the three constraints given in the DPP (1.15) as well as the optimality condition given in Equation (1.7). Then, we calculate the implied value function using the optimal b', and iterate to convergence.

Calibration

We calibrate the model such that aggregates in the non-binding case match the certain aggregates of Turkish data. In addition to the parameters used in the frictionless one-sector model, we introduce the following parameters, the values of which we summarize in Table 1.2.: y^N is set to 1.3418, which implies a share of non-tradables output in line with the average ratio of the non-tradable output to tradable output in between 1987-2004 for Turkey; μ is set to 0.316, which is the value Ostry and Reinhart (1992) estimate for emerging countries; the steady state relative price of non-tradables is normalized to unity, which implies a value of 0.4027 for the CES share of tradable consumption (ω), calculated by using the condition that equates the marginal rate of substitution between tradables and non-tradables consumption to the relative price of non-tradables (Equation (1.7)). The elasticity of the subjective discount factor (γ) is recalculated including these new variables in the solution of the non-linear system of equations implied by the steady-state equilibrium conditions of the model given in Equation (1.9). κ is set to 0.3 (i.e. households can borrow up to 30% of their current income), which is found by solving the model repeatedly until the model matches the empirical regularities of a typical Sudden Stop episode at a state where the borrowing constraint binds with a positive probability in the long run.

Table 1.2: Parameter Values

μ	0.316	elasticity of substitution	Ostry and Reinhart (1992)
y^N/y^T	1.3418	share of NT output	Turkish data
p^N	1	relative price of NT	normalization
κ	0.3	constraint coefficient	set to match SS dynamics
ω	0.4027	CES weight	calibration
γ	0.0201	elasticity of discount factor	calibration

Simulation Results

The stochastic simulation results are divided into three sets. In the first set, which we refer to as the frictionless economy, the borrowing constraint never binds. In the second set of results, which we refer to as the constrained economy, the borrowing constraint occasionally binds and households can issue only non-indexed bonds. In the last set, which we refer to as the indexed economy, borrowing constraint occasionally binds but households can issue indexed bonds.

Our results that compare the frictionless and constrained economies are analogous of those presented by Mendoza (2002). Hence, here we just emphasize the results that are specific and crucial to the analysis of indexed bonds and refer the interested reader to Mendoza (2002) for further details. Since at equilibrium, the relative price of non-tradables is a convex function of the ratio of tradables consumption to non-tradables consumption, a decline in tradables consumption relative to non-tradables consumption due to a binding borrowing constraint leads to a decline in the relative price of non-tradables, which makes the constraint more binding and leads to a further decline in tradables consumption.

Figure 1.3 shows the ergodic distributions of bond holdings. The distribution in the frictionless economy is close to normal and symmetric around its mean. Mean bond holdings are -0.299, higher than the steady state bond holdings of -0.35; this reflects the precautionary savings motive that arises as a result of uncertainty and the incompleteness of financial markets. The distribution of bond holdings in the constrained economy is shifted right relative to that of the frictionless economy.

Mean bond holdings in the constrained economy are 0.244, which reflects a sharp strengthening in the precautionary savings motive due to the borrowing constraint.

Table 1.8 presents the long-run business cycle statistics for the simulations. Relative to the frictionless economy, the correlation of consumption with the tradables endowment is higher in the constrained economy. In line with this stronger co-movement, the persistence (autocorrelation) of consumption is lower in the constrained economy.

Behavior of the model can be divided into three ranges. In the first range, debt is sufficiently low that the constraint is not binding. In this case, the response of the constrained economy to a negative endowment shock is similar to that of the frictionless economy, and a negative endowment shock is smoothed by a widening in the current account deficit as a share of GDP. There is also a range of bond holdings in which debt levels are too high. In this range, the constraint always binds regardless of the endowment shock. However, at more realistic debt levels where the constraint only binds when the economy suffers a negative shock, the model with non-indexed bonds roughly matches the empirical regularities of Sudden Stops. This range, which we call the "Sudden Stop region" following Mendoza and Smith (2005), corresponds to the 218-230th grid points.

In Figure 1.4, we plot the conditional forecasting functions of the frictionless and constrained economies for tradables consumption, aggregate consumption, the relative prices of non-tradables, and the current account-GDP ratios, in response to a one-standard deviation endowment shock. These forecasting functions are conditional on the 229th bond grid, which is one of the Sudden Stop states and has a *long-run probability* of 0.47%, and they are calculated as responses of these variables as percentage deviations from the long-run means of their frictionless counterparts.[17]

As these graphs suggest, the response of the constrained economy is dramatic. The endowment shock results in a 4.1% decline in tradable consumption. That compares to a decline of only 0.9% in the frictionless economy. In line with the larger collapse in the tradables consumption, the responses of aggregate consumption and the relative price of non-tradables are more dramatic in the constrained economy than in the frictionless economy. While households in the frictionless economy are able to absorb the shock via adjustments in the current account (the current account deficit slips to 1.4% of GDP), households in the constrained economy cannot due to the binding borrowing constraint (the current account shows a surplus of 0.02% of GDP). These figures also suggest that the effects of Sudden Stops are persistent. It takes more than 40 quarters for these variables to converge back to their long-run means.

Figures 1.5, 1.6, and 1.7 compare the detrended conditional forecasting functions of the constrained economy with that of the indexed economy to illustrate how indexed bonds can help smooth Sudden Stop dynamics (the degrees of indexation are provided on the graphs).[18] As Figure 1.5 suggests, when the degree of indexation is 0.05, indexed bonds provide little improvement over the constrained case; indeed, the difference in the forecasting functions is not visible. When indexation reaches 0.10, however, the improvements are minor yet noticeable. At this degree of

[17]Bond holdings on this grid point are equal to -0.674, which implies a debt-to-GDP ratio of 30%.

[18]These forecasting functions are detrended by taking the differences relative to the frictionless case.

indexation, aggregate consumption rises 0.11%, tradables consumption rises 0.24%, the relative price of non-tradables increases 0.30%.

With increases in the degree of indexation to 0.25 and 0.45, the initial effects are relatively small. Figure 1.6 suggests that the improvements in tradables consumption are close to 1% and 1.8% when the degrees of indexation are 0.25 and 0.45, respectively. Figure 1.7 suggests that when the degree of indexation gets higher, 0.7 and 1.0 for example, tradables consumption and aggregate consumption fall below the constrained case after the fourth quarter and stay below for more than 30 quarters despite the initially small effects of a negative endowment shock. In other words, degrees of indexation higher than 0.45 in an indexed economy imply more pronounced detrimental Sudden Stop effects than in a constrained economy.

Table 1.9 summarizes the initial effects of both a negative and a positive shock conditional on the same grid points used in the forecasting functions. When indexed bonds are in place, our results suggest that if the degree of indexation is within [0.05, 0.25], indexed bonds help to smooth the effects of Sudden Stops. As Table 1.9 suggests, when the degree of indexation is 0.05, indexed bonds provide little improvement. As we increase the degree of indexation, the initial impact of a negative endowment shock on key variables gets smaller. In this case, debt relief accompanies a negative endowment shock, and this relief helps to reduce the initial impact of a binding borrowing constraint. Hence, the depreciation in the relative price of non-tradables is milder, which in turn prevents the Fisherian debt-deflation.

Table 1.9 also suggests that although the smallest initial impact of a negative endowment shock occurs when the degree of indexation is unity (full-indexation), this level of indexation has significant adverse effects if a positive shock realizes. In this case, households must pay a significantly higher interest rate over and above the risk-free rate. Although the constrained economy is not vulnerable to a Sudden Stop when there is a positive endowment shock, agents in such an economy face a Sudden Stop due to a sudden jump in debt servicing costs.

Hence, our analysis suggests that household face a tradeoff when they engage in debt contracts with high degrees of indexation. If the households are hit by a negative endowment shock, highly indexed bonds can allow them to absorb the shock without suffering severely in terms of consumption. Such a shock might trigger a Sudden Stop if households were to borrow instead via non-indexed bonds (the initial effects are closest to the frictionless case when the degree of indexation is one). However, if they receive a positive endowment shock, the initial effects are larger in the indexed economy (where the degree of indexation equals 1) than in the constrained economy (e.g., the impact on tradable consumption jumps from -1.1% to -6.7%). Analyzing the results in columns 3-9, we conclude that degrees of indexation in the [0.45, 1.0] interval lead to stronger Sudden Stop effects. If we take the average of initial responses across the high and the low states in this range of values, we find that the minimum of these averages is attained when the degree of indexation is 0.25, which suggests that households with concave utility functions would attain a higher utility with this consumption profile than ones achieved with indexation levels higher than 0.25.

In Figure 1.8, we plot the time series simulations of the frictionless, constrained, and indexed economies. These simulations are derived first by generating a random exogenous endowment shock process using the transition matrix, $\mathcal{P}$, and then by feeding these series into each of the respective economies. On the top left graph, the dotted line is the tradable consumption series for the frictionless economy. The solid line is the series for the constrained economy. As the graphs reveal, although patterns of consumption in each economy mostly move together, there are cases (around periods 2000, 3600, 6500, 8800), where we observe sharp declines in constrained economy. These declines correspond to Sudden Stop episodes. In these cases, a consecutive series of negative endowment shocks make the constraint binding, which in turn triggers a debt-deflation that ultimately leads to a collapse in consumption.

When the return is indexed and the degree of indexation is 0.05 (top right graph), the volatility of consumption is noticeably lower than in the constrained case, and collapses in consumption during Sudden Stop episodes are milder. When we increase the degree of indexation to 0.45, however, there is a significant increase in the volatility of consumption, and there are more frequent collapses. When the degree of indexation is 1.0 (due to space limitations, we leave out the figures associated with other degrees of indexation), we observe a spike in volatility and much more frequent and sizeable collapses in consumption. These simulations illustrate that when indexation is full, the effect on consumption can be significantly negative, furthermore that indexation can yield benefits in terms of consumption volatility only if the degree of indexation is quite low.

Table 1.8 suggests that in addition to the tradeoff of gains in the low state versus losses in the high state, there is also a short run versus long run tradeoff with respect to issuing indexed bonds with high degrees of indexation. With higher indexation levels, indexed bonds can generate substantial short-run benefits, but also introduce more severe adverse effects in the long run; i.e., consumption volatility and its co-movement with income increase with greater degrees of indexation. Consistent with our findings in the frictionless one-sector model, the value of indexation that minimizes the co-movement of consumption with GDP and yields more persistent consumption is low (in the range of [0.05, 0.1] for this calibration). These results also suggest that, depending on the objectives, the optimal degree of indexation level may vary. As we illustrated before, the level of indexation that would minimize the effect of Sudden Stops is in the [0.25, 0.45] interval, whereas the one that minimizes long-run fluctuations is in the [0.05, 0.1] range. However, regardless of whether we would like to smooth Sudden Stops or long-run fluctuations, full-indexation is undesirable.

1.3.3 Sensitivity Analysis

This section presents the results of analysis aimed at evaluating the robustness of our results to several variations in model parameterization. Due to space limitations, for the first three sensitivity analysis we present result of the the frictionless one-sector model. These results are summarized in Table 1.10.

We first analyze the robustness of the results to changes in the number of exogenous state variables. For this analysis, we use a seven-state Markov chain that maintains the same autocorrelation and standard deviation of the shock as in the previous setup. Note that the simple persistence rule can be employed only if the number of exogenous state variables is two. In order to create the transition matrix with seven exogenous states, we employ the method described in Tauchen and Hussey (1991). The first block in Table 1.10 presents key long-run statistics, which are nearly identical to the ones presented in Table 1.5; in fact, for a given indexation level, the statistics are the same out to two decimal points. Hence, we conclude that our results are robust to the number of state variables used in the Markov process.

Second, we increase the standard deviation of the exogenous endowment shock to 4.5%. As Table 1.10 suggests, when bonds are not indexed, the precautionary savings motive is stronger, consumption is more volatile, and consumption displays greater correlation with income when we increase variation in the magnitude of the exogenous endowment shock. Comparing Table 1.10 with Table 1.5 for the indexed case, we conclude that the optimal indexation level that minimizes long-run macroeconomic fluctuations is in the [0.05, 0.1] interval in the former case, whereas it is in the [0.1, 0.25] interval in the latter one. In other words, the optimal degree of indexation decreases with increases in the volatility of the exogenous endowment shock.

Next, we evaluate the changes in results that arise when we lower the autocorrelation of the endowment shock. Compared to the baseline results given in Table 1.5, with an endowment shock autocorrelation of 0.4, agents engage in less precautionary savings. Furthermore, consumption volatility and its co-movement with income are lower. When indexed bonds are in place, the lower the persistence of the shock, the higher the degree of indexation that would minimize the co-movement of consumption with income. For instance, when the indexation is 0.1, the correlation of consumption with income is 0.07 when the autocorrelation of the shock is 0.4. By comparison, at the same indexation level, the correlation of consumption with income is 0.017 when the autocorrelation is 0.524.

As a final robustness check, we examine the effect of having a larger non-tradables sector. The results are summarized in Table 1.11. We set the y^N/y^T ratio to 1.6, which implies that the degree of openness of the country is lower than in the baseline case. Not surprisingly, the model in this case captures the empirical regularities of an economy with less financial integration. In particular, consumption is more volatile than in the baseline case (for instance, the volatility of the tradables consumption in the frictionless economy increases to 1.6%, compared to the baseline value of 1.5%), and the co-movement of consumption with income is stronger (the correlation of tradables consumption with income in the frictionless economy increases to 0.75 from the baseline value of 0.69). When we compare the initial responses of each of these economies to a one-standard-deviation endowment shock, the response of the constrained economy with a higher share of non-tradable output is stronger than that of the one with baseline parameters, which suggests that the debt-deflation process is more severe in the former economy. This result is consistent with the empirical evidence on the relationship between the degree of openness and the severity of Sudden Stops (see Calvo et al. (2003)). In order to compare the optimal indexation levels across different parameterizations, we compare the average responses of these economies in the high and the low states to a one-standard-deviation endowment shock. These results suggest that the minimum average response is attained when the degree of indexation is 0.25, which is the same degree of indexation in the baseline results. However, this result depends on the coarseness of the indexation intervals with which we are solving the problem. Economic intuition suggests that lower financial integration would require higher indexation levels to smooth exogenous shocks better.

The sensitivity analysis presented in this section suggests that the optimal indexation level depends on the properties of the exogenous shock, including its persistence and its volatility. Hence, the optimal degree of indexation needs to be country specific, since it is highly likely that each emerging country receives shocks with different statistical properties.The findings of this chapter suggest that while indexed bonds might aid many countries in averting or at least mitigating the effects of Sudden Stops in emerging markets, an indexation level appropriate for one country might not be optimal for another.

1.4 Conclusion

Recent policy proposals argue that indexing the debt of emerging markets could help prevent the sudden reversals of capital inflows accompanied by real exchange rate devaluations that were typical of the emerging market crises of the last decade. This chapter explores the quantitative implications of this policy in a DSGE model. Debt is denominated in units of tradables, and international lenders impose a borrowing constraint that limits debt to a fraction of national income. The benchmark model with non-indexed bonds and credit constraints features Sudden Stops as an equilibrium outcome that results from a debt-deflation process, the feedback mechanism between liability dollarization and the borrowing constraint that operates through the relative price of non-tradables.

We conducted our quantitative experiments to evaluate the effects of indexed bonds in two steps. First, we studied the effects of bonds indexed to output in a canonical one-sector small open economy model with varying degrees of indexation. We found that the introduction of indexed bonds partially completes the insurance market in such an economy, and whether they help to reduce precautionary savings, the volatility of consumption, and the correlation of consumption with income depends on the degree of indexation of the bond. When this degree is higher than a critical threshold (as with the full indexation for example), indexation can, in fact, make agents worse off. Because increase in the variance of trade balance (due to higher interest rate fluctuations) outweighed the improvement in the covariance of trade balance with income, which then led to higher volatility of consumption; and natural debt limits became tighter, which then led to an increase in precautionary savings.

In the second step, we analyzed the role of indexed bonds in smoothing Sudden Stops and RER fluctuations. We found that indexed bonds can reduce the initial capital outflow in the event of an exogenous shock that otherwise trigger a Sudden Stop in an economy with only non-indexed bonds. Indexed bonds can in turn reduce the depreciation in the RER and break the Fisherian debt-deflation mechanism. However, once again, the benefit of these bonds depends critically on the degree of indexation. When the level of indexation is lower than a critical value, indexed bonds weaken Sudden Stops. If indexation is higher than this critical value, although indexed bonds can provide some temporary relief in the event of a negative shock, the initial improvement is short lived. Moreover, in the event of a positive shock, the economy is vulnerable to a Sudden Stop even though such a shock would never trigger a Sudden Stop in an economy in which household facing borrowing constraints can only issue non-indexed bonds. Because in this case, positive shock commands higher repayment, which increases the need for larger borrowing, this in turn can make the borrowing constraint suddenly binding, and triggering a debt-deflation.

To conclude, bonds on which the return is indexed in a one-to-one fashion (i.e., full-indexation) will not necessarily provide benefits to emerging countries. However, indexed bonds with optimal degree of indexation can help these countries smooth Sudden Stops. This optimal value depends on the persistence and the volatility of the exogenous shocks a given country experiences, as well as the size of the country's non-tradables sector relative to the its tradables sector (i.e., the openness of the country). Hence, in terms of policy implications, our analysis reveals that the degree of indexation is a key variable that should optimally be chosen in order to smooth Sudden Stops, and furthermore that this value should be country specific.

In our analysis, we assumed that investors are risk-neutral and that indexing debt repayments would not require them to obtain more country specific information. It may be the case that indexed returns may affect investors' incentives to collect more country specific information. The implications of introducing risk-averse investors or informational costs in a dynamic setup are left for future research. The model can also be used to explore the implications of indexation to relative price of non-tradables, or to CPI, but it is left for further research. Analyzing if trading in option or futures markets can help emerging countries for mitigating Sudden Stops is an avenue of research. This would require a richer model, and it is left for further research, as well. Another avenue for future research could be analyzing the implications of indexed bonds on default probabilities. In order to carry out such an analysis, indexed bonds could be introduced into "willingness to pay" models such as those of Eaton and Gersovitz (1980) and Arellano (2004).

Table 1.3: Previous Attempts of Indexed Bonds

	Date Issued	Indexation Clause	Note
Argentina	1972-1989	CPI	
Australia	1985-1988	CPI	
Bosnia and Herzegovina	1990s	GDP	Issued as part of Brady Plan, VRRs
Brazil	1964-	CPI	
Bulgaria	1990s	GDP	Issued as part of Brady Plan, VRRs
Colombia	1967-	CPI	
Costa Rica	1990s	GDP	Issued as part of Brady Plan, VRRs
Chile	1956-	CPI	
Israel	1955-	CPI	
France	1973	Gold	Debt servicing cost increased significantly due to depreciation of French Franc against gold
	1970s	Oil	Petro-bonos
Mexico	1990s	Oil	Issued as part of Brady Plan, VRRs
	1989-	CPI	
Turkey	1994-	CPI	
UK	1975-	CPI	
Venezuela	1990s	Oil	Issued as part of Brady Plan, VRRs

Sources: Borensztein and Mauro (2004), Campell and Shiller (1996), Kopcke and Kimball(1999), Atta-Mensah (2004).

Table 1.4: Business Cycle Facts for Emerging Countries

Variable:x	$\sigma(x)$	$\sigma(x)/\sigma(Y)$	$\rho(x)$	$\rho(x,Y)$	Sudden Stop	Sudden Stop relative to std.
Argentina					2002:1-2	
GDP (Y)	4.022	1.000	0.865	1.000	-12.952	3.220
tradables GDP	4.560	1.134	0.667	0.923	-15.100	3.311
nontradables GDP	3.977	0.989	0.894	0.990	-12.169	3.060
consumption	4.475	1.113	0.830	0.975	-17.063	3.813
real exchange rate	15.189	3.777	0.754	0.454	-48.177	3.172
CA/Y	0.916	0.228	0.837	-0.802	1.353	1.476
Chile					1998:4-1999:1	
GDP (Y)	2.093	1.000	0.731	1.000	-4.492	2.147
tradables GDP	1.833	0.876	0.473	0.762	-5.068	2.764
nontradables GDP	2.520	1.204	0.796	0.961	-4.840	1.921
consumption	4.184	1.999	0.748	0.898	-8.410	2.010
real exchange rate	0.007	0.003	0.649	0.372	-0.019	2.578
CA/Y	3.302	1.578	0.352	-0.512	10.932	3.311
Mexico					1994:4-1995:1	
GDP (Y)	2.261	1.000	0.799	1.000	-7.440	3.290
tradables GDP	2.682	1.186	0.712	0.921	-8.976	3.347
nontradables GDP	2.189	0.968	0.832	0.978	-6.178	2.822
consumption	4.222	1.867	0.841	0.973	-11.200	2.653
real exchange rate	8.627	3.816	0.726	0.599	-32.844	3.807
CA/Y	0.698	0.309	0.831	-0.475	2.220	3.180
Turkey					1994:1-2	
GDP (Y)	3.695	1.000	0.667	1.000	-10.383	2.001
tradables GDP	3.511	0.950	0.524	0.962	-10.925	3.112
nontradables GDP	4.021	1.088	0.680	0.982	-10.007	2.489
consumption	4.134	1.119	0.746	0.919	-10.098	2.443
real exchange rate	9.110	2.465	0.675	0.602	-31.630	3.472
CA/Y	2.744	0.743	0.633	-0.591	9.704	3.375

Source: Argentinean Ministry of Finance (MECON), Bank of Chile, Bank of Mexico, Central Bank of Turkey, International Financial Statistics. The data cover periods 1993:Q1-2004:Q4 for Argentina, 1986:Q1-2001:Q3 for Chile, 1987:Q1-2004:Q4 for Mexico, 1987:Q1-2004:Q4 for Turkey. Data are quarterly seasonally adjusted real series. GDP and consumption data are logged and filtered using an HP filter with a smoothing parameter 1600. Real exchange rates are calculated using the IMF definition ($RER_i = NER_i \times CPI_i/CPI_{US}$ for country i).

Table 1.5: Long Run Business Cycle Statistics of the One-Sector Model

	Degree of Indexation (ϕ)								
	0.00	0.015	0.02	0.05	0.10	0.25	0.45	0.70	1.0
$E(b)$	-0.328	-0.349	-0.355	-0.385	-0.428	-0.042	0.522	1.458	2.026
$\sigma(cons)$	1.243	1.242	1.240	1.236	1.209	1.474	2.119	3.291	4.731
$\sigma(tb/y)$	3.486	3.516	3.527	3.590	3.674	4.211	4.820	5.724	6.755
$\rho(cons, y)$	0.186	0.160	0.151	0.097	0.017	-0.311	-0.409	-0.381	-0.304
$\rho(tb/y, y)$	0.936	0.937	0.937	0.939	0.945	0.943	0.916	0.849	0.752
$\rho(cons)$	0.978	0.980	0.980	0.981	0.984	0.909	0.870	0.876	0.886
$\rho(tb/y)$	0.549	0.549	0.548	0.546	0.541	0.542	0.562	0.601	0.646
$welfare$	n.a.	0.0025	0.0034	0.0090	0.0146	-0.0032	-0.0092	-0.0120	-0.0136

Note: Standard deviations are in percent of the mean. Welfare gains are in percent and relative to the non-indexed model.

Table 1.6: Returns and Natural Debt Limits

	Degree of Indexation (ϕ)								
	0.00	0.01	0.015	0.05	0.10	0.25	0.45	0.70	1.0
$R^i(L)$	1.016	1.016	1.015	1.014	1.012	1.007	1.000	0.991	0.981
$R^i(H)$	1.016	1.016	1.016	1.018	1.019	1.025	1.032	1.040	1.051
$NDL(L)$	**-61.487**	**-62.182**	**-62.894**	-68.503	-78.431	-138.754	5440.508	106.131	48.760
$NDL(H)$	-64.517	-63.819	-63.136	**-58.642**	**-53.262**	**-41.767**	**-32.434**	**-25.353**	**-20.089**

Note: First two rows are the corresponding gross returns in each states. In the last two rows, the implied natural debt limits are printed bolder.

Table 1.7: Variance Decomposition Analysis for Consumption

	Degree of Indexation (ϕ)								
	0.00	0.015	0.02	0.05	0.10	0.25	0.45	0.70	1.0
$\sigma(cons)$	1.243	1.242	1.240	1.236	1.209	1.474	2.119	3.291	4.731
$var(tb)$	12.241	12.463	12.540	13.008	13.638	17.707	22.903	31.959	44.788
$cov(tb, y)$	11.508	11.620	11.660	11.897	12.248	13.929	15.365	16.724	17.364
$var(tb)$ $-2cov(tb, y)$	-10.775	-10.777	-10.781	-10.792	-10.857	-10.147	-7.827	-1.488	10.061

Table 1.8: Long Run Business Cycle Statistics of the Two-Sector Model

	Degree of Indexation (ϕ)							
	F	C	0.05	0.10	0.25	0.45	0.70	1.0
$E(b)$	-0.299	0.244	0.122	0.276	0.594	1.599	2.328	2.516
$\sigma(c^T)$	1.530	1.268	1.251	1.389	1.851	2.835	3.914	5.266
$\sigma(c)$	0.775	0.638	0.631	0.697	0.923	1.392	1.889	2.508
$\sigma(p^N)$	2.026	1.682	1.660	1.845	2.467	3.804	5.291	7.162
$\sigma(tb/y)$	1.534	1.467	1.491	1.610	1.799	2.113	2.398	2.755
$\rho(c^T, y)$	0.687	0.663	0.636	0.567	0.609	0.773	0.875	0.930
$\rho(c, y)$	0.687	0.664	0.637	0.567	0.608	0.770	0.870	0.924
$\rho(p^N, y)$	0.687	0.663	0.636	0.567	0.609	0.774	0.877	0.933
$\rho(tb/y, y)$	0.512	0.648	0.646	0.548	0.290	-0.141	-0.404	-0.580
$\rho(c^T)$	0.986	0.971	0.976	0.967	0.953	0.926	0.911	0.907
$\rho(c)$	0.986	0.971	0.976	0.967	0.953	0.925	0.909	0.903
$\rho(p^N)$	0.986	0.971	0.976	0.967	0.953	0.927	0.912	0.909
$\rho(tb/y)$	0.581	0.546	0.540	0.546	0.572	0.609	0.631	0.661

Note: The first column is the frictionless economy, the second column is the constrained economy, and the rest of the columns are for the economy with borrowing constraint and indexed bonds (with given degrees of indexation). Standard Deviations are in percent.

Table 1.9: Initial Responses to a One-Standard-Deviation Endowment Shock

	Non-Indexed		Degree of Indexation (ϕ)					
	F	C	0.05	0.10	0.25	0.45	0.70	1.0
A) Negative Shock								
tradable consumption	-0.907	-4.126	-4.007	-3.888	-3.531	-3.056	-1.657	-1.748
aggregate consumption	-0.384	-1.780	-1.728	-1.676	-1.520	-1.312	-0.706	-0.745
relative price of non-tradables	-1.197	-5.398	-5.244	-5.090	-4.626	-4.007	-2.179	-2.299
B) Positive Shock								
tradable consumption	-0.291	-1.095	-2.019	-2.138	-2.494	-2.970	-4.369	-6.691
aggregate consumption	-0.120	-0.464	-0.862	-0.913	-1.068	-1.275	-1.887	-2.919
relative price of non-tradables	-0.387	-1.444	-2.653	-2.808	-3.274	-3.895	-5.714	-8.716

Note: The first column is the frictionless economy, the second column is the constrained economy, and the rest of the columns are for the economy with borrowing constraint and indexed bonds (with given degrees of indexation). Initial responses are calculated as percentage deviations relative to the long-run mean of the frictionless economy.

Table 1.10: Sensitivity Analysis of the One-Sector Model

	Degree of Indexation (ϕ)								
	0.00	0.015	0.02	0.05	0.10	0.25	0.45	0.70	1.0
I. seven-state markov chain									
$E(b)$	-0.320	-0.345	-0.351	-0.369	-0.371	-0.083	0.548	1.459	1.968
$\sigma(cons)$	1.246	1.245	1.244	1.243	1.258	1.487	2.147	3.319	4.776
$\rho(cons, y)$	0.182	0.154	0.144	0.079	0.031	-0.301	-0.410	-0.378	-0.293
$\rho(cons)$	0.970	0.971	0.971	0.974	0.982	0.906	0.869	0.870	0.869
II. σ_ε=0.045									
$E(b)$	-0.315	-0.335	-0.343	-0.359	-0.295	-0.017	0.908	1.741	2.064
$\sigma(cons)$	1.567	1.566	1.566	1.560	1.576	1.919	2.899	4.372	6.226
$\rho(cons, y)$	0.208	0.173	0.160	0.085	-0.046	-0.270	-0.357	-0.307	-0.230
$\rho(cons)$	0.983	0.987	0.988	0.991	0.974	0.927	0.892	0.893	0.898
III. ρ_ε=0.4									
$E(b)$	-0.335	-0.357	-0.361	-0.398	-0.477	-0.300	0.180	0.918	1.637
$\sigma(cons)$	1.074	1.069	1.068	1.060	1.034	1.202	1.462	2.229	3.351
$\rho(cons, y)$	0.178	0.157	0.152	0.112	0.070	-0.167	-0.361	-0.367	-0.301
$\rho(cons)$	0.966	0.968	0.969	0.970	0.975	0.944	0.865	0.865	0.885

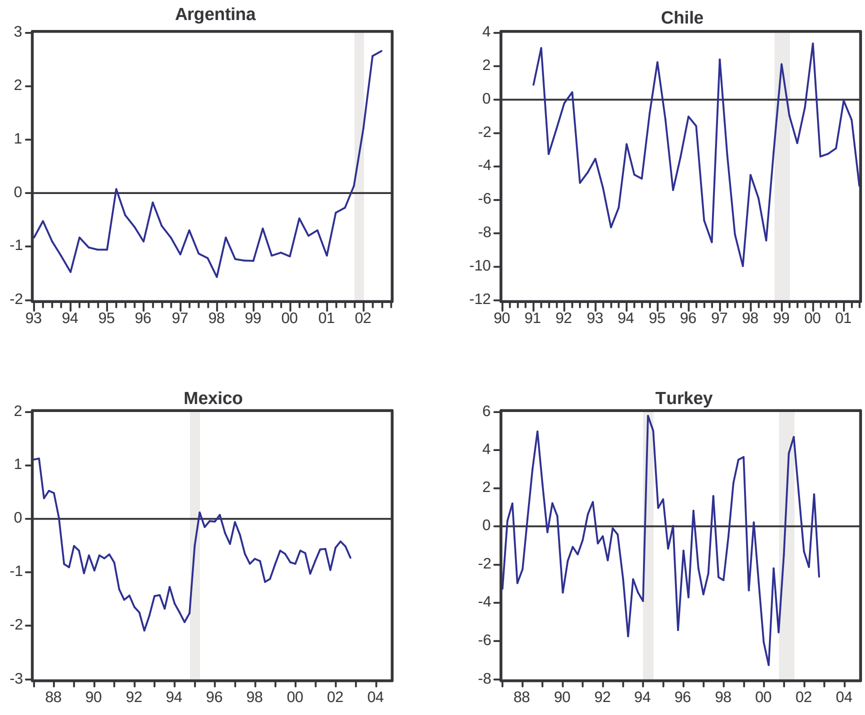
Note: Resulting transition matrix for seven-state markov chain is approximated using the method described in Tauchen and Hussey (1991). Standard deviations are in percent.

Table 1.11: Sensitivity Analysis of the Two-Sector Model: Higher Share of Non-tradable Output

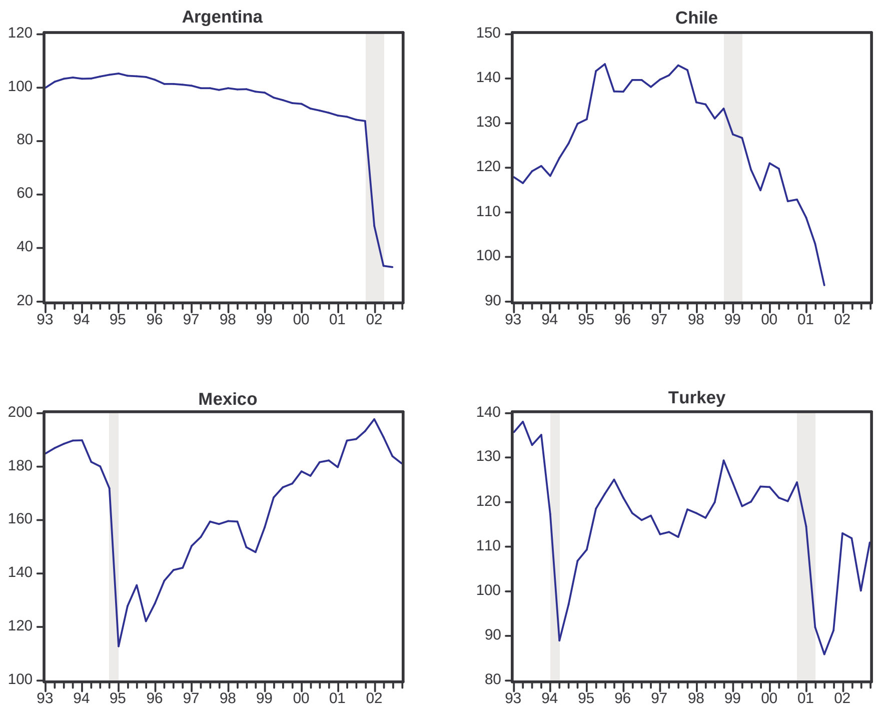
	Degree of Indexation (ϕ)							
	F	C	0.05	0.10	0.25	0.45	0.70	1.0
I. Long run statistics								
$E(b)$	-0.290	0.258	0.084	0.682	0.667	1.739	2.399	2.551
$\sigma(c^T)$	1.590	1.306	1.261	1.639	1.957	2.919	3.956	5.300
$\sigma(c)$	0.822	0.671	0.649	0.836	0.994	1.457	1.941	2.565
$\sigma(p^N)$	2.105	1.734	1.672	2.182	2.609	3.920	5.351	7.211
$\rho(c^T, y)$	0.749	0.716	0.691	0.664	0.714	0.844	0.913	0.951
$\rho(c, y)$	0.750	0.718	0.692	0.664	0.713	0.841	0.908	0.945
$\rho(p^N, y)$	0.749	0.716	0.691	0.664	0.714	0.845	0.915	0.953
$\rho(c^T)$	0.987	0.975	0.975	0.973	0.956	0.931	0.914	0.909
$\rho(c)$	0.987	0.976	0.976	0.974	0.956	0.930	0.911	0.905
$\rho(p^N)$	0.987	0.975	0.975	0.973	0.957	0.932	0.915	0.911
II. Initial Responses								
A) Negative Shock								
tradable consumption	-1.036	-4.254	-4.122	-3.991	-3.596	-3.070	-1.608	-1.623
aggregate consumption	-0.395	-1.655	-1.603	-1.551	-1.395	-1.187	-0.616	-0.622
relative price of non-tradables	-1.366	-5.565	-5.395	-5.224	-4.711	-4.025	-2.115	-2.135
B) Positive Shock								
tradable consumption	-0.420	-2.029	-2.156	-2.292	-2.686	-3.213	-4.675	-7.074
aggregate consumption	-0.157	-0.780	-0.818	-0.883	-1.037	-1.244	-1.823	-2.788
relative price of non-tradables	-0.557	-2.666	-2.985	-3.010	-3.525	-4.211	-6.111	-9.208

Notes: y^N/y^T ratio is set to 1.6 in this analysis. Standard deviations are in percent of the mean. The first column is the frictionless economy, the second column is the constrained economy, and the rest of the columns are for the economy with borrowing constraint and indexed bonds (with given degrees of indexation).

Figure 1.1: Sudden Stops in Emerging Markets

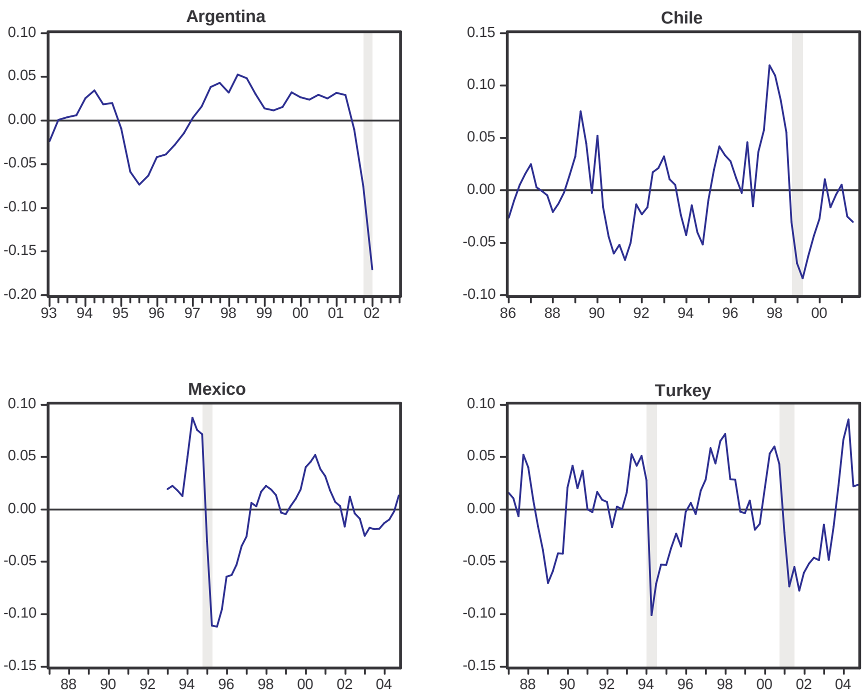


a. Current Account-GDP Ratio

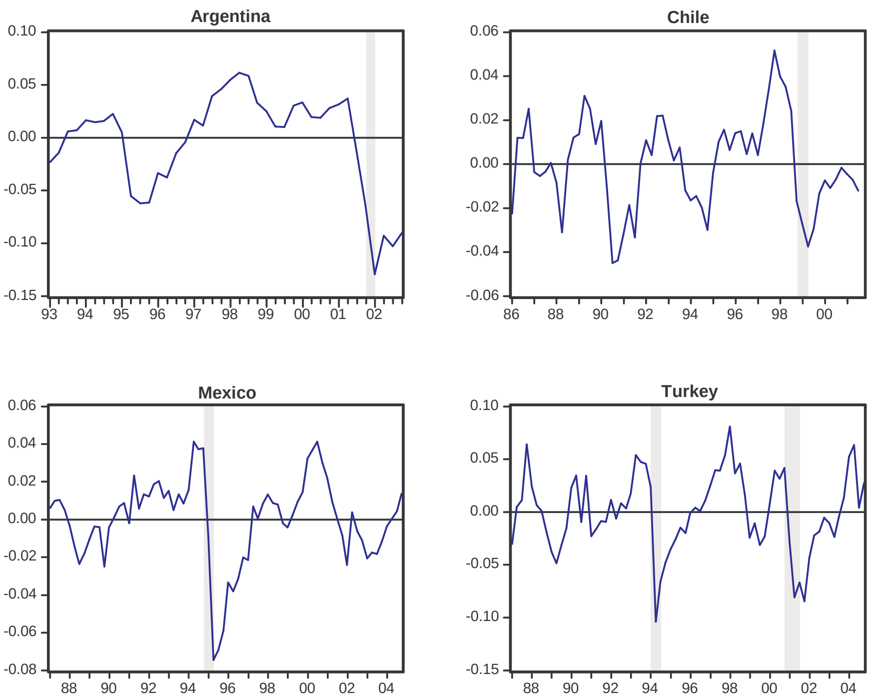


b. Real Exchange Rate

Figure 1.2: Deviations from Trend in Consumption and Ouput



a. Consumption



b. Output

Figure 1.3: Long Run Distributions of Bond Holdings in Non-Indexed Economies

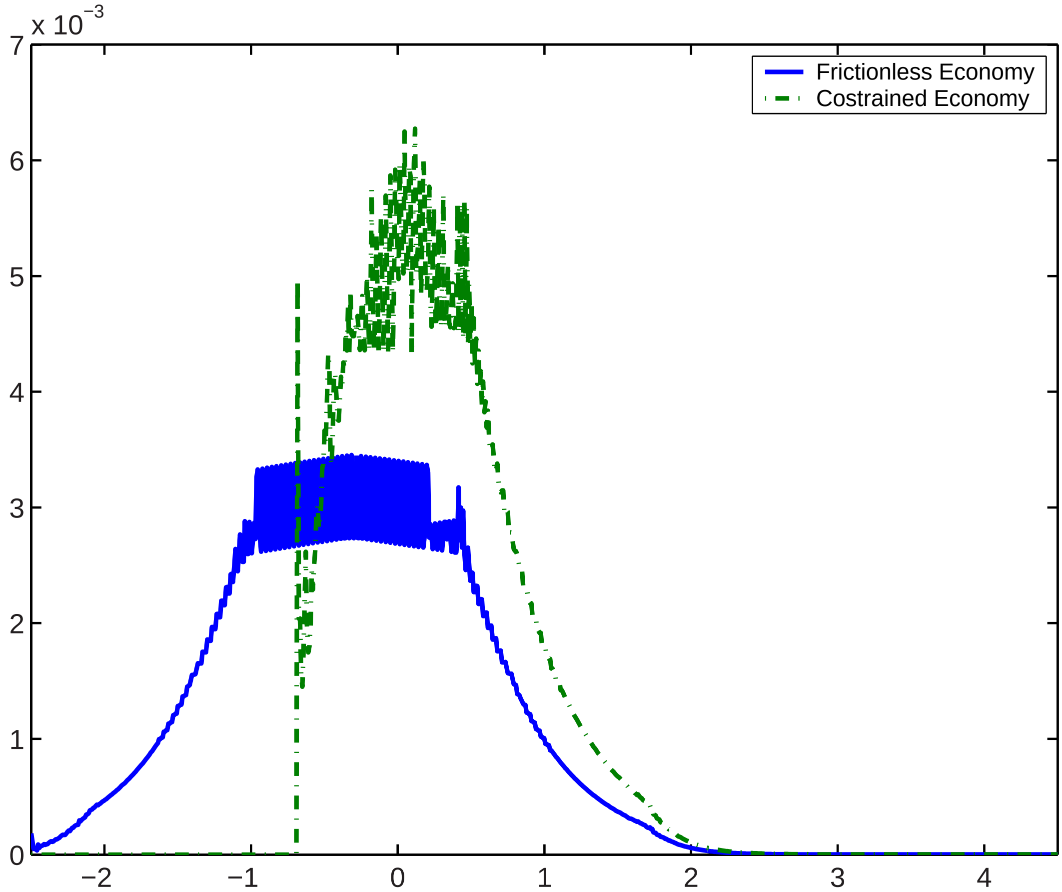
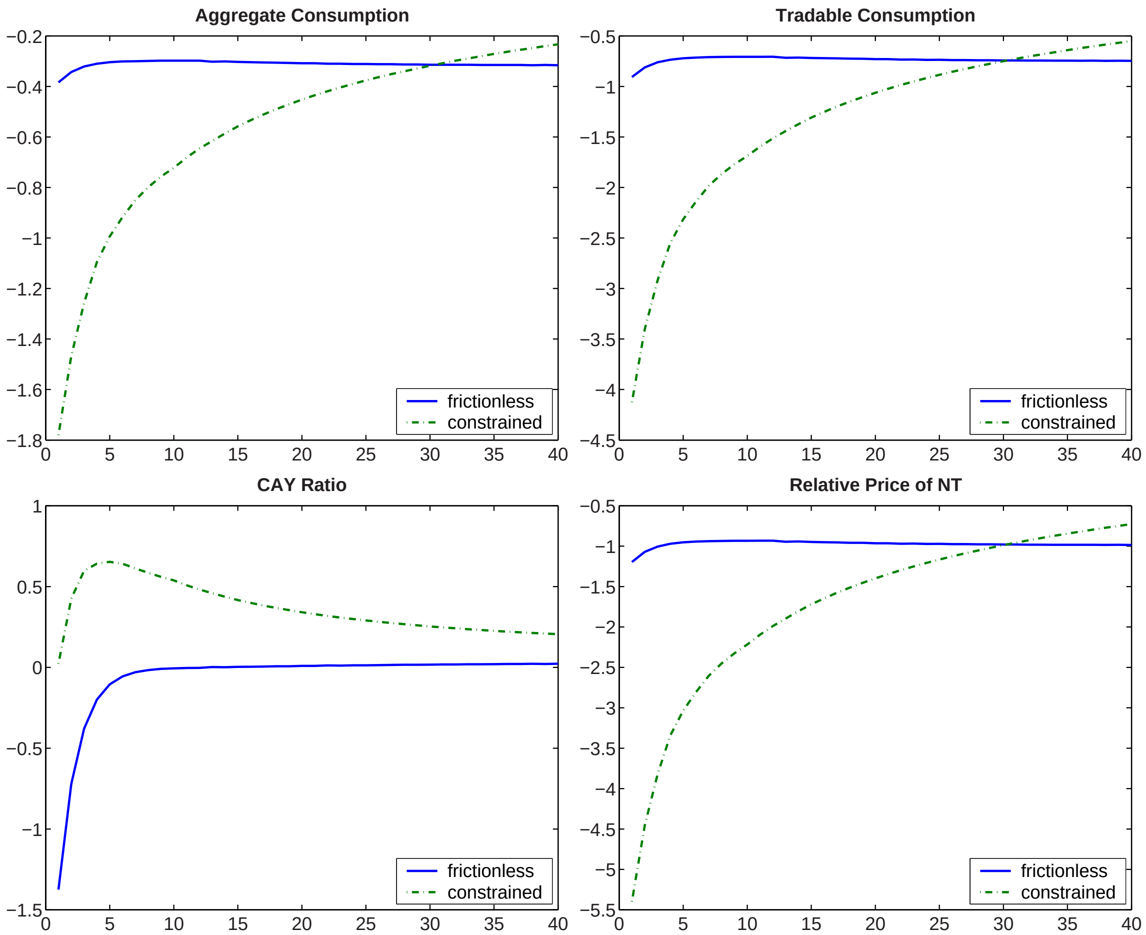
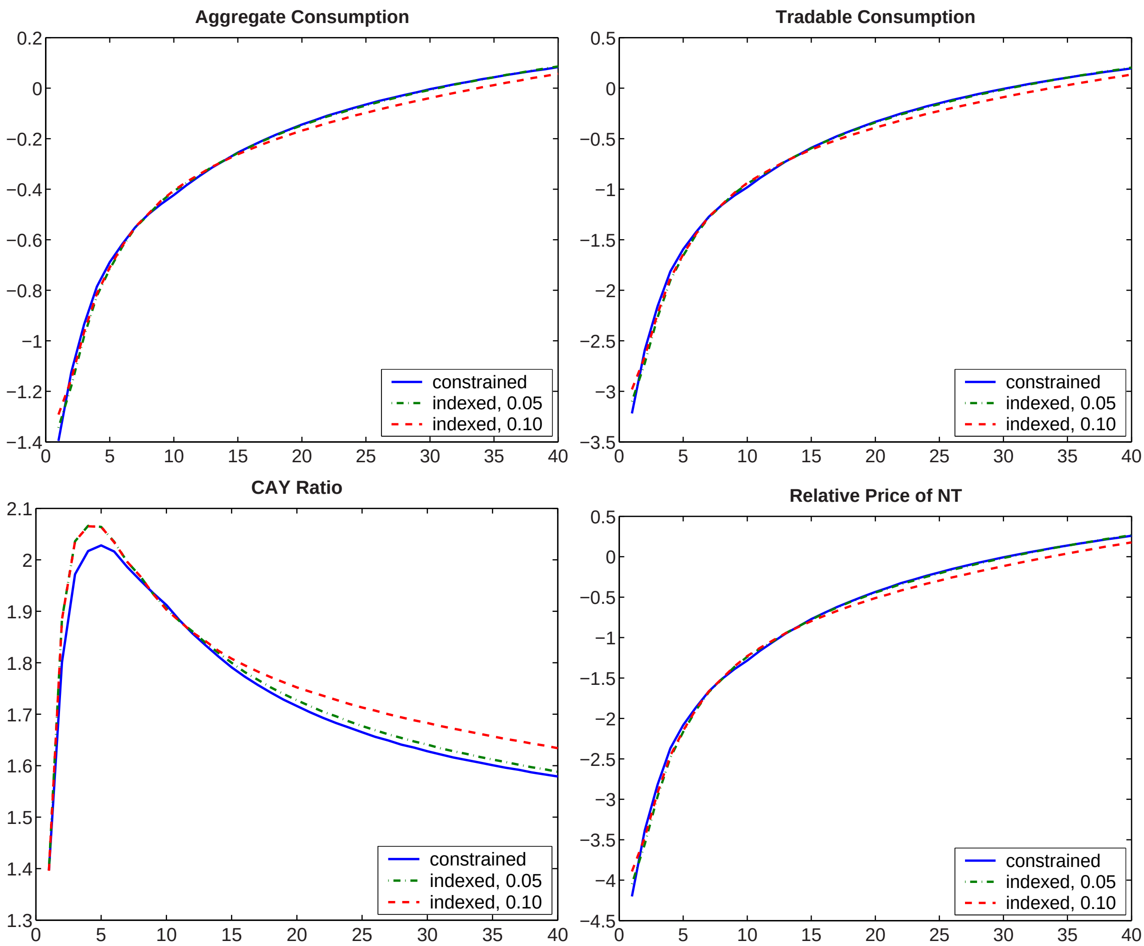


Figure 1.4: Conditional Forecasting Functions in Response to a One-Standard-Deviation Negative Endowment Shock



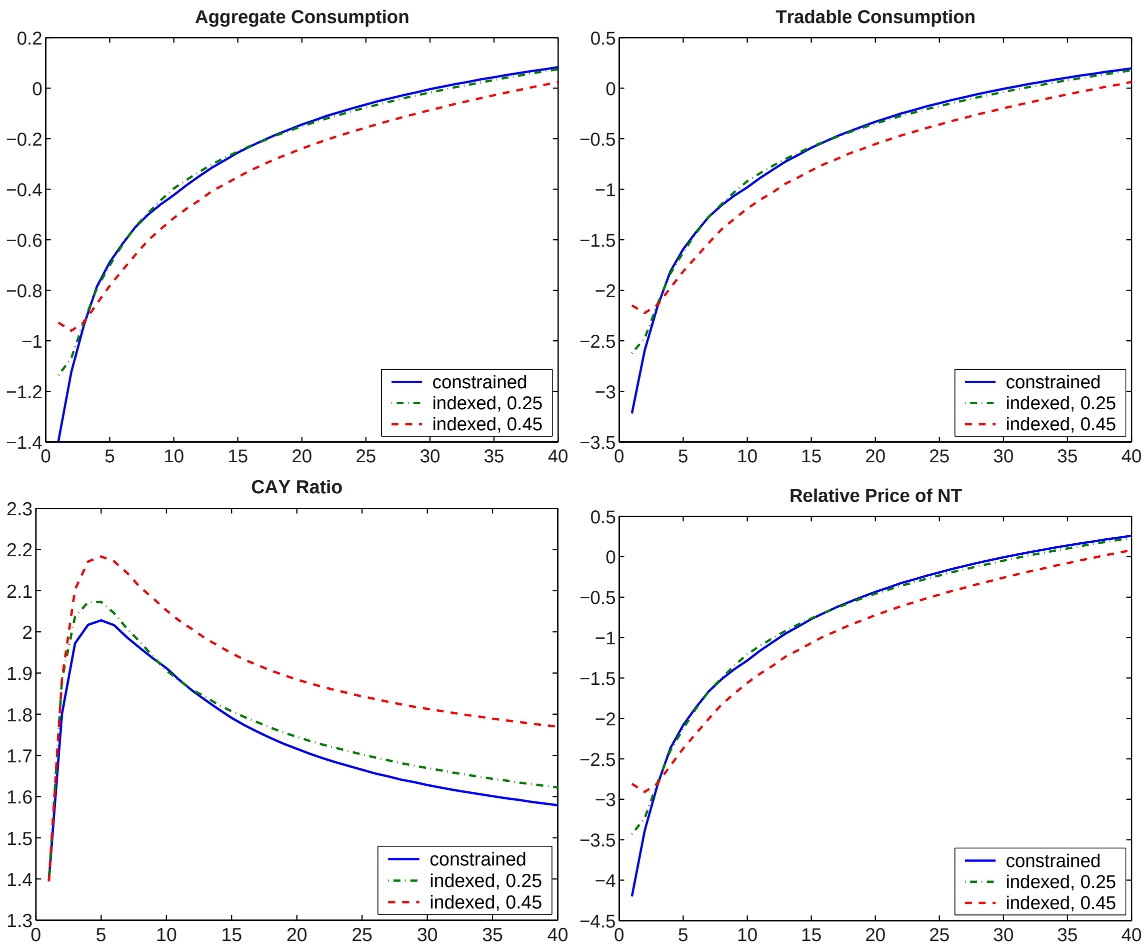
Note: Forecasting functions are conditional on the 229th grid point of the bond holdings, which implies a debt-to-GDP ratio of 30%. Solid and dashed lines are forecasting functions of the frictionless, and constrained economies, respectively.

Figure 1.5: Conditional Forecasting Functions in Response to a One-Standard-Deviation Negative Endowment Shock



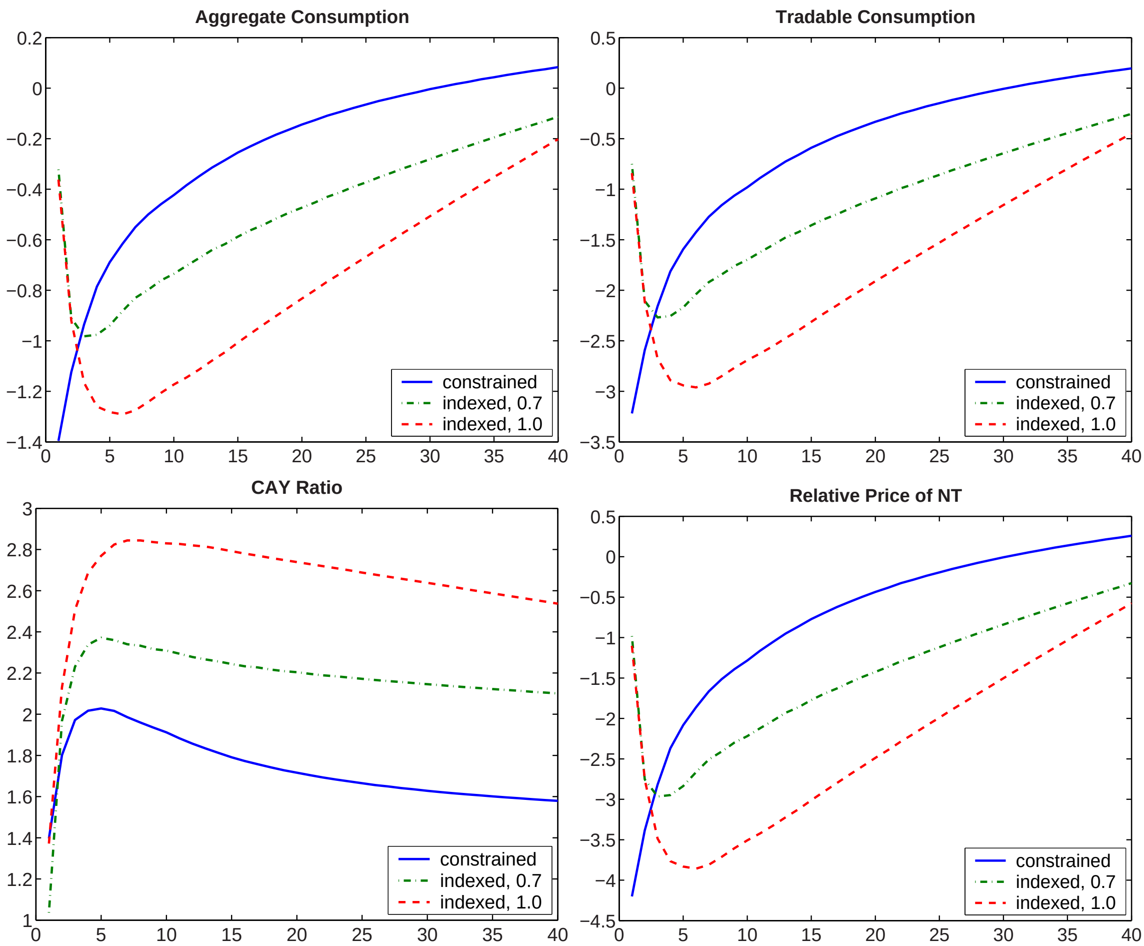
Note: Forecasting functions are conditional on the 229th grid point of the bond holdings, which implies a debt-to-GDP ratio of 30%.

Figure 1.6: Conditional Forecasting Functions in Response to a One-Standard-Deviation Negative Endowment Shock



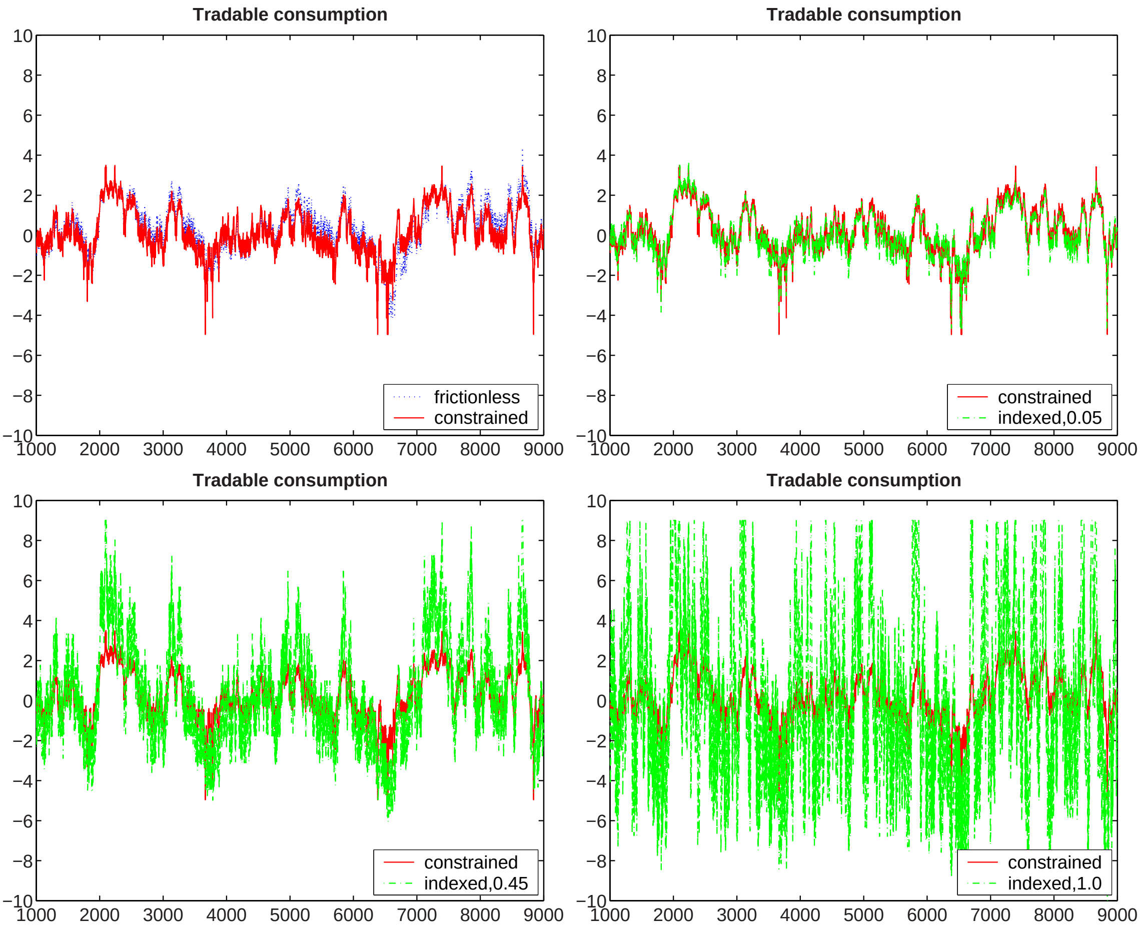
Note: Forecasting functions are conditional on the 229th grid point of the bond holdings, which implies a debt-to-GDP ratio of 30%.

Figure 1.7: Conditional Forecasting Functions in Response to a One-Standard-Deviation Negative Endowment Shock



Note: Forecasting functions are conditional on the 229th grid point of the bond holdings, which implies a debt-to-GDP ratio of 30%.

Figure 1.8: Time Series Simulation



Note: Consumptions are in percentage deviations from their corresponding means. The first 1,000 periods have been excluded from these graphs to focus on the data which are independent of initial conditions.

Chapter 2

Are Asset Price Guarantees Useful for Preventing Sudden Stops?: A Quantitative Investigation of the Globalization Hazard-Moral Hazard Tradeoff (coauthored with Enrique G. Mendoza)

2.1 Introduction

The Sudden Stop phenomenon of emerging markets crises is characterized by three stylized facts: sudden reversals of capital inflows and current account deficits, collapses in output and private absorption, and large relative price corrections in domestic goods prices and asset prices. A large fraction of the literature on this subject is based on a hypothesis that Calvo (2002) labeled "globalization hazard." According to this hypothesis, world capital markets are inherently imperfect, and hence prone to display contagion and overreaction in asset positions and prices relative to levels consistent with "fundamentals" (see Arellano and Mendoza (2003) for a short survey of this literature). This argument suggests that an international financial organization (IFO) could help prevent Sudden Stops by offering global investors ex-ante price guarantees on the emerging-markets asset class. Calvo proposed an arrangement for implementing this policy and compared it with other arrangements that favor ex-post guarantees (including the IMF's Contingent Credit Line and Lerrick and Meltzer's (2003) proposal).

Ex-ante price guarantees aim to create an environment in which asset prices can be credibly expected to remain above the crash levels that trigger Sudden Stops driven by globalization hazard. Calvo views this facility as akin to an open-markets operation facility: it would exchange a liquid, riskless asset (e.g., U.S. T-bills) for an index of emerging markets assets whenever the value of the index falls by a certain amount, and would re-purchase the riskless asset when the index recovers. Market participants would consider in their expectations that these guarantees would be executed if a systemic fire sale makes asset prices crash, and hence the guarantees could rule out rational expectations equilibria in which Sudden Stops occur. If globalization hazard is the only cause of Sudden Stops, and if the support of the probability distribution of the shocks that causes them is known (i.e., if there are no truly "unexpected" shocks), the facility would rarely trade.

A potentially important drawback of ex-ante price guarantees is that they introduce moral hazard incentives for global investors. Everything else the same, the introduction of the guarantees increases the foreign investors' demand for emerging markets assets, since the downside risk of holding these assets is transferred to the IFO providing the guarantees. This can be a serious drawback because a similar international moral hazard argument has been forcefully put forward as an alternative explanation of Sudden Stops (see the Meltzer Commission report and Lerrick and Meltzer (2003)).[1] Proponents of this view argue that Sudden Stops are induced by excessive indebtedness of emerging economies driven by the expectation of global investors that IFOs will bail out countries in financial difficulties. Based

[1]Part of the literature on Sudden Stops focuses on domestic moral hazard problems caused by government guarantees offered to domestic agents (see, for example, Krugman (2000)). This chapter focuses instead on Sudden Stops triggered by globalization hazard, and on the tradeoff between this hazard and the international moral hazard created by offering price guarantees to global investors.

on this premise, Lerrick and Meltzer proposed the use of ex-post price guarantees to be offered by an IFO to anchor the orderly resolution of a default once it has been announced and agreed to with the IFO. The IFO would determine the crash price of the asset in default and would require the country to commit to re-purchase the asset at its crash price (making the arrangement credible by committing the IFO to buy the asset at a negligible discount below the crash price if the country were unable to buy it).

The tensions between the globalization hazard and moral hazard hypotheses, and their alternative proposals for using price guarantees, reflect an important tradeoff that ex-ante price guarantees create. On one hand, ex-ante price guarantees could endow IFOs with an effective tool to prevent and manage Sudden Stops driven by globalization hazard. On the other hand, ex-ante guarantees could end up making matters worse by strengthening international moral hazard (even if it were true that globalization hazard was the only cause of Sudden Stops in the past).

The goal of this chapter is to study the globalization hazard-moral hazard tradeoff from the perspective of the quantitative predictions of a dynamic, stochastic general equilibrium model of asset pricing and current account dynamics. The model is based on the globalization hazard setup of Mendoza and Smith (2004). This chapter adds to their framework an IFO that offers ex-ante guarantees to foreign investors on the asset prices of an emerging economy. We are interested in particular in studying how the guarantees affect asset positions, asset price volatility, business cycle dynamics, and the magnitude of Sudden Stops.

Asset price guarantees have not received much attention in quantitative equilibrium asset pricing theory, with the notable exception of the work by Ljungqvist (2000), and these guarantees have yet to be introduced into the research program dealing with quantitative models of Sudden Stops. The theoretical literature and several policy documents on Sudden Stops have examined various aspects of the globalization hazard and international moral hazard hypotheses separately. From this perspective, one contribution of this chapter is that it studies the interaction between these two hypotheses in a unified dynamic equilibrium framework.

The two financial frictions that we borrow from Mendoza and Smith (2004) to construct a model in which globalization hazard causes Sudden Stops are: (a) a margin constraint on foreign borrowing faced by the agents of an emerging economy, and (b) asset trading costs incurred by foreign securities firms specialized in trading the equity of the emerging economy.[2] These frictions are intended to represent the collateral constraints and informational frictions that have been widely studied in the Sudden Stops literature (see, for example, Calvo (1998), Izquierdo (2000), Calvo and Mendoza (2000a, 2000b), Caballero and Krishnamurty (2001), and Mendoza (2004)).

The model introduces asset price guarantees in the form of ex-ante guarantees offered to foreign investors on the liquidation price (or equivalently, on the return) of the emerging economy's assets. Thus, these guarantees are akin to a "put option" with minimum return. An IFO offers these guarantees and finances them with a lump-sum tax on foreign investors' profits. Hence, forward-looking equity prices

[2]These two frictions are modeled following the closed-economy analysis of Aiyagari and Gertler (1999).

reflect the effects of margin constraints, trading costs and ex-ante price guarantees. The setup of the price guarantees is similar to the one proposed in Ljungqvist's (2000) closed-economy, representative-agent analysis, but framed in the context of what is effectively a two-agent equilibrium asset-pricing model with frictions.

Price guarantees have different implications depending on the level at which they are set. If they are set so low that they are never executed, globalization hazard dominates and the model yields the same Sudden Stop outcomes of the Mendoza-Smith model. If they are set so high that they are always executed, the model yields equilibria highly distorted by international moral hazard. Hence, the interesting range for studying the globalization hazard-moral hazard tradeoff lies between these two extremes. The quantitative analysis shows that guarantees set slightly above the model's "fundamentals" price (by 1/2 to 1 percent) contain the Sudden Stop effects of globalization hazard and virtually eliminate the probability of margin calls in the stochastic steady state. If the guarantee is non-state-contingent, however, the guarantee is executed often (with a long-run probability of about 1/3) and the model predicts persistent overvaluation of asset prices above the prices obtained in a frictionless environment. A guaranteed price set at the same level but offered only at high levels of external debt is executed much less often (with a long run probability below 1/100) and it is equally effective at containing Sudden Stops without inducing persistent asset overvaluation.

Analysis of the normative implications of the model shows that, when the elasticity of foreign demand for domestic assets is high, the guarantees improve domestic welfare measured from initial conditions at a Sudden Stop state, with negligible changes in long-run welfare levels. At the same time, the value of foreign traders' firms measured in a Sudden Stop state falls slightly, while their long-run average rises sharply. In this case the balance tilts in favor of using price guarantees to contain globalization hazard. On the other hand, when the elasticity of foreign demand for domestic assets is low, higher price guarantees are needed to prevent Sudden Stops, and as a result large moral hazard distortions reduce domestic welfare gains at Sudden Stop states and enlarge average welfare losses in the stochastic steady state. In this case, price guarantees can be a misleading policy instrument that yields a short-term improvement in macroeconomic indicators and welfare at the expense of a long-term welfare loss.

The chapter is organized as follows. Section 2.2 presents the model and characterizes the competitive equilibrium in the presence of margin constraints, trading costs and ex-ante price guarantees. Section 2.3 studies key properties of this equilibrium that illustrate the nature of the globalization hazard-moral hazard tradeoff. Section 2.4 represents the model's competitive equilibrium in a recursive form suitable for quantitative analysis and examines a set of baseline results. Section 2.5 conducts normative and sensitivity analyses. Section 2.6 concludes.

2.2 A Model of Globalization Hazard and Price Guarantees

Consider a small open economy (SOE) inhabited by a representative household that rents out labor and a time-invariant stock of capital to a representative firm. Households can trade the equity of this firm with a representative foreign securities firm specialized in trading the economy's equity, and can also access a global credit market of one-period bonds. In addition, an IFO operates a facility that guarantees a minimum sale price to foreign traders on their sales of the emerging economy's equity. Dividend payments on the emerging economy's equity are stochastic and vary in response to exogenous productivity shocks. Markets of contingent claims are incomplete because trading equity and bonds does not allow domestic households to fully hedge domestic income uncertainty, and the credit market is imperfect because of margin constraints and trading costs.

2.2.1 The Emerging Economy

The representative firm inside the SOE produces a tradable commodity by combining labor (n) and a time-invariant stock of physical capital (k) using a Cobb-Douglas technology: $\exp(\varepsilon_t)F(k,n)$, where ε_t is a Markov productivity shock. This firm participates in competitive factor and goods markets taking the real wage (w) as given. Thus, the choice of labor input consistent with profit maximization yields standard marginal productivity conditions for labor demand and the rate of dividend payments (d):

$$w_t = \exp(\varepsilon_t)F_n(k,n_t) \tag{2.1}$$

$$d_t = \exp(\varepsilon_t)F_k(k,n_t) \tag{2.2}$$

Households choose stochastic sequences of consumption (c), labor supply (n), equity holdings (α), and foreign bond holdings (b) so as to maximize the following utility function:

$$U(c,n) = E_0 \left[\sum_{t=0}^{\infty} \exp\left\{ -\sum_{\tau=0}^{t-1} \nu(c_\tau - h(n_\tau)) \right\} u(c_t - h(n_t)) \right] \tag{2.3}$$

This utility function is a time-recursive, intertemporal utility index with an endogenous rate of time preference that introduces an "impatience effect" on the marginal utility of consumption (i.e., changes in ct alter the subjective discount rate applied to future utility flows). Utility functions with this feature are commonly used in small open economy models to obtain well-defined long-run equilibria for holdings of foreign assets.[3] As Section 2.3 shows, in models with credit constraints these preferences are also critical for supporting long-run equilibria in which credit constraints can bind.

The period utility function $u(\cdot)$ is a standard, concave, twice-continuously differentiable utility function. The function $\nu(\cdot)$ is the time preference function, which is also concave and twice-continuously differentiable. The argument of both functions is a composite good defined by consumption minus the disutility of labor $c - h(n)$, where $h(\cdot)$ is an increasing, convex, continuously-differentiable function. Greenwood, Hercowitz and Huffman (1988), GHH, introduced this composite good as a way to eliminate the wealth effect on labor supply. As in Mendoza and Smith (2004), this property of preferences, together with conditions (2.1) and (2.2), separates the determination of equilibrium wages, dividends, labor and output from the equilibrium allocations of consumption, saving and portfolio choice.

[3] See Arellano and Mendoza (2003) for further details on this issue.

The household maximizes lifetime utility subject to the following budget constraint:

$$c_t = \alpha_t k d_t + w_t n_t + q_t(\alpha_t - \alpha_{t+1})k - b_{t+1} + b_t R \tag{2.4}$$

where α_t and α_{t+1} are beginning- and end-of-period shares of capital owned by households, q_t is the price of equity, and R is the world real interest rate (which is kept constant for simplicity).

Foreign debt contracts feature a collateral constraint in the form of a margin clause that limits the debt not to exceed the fraction κ of the market value of the SOE's equity holdings:

$$b_{t+1} \geq \; -\kappa q_t \alpha_{t+1} k, \quad 0 \leq \kappa \leq 1 \tag{2.5}$$

Margin clauses of this form are widely used in international capital markets. In some instances they are imposed by regulators with the aim of limiting the exposure of financial intermediaries to idiosyncratic risk in lending portfolios, but they are also widely used by investment banks and other lenders to manage default risk (either in the form of explicit margin clauses attached to specific securities offered as collateral, or as implicit margin requirements linked to the volatility of returns of an asset class like those implied by value-at-risk collateralization). Margin clauses are a particularly effective collateral constraint (compared to the classic constraint of Kiyotaki and Moore (1997) that limits debt to the discounted liquidation value of assets one period ahead) because: (a) custody of the securities offered as collateral is surrendered at the time the credit contract is entered and (b) margin calls to make up for shortfalls in the market value of the collateral are automatic once the value of the securities falls below the contracted value.

Households in the small open economy also face a short-selling constraint in the equity market: $\alpha_{t+1} \geq \chi$ with $-\infty < \chi < 1$ for all t. This constraint is necessary in order to make the margin constraint non-trivial. Otherwise, any borrowing limit in the bond market implied by a binding margin constraint could always be undone by taking a sufficiently short equity position.

2.2.2 The Foreign Securities Firm, the IFO & the Price Guarantees

The representative foreign securities firm obtains funds from international investors and specializes in investing them in the SOE's equity. This firm maximizes its net present value discounted at the discount factor of its international clients (i.e., the world interest rate). Thus, the foreign traders' problem is to choose α^*_{t+1}, for $t = 1, ..., \infty$, so as to maximize:

$$\begin{aligned} D &= E_0 \left[\sum_{t=0}^{\infty} R^{-t} \pi_t \right], \\ \pi_t &\equiv k \left[\alpha^*_t d_t - \left(q_t \alpha^*_{t+1} - \max(q_t, \tilde{q}_t) \alpha^*_t \right) - q_t \left(\frac{a}{2} \right) \left(\alpha^*_{t+1} - \alpha^*_t + \theta \right)^2 - T^*_t \right]. \end{aligned} \tag{2.6}$$

The total net return of the foreign securities firm (π_t) is the sum of: (a) dividend earnings on current equity holdings ($k\alpha^*_t d_t$), minus (b) the value of equity trades, which is the difference between equity purchases $q_t k \alpha^*_{t+1}$ and equity sales $\max(q_t, \tilde{q}_t) k \alpha^*_t$ executed at either the market price q_t or the guaranteed price $\tilde{q}_t$, whichever is greater, minus (c) trading costs, which include a term that depends on the size of trades $(\alpha^*_{t+1} - \alpha^*_t)$ and a recurrent trading cost $(theta)$, minus (d) lump sum taxes paid to the IFO (kT^*_t). Trading costs are specified in quadratic form, so a is a standard adjustment-cost coefficient.

The IFO buys equity from the foreign traders at the guaranteed price and sells it at the equilibrium price. Thus, the IFO's budget constraint is:

$$T^*_t = \max(0, (\tilde{q}_t - q_t)\alpha^*_t) \tag{2.7}$$

If the guarantee is not executed, the tax is zero. If the guarantee is executed, the IFO sets the lump-sum tax to match the value of the executed guarantee (i.e., the extra income that foreign traders earn by selling equity to the IFO instead of selling it in the equity market). Since the return on equity is $R^q_t \equiv [d_t + q_t]/q_t - 1$, the IFO's offer to guarantee the date-t price implies a guaranteed return on the emerging economy's equity $\tilde{R}^q_T = [\tilde{q} + d_t]/q_{t-1}$.

2.2.3 Equilibrium

A competitive equilibrium is given by stochastic sequences of prices and allocations such that: (a) households maximize the utility function (2.3) subject to the constraints (2.4) and (2.5) and the short-selling constraint, taking prices, wages and dividends as given, (b) domestic firms maximize profits so that equations (2.1) and (2.2) hold, taking wages and dividends as given, (c) foreign traders maximize (2.6) taking the price of equity, the price guarantees and lump-sum taxes as given, (d) the budget constraint of the IFO in equation (2.7), holds and (e) the equity market clears (i.e., $\alpha_t + \alpha_t^* = 1$ for all t).

2.3 Characterizing the Globalization Hazard-Moral Hazard Tradeoff

The tradeoff between the globalization hazard introduced by the distortions that margin constraints and trading costs create and the moral hazard introduced by distortions due to price guarantees can be illustrated with the optimality conditions of the competitive equilibrium. Consider the first-order conditions of the domestic household's maximization problem:

$$U_c(c,n) = \lambda_t \tag{2.8}$$

$$h'(n_t) = w_t \tag{2.9}$$

$$q_t(\lambda_t - \eta_t \kappa) = E_t[\lambda t + 1(d_{t+1} + q_{t+1})] + \upsilon_t \tag{2.10}$$

$$\lambda_t - \eta_t = E_t[\lambda_{t+1} R] \tag{2.11}$$

$U_c(c,n)$ is the derivative of the SCU function with respect to c_t (which includes the impatience effect), and λ_t, η_t and υ_t are the Lagrange multipliers on the budget constraint, the margin constraint, and the short-selling constraint respectively.

Condition (2.8) has the standard interpretation: at equilibrium, the marginal utility of wealth equals the lifetime marginal utility of consumption. Condition (2.9) equates the marginal disutility of labor with the real wage. This is the case because the GHH composite good implies that the marginal rate of substitution between c_t and n_t is equal to the marginal disutility of labor $h'(n_t)$, and thus is independent of c_t. It follows from this result that condition (2.9) together with (2.1) and (2.2) determine the equilibrium values of n_t, w_t and d_t as well as the equilibrium level of output. These "supply-side" solutions are independent of the dynamics of consumption, saving, portfolio choices and equity prices, and are therefore also independent of the distortions induced by financial frictions and price guarantees. This result simplifies significantly the numerical solution of the model. Mendoza (2004) studies the implications of margin constraints in a small-open-economy model with endogenous investment in which financial frictions affect dividends, investment and the Tobin Q, but abstracting from international equity trading.

Conditions (2.10) and (2.11) are Euler equations for the accumulation of equity and bonds respectively. As in Mendoza and Smith (2004), these conditions can be combined to derive expressions for the forward solution of equity prices and the excess return on equity from the perspective of the emerging economy. The forward solution for equity prices is:

$$q_t = E_t \left(\sum_{i=0}^{\infty} \left[\prod_{j=0}^{i} \left(1 - \frac{\eta_{j+1}}{\lambda_{j+1}} \kappa \right)^{-1} \right] M_{t+1+i} d_{t+1+i} \right) \tag{2.12}$$

where $M_{t+1+i} \equiv \lambda_{t+1+i}/\lambda_t$, for $i = 0, ..., \infty$, is the marginal rate of substitution between c_{t+1+i} and c_t. The excess return on domestic equity is:

$$E_t \left[R^q_{t+1} \right] - R = \frac{\eta_t (1-\kappa) - \frac{\upsilon_t}{q_t} - COV_t(\lambda_{t+1}, R^q_{t+1})}{E_t[\lambda_{t+1}]} \tag{2.13}$$

Given these results, the forward solution for equity prices can also be expressed as:

$$q_t = E_t \left(\sum_{i=0}^{\infty} \left[\prod_{j=0}^{i} \left(R^q_{t+1+j} \right)^{-1} \right] d_{t+1+i} \right) \tag{2.14}$$

Expressions (2.12)-(3.14) show the direct and indirect effects of margin calls on domestic demand for equity and excess returns. The direct effect of a date-t margin call is represented by the term $\eta_t(1-\kappa)$ in (2.13), or the term $\eta_t\kappa$ in (2.12): When a margin call occurs, domestic agents "fire sale" equity in order to meet the call and satisfy the borrowing constraint. Everything else the same, this effect lowers the date-t equity price and increases the expected excess return for t+1. The indirect effect of the margin call is reflected in the fact that a binding borrowing limit makes "more negative" the co-variance between the marginal utility of consumption and the rate of return on equity (since a binding borrowing limit hampers the households' ability to smooth consumption). These direct and indirect effects increase the rate at which future dividends are discounted in the domestic agents' valuation of asset prices, and thus reduce their demand for equity. Interestingly, the date-t equity price along the domestic agents' demand curve is reduced by a margin constraint that is binding at date t or by any expected binding margin constraint in the future. As a result, equity prices and the domestic demand for equity can be distorted by the margin requirements even in periods in which the constraint does not bind.

In a world with frictionless asset markets, domestic agents facing margin calls could sell assets in a perfectly-competitive market in which the world demand for the emerging economy's assets is infinitely elastic at the level of the fundamentals price. Margin calls would trigger portfolio reallocation effects without any price movements. However, in the presence of frictions that make the world demand for the emerging economy's assets less than infinitely elastic, the equilibrium asset price falls. Since households were already facing margin calls at the initial price, this price decline tightens further the margin constraint triggering a new round of margin calls. This downward spiral in equity prices is a variant of Fisher's (1933) debt-deflation mechanism, which magnifies the direct and indirect effects of the margin constraint.

The foreign demand for the emerging economy's assets is less than infinitely elastic because of the trading costs that foreign traders pay. Define the fundamentals price as the conditional expected value of dividends discounted at the world interest rate $q_t^f \equiv E_t\left(\sum_{i=0}^{\infty} R^{-(t+1+i)} d_{t+1+i}\right)$. The first-order condition for the optimization problem of foreign traders implies then:

$$\left(\alpha_{t+1}^* - \alpha_t^*\right) = \frac{1}{a}\left(\frac{q_t^f}{q_t} - 1 + \frac{E_t\left[\sum_{i=1}^{\infty} R^{-(t+i)}\left(\max(q_{t+i}, \tilde{q}_{t+i}) - q_{t+i}\right)\right]}{q_t}\right) - \theta \quad (2.15)$$

The foreign traders' demand for the emerging economy's assets is an increasing function of: (a) the percent deviation of qt f relative to qt (with an elasticity equal to $1/a$) and (b) the expected present discounted value of the "excess prices" induced by the price guarantees in percent of today's equity price. The first effect reflects the influence of the per-trade trading costs. If $a = 0$ and there are no price guarantees, the foreign traders' demand function is infinitely elastic at q^f. The second effect is the international moral hazard effect of the guarantees, which acts as a demand shifter on the foreign traders' demand function. Foreign traders that expect price guarantees to be executed at any time in the future have a higher demand for domestic assets at date t than they would in a market without guarantees. The recurrent trading costs are also a demand shifter (the foreign traders' demand function is lower the higher is θ).

In light of the previous results, the tradeoff between globalization hazard and international moral hazard can be summarized as follows. Suppose the date-t asset price in a market without margin constraints and without price guarantees is determined at the intersection of the domestic agents' and foreign traders' demand curves (HH and FF respectively) at point A in Figure 2.1.

The demand function of foreign traders is simply equation (2.15), shown in Figure 2.1 as a linear function for simplicity and as an upward sloping curve because the horizontal axis measures α, which is the complement of α^*. This FF curve is relatively flat to approximate a situation with low per-trade costs. There is no closed-form solution for HH, so the curve depicted is intended only to facilitate intuition. HH is shown as a downward-slopping curve but, since domestic agents respond to wealth, intertemporal-substitution and portfolio-composition effects in choosing their equity holdings, HH can be downward or upward slopping depending on which effect dominates.

Suppose that a margin call hits domestic agents because an adverse shock hits the economy when their debt is sufficiently high relative to the value of their assets. As a result, HH shifts to HH'. In Figure 2.1, HH' represents the "final" demand function, including the magnification effect of the Fisherian debt-deflation mechanism. Without price guarantees, the date-t equilibrium price would fall to point B. This is the "Sudden Stop scenario," in which margin calls result in lower asset prices and reversals in consumption and the current account. Enter now an IFO that sets a price guarantee higher than the market price at B. The international moral hazard effect shifts the foreign traders' demand curve to FF' and the new date-t market price is determined at point C, which yields the fundamentals price. The scenario depicted here is an ideal one in which the IFO is assumed to know exactly at what level to set the *guaranteed* price so as to stabilize the *market* price at the fundamentals level. In contrast, if the guarantee is set below the price at B, it would have no effect on the Sudden Stop equilibrium price, and thus price guarantees would be irrelevant. If the guarantee is set too high, it can lead to a price higher than the fundamentals price (with the overpricing even larger than the underpricing that occurs at B). Hence, ex-ante price guarantees do not necessarily reduce the volatility of asset prices (as Ljungqvist's (2000) findings showed).

From the perspective of the dynamic stochastic general equilibrium model, Figure 2.1 is a partial equilibrium snapshot of the date-t asset market. The forward-looking behavior of domestic households and foreign traders implies that changes that affect the date-t asset market spillover into the market outcomes at other dates and vice versa. For example, the price guarantee may not be in force at t but the expectation of executing future price guarantees will shift upward the FF curve at t. Similarly, the margin constraint may not bind at t, but the expectation of future margin calls is enough to shift the date-t HH curve. Given the lack of closed-form solutions for equilibrium allocations and prices, the only way to study the effects of price guarantees on the dynamics of consumption, the current account, asset holdings, and asset prices is by exploring the model's quantitative implications via numerical simulation.

2.4 Quantitative Analysis

2.4.1 Recursive Equilibrium and Solution Method

In the recursive representation of the equilibrium, the state variables are the current holdings of assets and bonds in the emerging economy, α and b, and the realization of the productivity shock e. The state space of asset positions spans the discrete grid of NA nodes $A = \alpha_1 < \alpha_2 < \ < \alpha_{NA}$ with $\alpha_1 = \chi$, and the state space of bonds spans the discrete grid of NB nodes $B = b_1 < b_2 < \ < b_{NB}$. The endogenous state space is defined by the discrete set $Z = A \times B$ of $NA \times NB$ elements. Productivity shocks follow a stationary, two-point Markov chain with realizations $E = \varepsilon_L < \varepsilon_H$. Equilibrium wages, dividends, labor and output are determined by solving the supply-side system given by equations (2.1), (2.2), (2.9) and the production function. The solutions are given by functions that depend only on ε: $w(\varepsilon)$, $d(\varepsilon)$, $n(\varepsilon)$ and $F(\varepsilon)$.

The numerical solution of the recursive equilibrium is obtained using a modified version of Mendoza and Smith's (2004) quasi-planning problem algorithm. The algorithm starts with a conjecture for the function $\hat{G}(\alpha, b, \varepsilon) : E \times Z \to R^+$, which returns the expected present discounted value of "excess prices" for any triple (α, b, ε) in the state space. Given this conjecture, the optimal decision rules for equity and bond holdings of domestic agents, are obtained by solving the following dynamic programming problem:

$$V(\alpha, b, \varepsilon) = \max_{\alpha', b' \in A \times B} \{u(c - h(n(\varepsilon))) + \exp(-\nu(c - h(n(\varepsilon))))E[V(\alpha', b', \varepsilon')]\} \tag{2.16}$$

subject to:

$$c = \alpha k d(\varepsilon) + w(\varepsilon)n(\varepsilon) + \frac{q^f(\varepsilon) + \hat{G}(\alpha, b, \varepsilon)}{1 + a\theta + a(\alpha - \alpha')} k(\alpha - \alpha') - b' + bR \tag{2.17}$$

$$b' \geq -\kappa \frac{q^f(\varepsilon) + \hat{G}(\alpha, b, \varepsilon)}{1 + a\theta + a(\alpha - \alpha')} \alpha' k \tag{2.18}$$

Note that equity prices in (2.19) and (2.20) were replaced with the prices along the demand curve of foreign traders by imposing equity market clearing and solving for equity prices using (2.15).

The decision rule for equity holdings is plugged into equation (2.15) to derive an "actual" asset pricing function (for the given conjecture $\hat{G}(\alpha, b, \varepsilon)$). The decision rules for bonds and equity, the guaranteed prices, and this "actual" pricing function are then used to solve for the "actual" function. The conjectured and actual G functions are then combined to create a new conjecture using a Gauss-Siedel rule, and the procedure starts again with the Bellman equation (2.18). The process is repeated until $\hat{G}(\cdot)$ and $G(\cdot)$ converge, so that the function $\hat{G}(\alpha, b, \varepsilon)$ that is taken as given in the dynamic programming problem is consistent with the function $G(\alpha, b, \varepsilon)$ implied by the asset pricing function and decision rules that are endogenous outcomes of that problem.

The drawback of this method is that it assumes that the emerging economy internalizes the demand function of foreign traders. As a result, the equilibrium of problem (2.18) is equivalent to a competitive equilibrium for a variant of the model with a proportional tax or subsidy on asset returns, with tax revenues rebated as a lump-sum transfer. In the simulations we discuss below, however, the implied taxes are negligible: The maximum taxes in absolute values range between 0.08 (0.4) and 0.2 (0.8) percent when $a = 0.2(2)$. The average tax in absolute value is 0.03 (0.3) percent in the simulations with $a = 0.2(2)$.

2.4.2 Deterministic Steady State and Calibration to Mexican Data

The functional forms that represent preferences and technology are the following:

$$F(k, n_t) = k^{(1-\gamma)} n_t^{\gamma}, \quad 0 \leq \gamma \leq 1 \tag{2.19}$$

$$u(c_t - h(n_t)) = \frac{[c_t - h(n_t)]^{1-\sigma} - 1}{1-\sigma}, \quad \sigma > 1 \tag{2.20}$$

$$\nu(c_t - h(n_t)) = \beta[Ln(1 + c_t - h(n_t))], \quad 0 < \beta \leq \sigma \tag{2.21}$$

$$h(n_t) = \frac{n_t^{\delta}}{\delta}, \quad \delta > 1 \tag{2.22}$$

γ is the labor income share, σ is the coefficient of relative risk aversion, β is the elasticity of the rate of time preference with respect to $1 + c_t - h(n_t)$, and δ sets the wage elasticity of labor supply (which is equal to $1/(\delta - 1)$). The condition $0 < \beta \leq \sigma$ is required to limit impatience effects and obtain a well-defined limiting distribution of foreign bonds (see Arellano and Mendoza (2003) for details).

The calibration strategy differs markedly from the one in Mendoza and Smith (2004). They normalize the capital stock to k=1 and let the steady-state equity price adjust to the value implied by the asset pricing condition, given a set of parameter values taken directly from the data or set to enable the model to match ratios of national accounts statistics. Here, we normalize instead the steady-state equity price so that the capital stock matches the deterministic, steady-state capital stock of a typical RBC-SOE model calibrated to Mexican data (see Mendoza (2004)). The steady state of this RBC-SOE model is a frictionless, neoclassical stationary equilibrium. Calibrating to this frictionless equilibrium helps focus the analysis on the use of price guarantees to prevent Sudden Stops triggered by margin calls that hit the economy only when it is highly leveraged (and hence off the long-run equilibrium).

The risk aversion parameter is set at $\sigma = 2$ in line with values often used in RBC-SOE studies. The parameter values that enter into the supply-side system are determined as follows. The labor share is set at $\gamma = 0.65$, in line with international evidence on labor income shares. The Mexican average share of labor income in value added in an annual sample for 1988-2001 is 0.34, but values around 0.65 are the norm in several countries and there is concern that the Mexican data may measure inaccurately proprietors income and other forms of labor income (see Mendoza (2004) for details). The real interest rate is set at 6.5 percent, which is also a value widely used in the RBC literature. Since the model is set to a quarterly frequency, this implies $R = 1.065^{1/4}$. The labor disutility coefficient is set to the same value as in Mendoza and Smith (2004), $\delta = 2$, which implies a unitary wage elasticity of labor supply.

As in a typical RBC calibration exercise, the calibration is designed to yield a set of parameter values such that the model's deterministic steady state matches actual averages of the GDP shares of consumption (sc), investment (si), government purchases (sg) and net exports (snx). In the Mexican data, these shares are $sc = 0.684$, $si = 0.19$, $sg = 0.092$, and $snx = 0.034$. Since the model does not have investment or government purchases, their combined share (0.282) is treated as exogenous absorption of output equivalent to 28.2 percent of steady-state GDP. In the stochastic simulations we keep the corresponding *level* of these expenditures constant at 28.2 percent of the value obtained for steady-state output in the calibration.

The typical RBC-SOE model features a standard steady-state optimality condition that equates the marginal product of capital net of depreciation with the world interest rate, and a standard law of motion of the capital stock that relates the steady-state investment rate to the steady-state capital-output ratio. Given the values of si, γ, δ and R, these two steady-state conditions yield values of the depreciation rate (dep) and the capital-output ratio (sk). On an annual basis, the resulting depreciation rate is 7.75 percent and sk is about 2.5.

In a deterministic steady state of the model of Section 2 in which the credit constraint does not bind and there are no price guarantees, the equity price is $q = q^f = d/(R-1)$. Given the RBC-SOE calibration criterion that the steady-state marginal product of capital net of depreciation equals the net world interest rate, q^f can be re-written as $F_k(k,n)/(F_k(k,n) - dep)$. With the Cobb-Douglas production function this reduces to $q^f = (1-\gamma)/(1-\gamma-si)$. Thus, the requirement that the model's dividend rate must match a typical RBC-SOE calibration implies that the steady-state equity price is determined by si and g. With the parameter values set above we obtain $q^f = 2.19$.

Given the values of γ, δ, R, and q^f the steady-state solutions for n, w, k, and $F(k,n)$ follow from solving the supply-side system conformed by (2.1), (2.2), (2.9) and (2.21). The resulting steady-state capital stock is $k = 79$. By construction, this capital stock is also consistent with the estimated capital-output ratio of 2.5 and the observed Mexican investment rate of 0.19.

The parameters that remain to be calibrated are the time-preference elasticity coefficient b and the financial frictions parameters a, θ and k. The value of β is derived from the consumption Euler equation as follows. In the deterministic stationary state of the model there are no credit constraints and hence the endogenous rate of time preference equals the real interest rate:

$$\left(1 + scF(k,n) - \frac{n^{\delta}}{\delta}\right)^{\beta} = R \tag{2.23}$$

Given the values of R, δ, n, $F(k,n)$ and sc, this condition can be solved for the required value of β. The solution yields $\beta = 0.0118$. The total stock of domestic savings at steady state follows then from the resource constraint as $s = [c - F(k,n)(si + sg) - wn]/(R-1) = \alpha q^f k + b$.

Up to this point the calibration followed the typical RBC-SOE deterministic calibration exercise. A problem emerges, however, when we try to determine the composition of the savings portfolio because the allocation of savings across bonds and equity is undetermined. Any portfolio $(\alpha, b) \in A \times B$ is consistent with the RBC-SOE deterministic steady state as long as it supports the unique steady-state level of savings (i.e., $\alpha q^f k + b = s$) and the margin and short-selling constraints do not bind ($b > -\kappa\alpha q^f k$ and $\alpha > \chi$). Moreover, given the values of s, q^f and k implied by the calibration, it follows from the definition of savings that there is only a small subset of portfolios in which the economy borrows in the bond market (i.e., portfolios with $b < 0$) in the set of multiple steady-state portfolios. Debt portfolios require $\alpha > 0.9$. If domestic agents own less than 90 percent of k, their steady-state bond position is positive and grows larger the smaller is a. This also implies that it will take low values of κ to make the margin constraint bind. In particular, setting the upper bound of α at 100 percent, it takes $\kappa \leq 0.10$ for the margin constraint to bind for at least some of the multiple steady-state pairs of (α, b). These low values of κ can be justified by considering that the margin constraint represents the fraction of domestic capital that is useful collateral for external debt. Several studies in the Sudden Stops literature provide arguments to suggest that this fraction is small (see, for example, Caballero and Krishnamurty (2001)).

The stochastic RBC-SOE without credit constraints has the additional unappealing feature that it can lead to degenerate long-run distributions of equity and bonds in which domestic agents hold the smallest equity position (χ) and use bonds to engage in consumption smoothing and precautionary saving. The reason is that, without credit constraints and zero recurrent trading costs, risk-averse domestic agents demand a risk premium to hold equity while risk-neutral foreign traders do not.[4] Hence, domestic agents end up selling all the equity they can to foreign traders, although the process takes time because of the trading costs that foreign traders pay.

To circumvent the problems of portfolio determination in the deterministic and stochastic RBC-SOE steady states, we calibrate the values of the financial frictions parameters (θ, q and k) so that the allocations and prices obtained with the deterministic RBC-SOE steady state can be closely approximated as the deterministic steady state of an economy with negligible (but positive) recurrent trading costs and a margin constraint that is just slightly binding. This calibration scenario is labeled the "nearly frictionless economy"(NFE).

The deterministic steady state of the NFE has well-defined, unique solutions for bond and equity positions. In particular, foreign traders hold a stationary equity position at the price $q = q^f/(1 + a\theta)$. Since this price is less than q^f, which is the price at which the return on domestic equity equals R, it follows that at this lower price $R^q > R$. Thus, foreign traders now require an equity premium to hold a stationary equity position. The ratio of the Lagrange multipliers of the domestic agent's margin constraint and budget constraint can then be found to be $\eta/\lambda = (R^q - R)/(R^q - R\kappa)$. In addition, since the margin constraint binds, bond holdings must satisfy $b = -\kappa\alpha qk$, and hence a unique stationary domestic equity position can be obtained from the steady-state consumption Euler equation. This

[4]With $\theta = 0$ and no price guarantees, equation (2.15) implies that foreign traders attain a stationary equity position when the equity price equals the fundamentals price, and the latter implies a stationary asset return equal to R. Thus, at this steady state foreign traders hold equity at zero equity premium.

is the value of a that solves the following expression:

$$\left(1 + \alpha kd + wn - \kappa q\alpha k(R-1) - \frac{n^{\delta}}{\delta}\right)^{\beta} = \frac{R}{1-(\eta/\lambda)} \tag{2.24}$$

Equation (26) illustrates the key role of the endogenous rate of time preference in supporting deterministic stationary equilibria with binding credit limits: it allows the rate of time preference to adjust so as to make the higher long-run consumption level, implied by the fact that the credit constraint prevents domestic agents from borrowing as they desire in the transition to steady state, to be consistent with the higher effective long-run real interest rate also implied by the credit constraint. The recurrent trading cost is also critical. With $\theta = 0$, a stationary equity position for foreign traders requires a price equal to q^f and a return on equity equal to R, but the latter implies that $\eta/\lambda = 0$, so the borrowing constraint could not bind.

In the NFE steady state, the values of a, θ and *kappa* are set to support a deterministic steady state with a binding borrowing constraint that satisfies the following conditions: (1) the debt-GDP ratio is in line with Mexican data, (2) the allocations, factor payment rates and the equity price are nearly identical to those obtained for the frictionless RBC-SOE deterministic steady state, and (3) the elasticity of the foreign trader's demand curve is relatively high. The values of the financial frictions parameters are: $a = 0.2$, $\theta = 0.001$ and $\kappa = 0.03$. With these parameter values, and the values set earlier for γ, θ, β, and R, the NFE steady state yields values of c, s, n, w, d, q, and R^q nearly identical to those of the RBC-SOE deterministic steady state, but the NFE also has unique portfolio allocations of $\alpha = 0.931$ and $b = -4.825$ (which implies a debt-GDP ratio of about 0.62).

2.4.3 Stochastic Simulation Framework

The stochastic simulations are solved over a discrete state space with 78 evenly-spaced nodes in the equity grid and 120 evenly-spaced nodes in the bonds grid. The lower bound for equity is set at c=0.84, so the equity grid spans the interval [0.84,1]. These equity bounds, together with the maximum equity price defined in (2.17) and the margin constraint, set the lower bound for bonds as $-\kappa q^{max} k = -5.2$. This is the largest debt that the SOE could leverage by holding the largest possible equity position at the highest possible price. The upper bound of bonds is found by solving the model repeatedly starting with an upper bound that supports steady state savings with the equity position at its lowest, and then increasing the upper bound until the grid captures the support of the ergodic distribution of bonds. The resulting grid spans the interval [-5.2,25.7]. The segment of debt positions inside this interval is relatively small, reflecting the fact that, despite the frictions induced by asset trading costs, domestic agents still have a preference for riskless bonds as a vehicle to smooth consumption and build a buffer stock of savings.

A lower bound on domestic equity holdings of 84 percent seems much higher than the conventional short-selling limit set at 0 but it is consistent with the national aggregates targeted in the calibration. In Mexico, the 1988-2000 average ratio of stock market capitalization to GDP was 27.6 percent. Since the calibration produced an estimate of the capital-output ratio of about 2.5, the shares of publicly traded firms constitute just 11 percent of the capital stock. A large fraction of Mexico's capital is owned by non-publicly-traded firms and by owners of residential property, and thus does not have a liquid market in which shares are traded with foreign residents. In general, it is hard to argue that a large fraction of the physical capital of most emerging economies has a liquid international market. Moreover, the result from the calibration showing that bond positions become positive and unrealistically large for $\alpha < 0.9$ also argues for a high value of χ.

Productivity shocks are modeled as a two-point, symmetric Markov process that follows the "simple persistence" rule. The two points of the Markov chain and the transition probability matrix are set so that the model mimics the standard deviation and first-order autocorrelation of the quarterly cyclical components of Mexico's GDP reported in Mendoza (2004) – 2.64 percent and 0.683 respectively. This requires a Markov process of productivity shocks with a standard deviation (σ_ε) of 1.79 percent and a first-order autocorrelation coefficient (ρ_ε) of 0.683. The simple persistence rule implies then that the two points of the Markov chain are -$\varepsilon_L = \varepsilon_H = 0.0179$ and these two states a long-run probability of . The transition probability of remaining in either state is given by $(1 - \rho_\varepsilon) + \rho_\varepsilon = 0.8415$ and the transition probability of shifting across states is $(1 - \rho_\varepsilon) = 0.1585$.

2.4.4 Baseline Results: Globalization Hazard and Sudden Stops without Price Guarantees

The baseline results include four simulations: (1) the NFE case, (2) the economy with binding margin requirements (BMR), which uses a margin coefficient set at $\kappa = 0.005$, (3) a simple price-guarantees policy that sets a single, non-state-contingent guaranteed price (NSCG) for all dates and states, and (4) an economy with the same guaranteed price but as a state-contingent guarantee (SCG) that applies only in a subset of the state space.

The key result that emerges from comparing the NFE and BMR economies is that the financial frictions representing globalization hazard in the model do cause Sudden Stops when the ratio of debt to the market value of equity is high and the equity market has enough liquidity (i.e., domestic agents are not at their short-selling limit). Since this result echoes findings from Mendoza and Smith (2004), we keep the presentation short and refer the reader to their article for details.

Figures 2 shows the long run distributions of equity and bonds for the four simulations. Comparing the bond distributions of the NFE and BMR simulations, the effect of the margin constraint is evident. The distribution is biased to the left in the two economies but it shifts markedly to the right in the BMR case. The opposite occurs with the distribution of equity. The bias to the left in the distribution of equity reflects the incentive that risk-averse domestic agents have to sell equity to risk-neutral foreign traders. Binding margin constraints shift the equity distribution further to the left because of the equity fire sales triggered by margin calls. These shifts in the distributions of equity and bonds also reflect the outcome of precautionary saving. Domestic agents, aware of the imperfections of financial markets, have an incentive to build up a buffer stock of savings so as to minimize the risk of large declines in consumption, and in doing so they also lower the risk of facing states in which margin constraints bind in the long run (Figure 2 shows that the long run distribution of bonds of the BMR economy rules out states with very large debt positions). Still, Table 1 shows that the long-run probability of binding margin constraints is about 4 percent. Sudden Stops are therefore rare but non-zero probability events in the stochastic steady state (although many of the states in which margin constraints bind in the long run do not trigger Sudden Stops, as explained below). Note also that margin constraints cause a portfolio reallocation of savings from equity into bonds. Table 1 shows that the long-run average of the bonds-output ratio increases from 18 percent in the NFE to 50 percent in the BMR economy.

Financial frictions have negligible effects on business cycle moments (see Table 2.1). Hence, as in Mendoza and Smith (2004), we study Sudden Stops by examining the model's dynamics in the high-debt region of the state space in which the margin constraint binds (i.e., the "Sudden Stop region"). Figure 2.3 shows the date-0 responses (or impact effects) of consumption, and the current account-GDP ratio (ca/y) to a negative, one-standard-deviation productivity shock for (α, b) pairs in the Sudden Stop region, measured in percent of the long-run mean of each variable. The Sudden Stop region includes the first 25 nodes of the B grid and all 72 nodes of the A grid.

Figure 3 suggests that there are two key factors driving impact effects in the Sudden Stop region: (1) The leverage ratio, defined as the ratio of debt to the market value of equity, and (2) The liquidity of the equity market, defined as the difference between α and χ. Sudden Stops with large reversals in c and ca/y occur when the leverage ratio is high, but given high leverage the impact on asset prices is different depending on asset market liquidity. If the asset market is illiquid, the Sudden Stop can feature negligible asset price declines because domestic agents are close to χ and hence have little equity to sell (see Figure 2.5a), but if there is some liquidity in the asset market, the Sudden Stop in c and ca/y is accompanied by a fall in q. In contrast, when the leverage ratio is sufficiently low and the asset market is sufficiently liquid, the drop in consumption and the current account reversal are small (nearly as small as in the NFE case) but the drop in asset prices is larger. In this case, domestic agents liquidate more equity and trigger larger asset price collapses, but they do so in order to swap their limited borrowing ability via bonds for equity sales so as to minimize the drop in consumption. This pattern of larger current account corrections coinciding with smaller asset price collapses fits the observations of some emerging markets crises. The current account reversal in the first quarter of 1995 in Mexico was 5.2 percent of GDP but the drop in real equity prices was nearly 29 percent. In contrast, in Korea the current account reversal in the first quarter of 1998 was twice as large but the asset price drop was just 10 percent.

Figure 2.4 illustrates Sudden Stop dynamics using the conditional forecasting functions of c, q and ca/y. The first two are shown as percentages of their long-run averages in the NFE and the last is shown as the percentage points difference relative to the long-run average in the NFE. These forecasting functions represent non-linear impulse response functions to a negative, one-standard-deviation productivity shock conditional on initial positions of equity and bonds inside the Sudden Stop region. The Figures plot two sets of forecasting functions, one for a high leverage initial state, at which $\alpha = 0.938$ and $b = -4.68$ (with debt ratio of 60 percent of GDP and a leverage ratio of 3 percent of GDP), and one for a low leverage state with the same a but $b = -3.38$ (with a debt ratio of 43 percent of GDP and a leverage ratio of 2 percent of GDP). Since these initial states are distant from the corresponding long-run averages, the data in the Figures were adjusted to remove low-frequency transitional dynamics driven by the convergence of bonds and equity to their long-run means. Given that c, q and ca/y have nearly identical long-run averages in the four baseline experiments (except for the mean of q in the NSCG economy, which is higher), the forecasting functions were detrended by taking differences relative to the NFE forecasting functions.

The impact effects in the initial date of the forecasting functions of the BMR economy differ sharply across the high and low leverage states, and those of the high leverage state deviate significantly from those of the NFE (or from zero in terms of Figure 2.4, since the data are plotted as differences relative to the NFE). In the high leverage state of the BMR economy, the negative shock triggers a Sudden Stop driven by the mechanisms described in Section 2.3: Domestic agents sell equity to meet margin calls and trigger a Fisherian deflation that reduces further their ability to borrow. The net result is that, on impact, a one-standard-deviation shock to productivity causes c and q to drop by 1.5 and 0.4 percent more than in the NFE respectively and ca/y to rise by about 1 percentage point of GDP. In the low leverage state, domestic agents are better positioned to smooth consumption by substituting debt for equity to finance a current account deficit. As a result, the responses of c and ca/y in the BMR economy are nearly identical to those in the NFE, so their detrended forecasting functions hover around zero. This occurs even though the sales of equity still make q fall by about the same amount as in the high leverage scenario. Notice also that the drop in asset prices is small relative to observed Sudden Stops, but very large relative to the standard deviation of asset prices in the NFE.

One caveat about the plots in Figure 2.4: The initial bond and equity positions used to generate them yield outcomes consistent with Sudden Stops, but the set of impact effects that the model predicts for all initial conditions inside the Sudden Stop region are shown in Figures 2.3. As these Figures show, the Sudden Stop region includes scenarios with much larger consumption and current-account reversals than those shown in Figure 2.4, as well as scenarios in which there is little difference between the BMR and NFE because the asset market is sufficiently liquid to maintain a similar current account deficit by selling equity when the margin constraint binds. Precautionary saving implies, however, that all the scenarios with very large reversals in consumption have zero probability in the long run. Notice also that, since the Sudden Stop region includes instances in which the margin constraint binds but fire sales of assets prevent a sharp current account reversal, the probability of binding margin constraints is not identical to the probability of Sudden Stops.

Figure 2.4 suggests that Sudden Stops in the model are short-lived. The responses of the BMR economy converge to those of the NFE in about 4 quarters. Mendoza and Smith (2004) obtained Sudden Stops with more persistence using higher per-trade costs, which hamper the foreign traders' ability to adjust equity holdings.

2.4.5 Baseline Results: State-Contingent and Non-State-Contingent Price Guarantees

The price guarantees are set above the fundamentals price in the low productivity state.[5] This is motivated by a theoretical result that holds for stationary decision rules (i.e., $\alpha_{t+1} = a_t, b_{t+1} = b_t$) and equilibrium equity prices in the high productivity state that exceed a time- and state-invariant guaranteed price. Under these assumptions, we can show that $G(\alpha, b, \varepsilon_L) = z\left(\tilde{q} - \frac{q^f(\varepsilon_L)}{1+a\theta}\right)$, where z is a positive fraction that depends on R, a, θ and the transition probabilities of the shocks. Hence, $\tilde{q} > \frac{q^f(\varepsilon)}{1+a\theta}$ is a necessary condition for the guarantees to be executed at least in some states.

The non-state-contingent price guarantee is set of a percentage point above the fundamentals price in the low productivity state (2.185). Hence, the guaranteed price is 2.196. This guarantee is offered in all states (α, b, ε) in the NSCG economy. In contrast, the SCG economy provides the same guaranteed price only for (a,b) pairs inside the Sudden Stop region.

[5]Note that incomplete asset markets and the risk-averse nature of domestic agents imply that equilibrium prices in the NFE differ from the fundamentals price that discounts dividends at the risk-free rate.

Figure 2.2 shows that, relative to the BMR case, the non-state-contingent guarantee shifts the distribution of equity (bonds) markedly to the left (right). The long-run average of the expected present value of excess prices (i.e., the long-run average of G) is 0.01, which is about of a percent above the mean equity price in the stochastic stationary state. Comparing long-run moments across Panels I, II and III of Table 1, the main change in the NSCG simulation is the reduction in the probability of binding margin constraints. The probability is almost zero with price guarantees, compared with 4 percent in the BMR economy. The long-run moments of the model's endogenous variables vary slightly with the non-state-contingent guarantee. Asset-price fluctuations display less variability, persistence and co-movement with output in the NSCG economy relative to the NFE and BMR cases. The mean equity price increases by 0.053 percent, slightly more than the percent difference between the guaranteed price and the fundamentals price of the low productivity state. The coefficient of variation of consumption falls by about 1/5 of a percentage point and the variability of the current account and the trade balance increase slightly. Consumption also becomes less correlated with GDP.

The effects of the price guarantee on Sudden Stop dynamics are shown in Figure 2.4. Price guarantees are an effective policy for containing Sudden Stops. Comparing the NSCG and BMR economies in the high leverage state, the initial consumption and current account reversals are smaller in the NSCG economy, and the drop in equity prices turns into an increase of about 1/2 of a percentage point. In the low leverage state, the increase in equity prices in the NSCG economy is slightly larger than in the high leverage state, and we now obtain an increase in consumption and a widening of the current account deficit at date 0. The price guarantee results in a price of equity at date 0 that is 2/3 of a percentage point higher in the NSCG than in the BMR economy in both the high and low leverage states. The price guarantee is executed in both states of the NSCG economy.

Figure 5 plots the levels of equity prices in the low productivity state of the NFE, BMR and NSCG economies for all equity and bond positions. The plots show that the non-state-contingent guarantee not only results in higher prices in the Sudden Stop region, but it actually increases prices in all states. In fact, the guarantee produces significantly higher asset prices in the NSCG economy than in either the NFE or BMR economies in states well outside the Sudden Stop region. This is a potentially important drawback of non-state-contingent price guarantees: they distort asset prices even when the economy is in states where it is far from vulnerable to Sudden Stops.

One alternative to remedy the drawbacks of non-state-contingent price guarantees is to consider state-contingent guarantees. Figure 2.2 shows that the SCG economy yields a long-run distribution of equity (bonds) that is less skewed to the left (right) than in the NSCG economy. Table 1 shows that the changes in the long-run business cycle moments of the SCG economy relative to the NFE and BMR cases are qualitatively similar to those noted for the NSCG economy but the magnitude of the changes is smaller. The SCG economy still features near-zero percent probability of observing states of nature in which the margin constraint binds. Hence, the state-contingent guarantee is as effective as the non-state-contingent guarantee at eliminating the possibility of hitting states with binding margin requirements in the long run.

Figure 2.4 shows that, in both the high and low leverage states, the SCG economy features nearly identical date-0 responses in consumption and the current account as the NSCG economy and a slightly smaller recovery in asset prices. After date 0, the SCG economy converges faster to the dynamic paths of the NFE economy. Finally, a comparison of the middle and bottom plots of Figure 5 shows that the SCG economy yields higher asset prices mainly in the Sudden Stop region of the state space. Thus, state contingent guarantees induce smaller distortions on asset demand and asset prices than the non-state-contingent guarantees, particularly outside the Sudden Stop region, yet they have similar effects in terms of their ability to prevent Sudden Stops.

2.5 Normative Implications and Sensitivity Analysis

2.5.1 Normative Implications of the Baseline Simulations

We study next the normative implications of the baseline simulations by examining how domestic welfare and the value of foreign securities firms varies across the NFE, BMR, NSCG and SCG simulations. Welfare costs, $W(\alpha, b, \varepsilon)$, are measured by computing compensating variations in date-0 consumption that equate expected lifetime utility in the BMR, NSCG and SCG economies with that of the NFE for any triple (α, b, ε) in the state space. Welfare effects are typically computed as compensating variations that apply to consumption at all dates, but in principle both measures are useful for converting ordinal units of utility into the cardinal units needed for quantitative welfare comparisons. The two measures yield identical welfare rankings for the four experiments, but the measure based on date-0 consumption highlights better the welfare costs of Sudden Stops and the potential benefits of price guarantees because large deviations from the consumption dynamics of the NFE occur only in Sudden Stop states (in which bond and equity positions are distant from their long-run averages).

The model belongs to the class of models in which capital markets are used to smooth consumption over the business cycle. Hence, since it is well-known that the welfare cost of "typical" consumption fluctuations is small in these models, the mean welfare costs of deviating from the NFE ($E[W(\alpha, b, \varepsilon)]$) computed with the ergodic distribution) should be small. As Table 2.2 shows, welfare comparisons based on date-0 consumption preserve this result. Agents in the BMR, NSCG and SCG economies incur average welfare losses relative to the NFE equivalent to cuts of less than 0.07 percent in c_0. This is also in line with Mendoza's (1991) results showing trivial welfare costs for giving up access to world capital markets in an RBC-SOE model.

The situation is very different when comparing welfare conditional on Sudden Stop states. Since the Bellman equation implies that lifetime utility as of date 0 can be expressed as $V(t) = u(t) + exp(-v(t))Et[V(t+1)]$, Table 2 decomposes the total welfare cost into a short-run cost (i.e., the percent change in c_0 that equates $u(0)$ in the distorted economies with that of the NFE) and a long-run cost (i.e., the percent change in c0 that equates $exp(-v(0))E_0[V(1)]$ in the distorted economies with that of the NFE). The Table also lists the rate of time preference, $exp(-v(0))$, to show that changes in the endogenous subjective discount are irrelevant for the welfare analysis.

In the high leverage Sudden Stop state, which is the one that in the BMR economy produces dynamics closer to those of observed Sudden Stops, the short-run welfare costs show that domestic agents are worse off in the BMR, NSCG and SCG economies than in the NFE. The welfare cost is 1.4 percent for the BMR economy and 0.9 and 1 percent for the NSCG and SCG economies respectively. This ranking reflects the fact that declines in date-0 consumption, and hence $u(0)$, are smallest in the NFE because it provides the best environment for consumption smoothing, followed by the economies in which price guarantees help contain Sudden Stops.

The long-run costs are negative (i.e., domestic agents make welfare gains) because consumption after date 0 increases at least temporarily in the BMR, NSCG and SCG economies. In the high leverage case of the BMR economy, the binding credit constraint tilts the consumption profile by reducing consumption at date 0 and increasing it later, resulting in a long-run welfare gain of about 1 percent. Consumption tilting is also at work in the NSCG and SCG economies, but in addition the higher (distorted) asset prices lead to higher consumption relative to both the BMR and the NFE for three quarters beyond the initial date (see Figure 4). This expansion of consumption in the economies with price guarantees is driven in turn by larger current account deficits, which are financed by equity sales at higher prices. After date 0, domestic agents set to rebalance their portfolios from equity into bonds gradually, but in economies with price guarantees the capital inflows from equity sales exceed the outflows from bond purchases in the early periods of transition thus producing larger external deficits. This leads to long-run welfare gains in the high leverage NSCG and SCG economies (1.9 and 1.3 percent respectively) that are large enough to offset the short-run costs, so that domestic agents obtain total welfare gains of 1 percent in the NSCG and 0.3 percent in the SCG. These results show that the asset price changes induced by price guarantees represent non-trivial distortions relative to the NFE. Moreover, as we show below, the same distortions that increase domestic welfare in the high leverage Sudden Stop states of the NSCG and SCG economies reduce the value of foreign traders' firms in those states.

At equilibrium, the foreign traders' net returns can be written as:

$$\begin{aligned}\hat{\pi}(\alpha, b, \varepsilon) \equiv k\{[(1-\alpha)d(\varepsilon)] - [q(\alpha, b, \varepsilon)(\alpha - \hat{\alpha}'(\alpha, b, \varepsilon))] - \\ \left[q(\alpha, b, \varepsilon)\left(\frac{a}{2}\right)(\alpha - \hat{\alpha}'(\alpha, b, \varepsilon) + \theta)^2\right]\}\end{aligned} \tag{2.25}$$

The three terms in square brackets in the right-hand-side of this expression represent the foreign traders' dividend earnings, the net value of their trades, and the trading costs they incur. Notice that, since the budget constraint of the IFO holds, the lump sum taxes paid by foreign traders cancel with the value of the executed guarantees. Thus, price guarantees distort the traders' optimality condition with the moral hazard effect identified in (2.15) without direct income effects.

The payoff of foreign traders D is the expected present discounted value of the stream of net returns. In the recursive representation of the equilibrium, this present value of returns is a function $D(\alpha, b, \varepsilon)$, and hence we can compute long-run averages of net returns, $E[D(\alpha, b, \varepsilon)]$, and values of $D(\alpha, b, \varepsilon)$ conditional on Sudden

Stop states. Since the model has a well-defined stochastic steady state, the long-run mean of net returns is given by $E[D] = kE[\hat{\pi}]R(R-1)^{-1}$.

Table 2.2 shows that, relative to the NFE, $E[D]$ and are 14.5 percent higher in the BMR economy and 52.6 and 42.5 percent higher in the NSCG and SCG economies respectively. Thus, from the perspective of the long-run average of the value of their firms, foreign traders are better off in the BMR economy and significantly better off in the economies with price guarantees than in the NFE. Table 2.2 also shows that this is the case mainly because of the increased average equity holdings of foreign traders in the BMR, NSCG and SCG economies, and the corresponding increase in their average dividend earnings. The contribution of changes in the value of trades to changes in $E[D]$ and is zero by definition (since the unconditional means of at and α_{t+1} are identical) and the contribution of changes in trading costs is negligible. Foreign traders build up a larger equity position in the BMR economy as a result of the rebalancing of the portfolio of domestic agents from equity into bonds shown in Figure 2.2, and also because in some states foreign traders buy assets at crash prices (i.e., when domestic agents fire sale assets to meet margin calls). Foreign traders are much better off when price guarantees are in place because the price guarantees are equivalent to a guaranteed minimum return, which reduces sharply the downside risk of holding equity and results in even larger domestic portfolio reallocations from equity into bonds.

The result that the payoff of foreign traders is significantly higher on average in the long run with price guarantees hides the fact that, when evaluated conditional on a Sudden Stop state, the payoff of foreign traders is lower in economies with price guarantees. Table 2.2 shows that the ranking of foreign traders' payoffs obtained by comparing $D(\alpha, b, \varepsilon)$ across Sudden Stop states with low or high leverage is the opposite from the one obtained by comparing $E[D]$. Relative to the NFE, the present value of profits is nearly unchanged in the BMR economy and it falls in the high and low leverage states of the economies with price guarantees (by about 0.7 and 0.3 percent in the NSCG and SCG economies respectively). The latter occurs because in the NSCG and SCG economies the increase in the long-run average of net returns ($E[\hat{\pi}]$) is not sufficient to offset the short-run decline in returns ($\hat{\pi}(\alpha, b, \varepsilon)$) that occurs at date 0 when a Sudden Stop hits (see Table 2.2). In turn, this decline in net returns at date 0 is almost entirely driven by changes in the value of trades. The value of trades in the high (low) leverage state rises from 0.36 in the NFE to 3.93 (3.22) in the BMR economy and to about 3.95 (3.24) in the NSCG and SCG economies. In the BMR economy, the increase reflects the domestic agents' fire sales of equity to meet margin calls. The equity price falls, and when it falls foreign traders demand more equity and the value of their trades increases. In the economies with price guarantees, the moral hazard distortion exacerbates this effect by increasing the foreign traders' equity demand and producing equilibrium prices higher than in the BMR economy. In line with the increase in trading values, trading costs rise sharply from the NFE economy to the other economies, but their absolute amounts remain small. Dividend earnings do not change because date-0 equity holdings are the same in all four economies and the dividends of domestic firms are independent of financial frictions and price guarantees.

In principle, the present value of foreign traders' net returns conditional on a Sudden Stop state could be higher or lower with price guarantees than without depending on whether the short-run effect lowering date-0 net returns is weaker or stronger than the long-run effect increasing average net returns. The strength of these effects depends in turn on how much and how fast equilibrium equity positions and equity prices move, which depends on the parameters driving the demand for equity of domestic agents and foreign traders. According to Table 2, however, the substantial increases in the average payoff of foreign traders ($E[D]$) in the NSCG and SCG economies exceed by large margins the small reductions in $D(\alpha, b, \varepsilon)$ to which foreign traders are exposed with very low probability in the long run.

To analyze the distributional implications of price guarantees, consider the "resource constraint" implied by the households' budget constraint and the traders' net returns:

$$c = \varepsilon F(k, n) - [k\alpha^* d - b(R-1)] + [qk(\alpha'^* - \alpha^*) - (b' - b)] \tag{2.26}$$

As noted earlier, the long-run averages of consumption in the NFE, BMR, NSCG and SCG economies are nearly identical (see Table 1). On the other hand, Table 2.2 shows that the long-run average of the foreign traders' dividend earnings is higher in the latter three than in the NFE. Taking the long-run average of equation (28), it follows from these two observations that domestic agents can sustain similar long-run average consumption levels because their average savings remain nearly unchanged: The drop in dividend earnings on equity is nearly offset by increased interest income from bonds. Thus, the baseline results suggest that globalization hazard and price guarantees, as modeled in this chapter, do not alter the long-run average shares of global income and wealth across the small open economy and the rest of the world. Foreign traders receive a larger share of domestic GDP but GNP is unaffected because domestic agents increase bond holdings and thus collect more interest income from abroad. The independence of GDP from financial frictions and price guarantees is a strong assumption that plays a key role in this result. The SOE assumption also plays a role because it allows the domestic portfolio swap of equity for bonds to occur without increasing the price of these bonds, which would lower the world interest rate.

Short-run distributional effects at a Sudden Stop state are different. GNP and GDP are unchanged across the four simulations, but there is a redistribution of world income via the current account. Relative to the NFE, foreign traders transfer income to domestic households in the BMR, NSCG and SCG economies, as the value of trades in the third term of the right-hand-side of (28) increases because domestic agents fire-sale equity to meet margin calls. But whether the domestic economy receives more or less income from the rest of the world as a whole depends on whether the fire sale of assets can prevent the current account reversal, which in turn depends on the leverage ratio and the liquidity of the asset market. Table 2.2 shows that $\hat{\pi}(\alpha, b, \varepsilon)$ falls at date 0 in the high and low leverage states, but Figure 2.4 shows that the reversal in ca/y is larger in the former. Thus, the high leverage state features a redistribution of income from foreign traders to domestic agents via the equity market, but the larger current account reversal indicates that this redistribution is more than offset by the loss of access to the credit market, so that the domestic economy reduces the share of world output that it absorbs. In contrast, in the low leverage state the current account deficit remains close to the level of the NFE and hence the domestic economy maintains its share of world output. These results hold across the BMR, NSCG and SCG economies compared to the NFE but the effects are stronger in the economies with price guarantees.

The above results show that, comparing long-run averages of the payoffs of domestic agents and foreign traders, foreign traders are significantly better off in the economies with price guarantees than in the NFE or BMR economies, while domestic agents are nearly indifferent. This suggests that price guarantees could be close to a win-win situation, but this result has some caveats. In particular, domestic agents are nearly indifferent between the long-run outcomes of the four economies because of the trivial cost of consumption fluctuations in models of the class examined here, and foreign traders make large gains in the BMR, NSCG and SCG economies because their dividend earnings are unaffected by financial frictions. Interestingly, in the short run and starting at a Sudden Stop state, the moral hazard distortion of economies with price guarantees yields persistently higher asset prices that redistribute income from foreign traders to domestic agents by more than is needed if the aim were just to recover the outcome of the NFE (hence making domestic agents better off and foreign traders worse off). Still, foreign traders are much better off in the long run because the large increase in $E[D]$ in the NSCG and SCG economies dwarfs the small, near-zero-probability reduction in $D(\alpha, b, \varepsilon)$ for Sudden Stop states.

2.5.2 Sensitivity Analysis

Table 2.3 reports the results of a sensitivity analysis that evaluates the robustness of the baseline results to the following parameter changes: Columns (II) and (III), larger and more persistent productivity shocks (σ_ε =0.024 and ρ_ε =0.8), Column (IV), higher price guarantees (1 percent above $q^f(\varepsilon_L)$), Column (V), higher recurrent trading costs (θ =0.01), and Column (VI), higher per-trade costs (a =2). Column (I) reproduces the baseline results. The Table shows panels with results for the BMR, NSCG and SCG economies for all six scenarios. In each case, three sets of results are listed: (a) Sudden Stop effects as measured by the detrended, date-0 forecasting functions conditional on the high leverage state, (b) key moments of the ergodic distribution, and (c) changes in the payoffs of domestic agents and foreign traders, relative to the corresponding NFE simulation, for the high leverage Sudden Stop state and in the long-run averages.

Consider first the BMR panel. Columns (I)-(VI) show that the results of the comparison of the baseline NFE and BMR economies are robust to the parameter changes considered. Increases in se and re result in small changes in Columns (II) and (III) relative to Column (I). The exceptions are the probability of binding margin constraints, which rises (falls) to 4.2 (2.3) percent when re (σ_ε) increases, and the long-run average of the value of the foreign traders' firms, which falls to 12.2 and 4.4 percent in Columns (II) and (III) respectively. The changes in the probability of margin calls result from portfolio rebalancing effects. More persistent (variable) shocks increase (reduce) slightly the long-run average of domestic equity holdings, and have the opposite effects on bond holdings. As a result, the economy with more persistent (variable) shocks is more (less) likely to hit low bond positions (i.e., high debt positions) in which the margin constraint binds.

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In line with the findings of Mendoza and Smith (2004), Columns (V) and (VI) show that BMR economies with higher θ or higher a display larger Sudden Stops, with the latter showing stronger effects. The long-run probability of margin calls is also sharply higher in these economies, reaching 16.7 percent with $q = 0.01$ and 19.4 percent with a =2. The BMR economy with a =2 is the only scenario in Table 3 that can account for large consumption and current account reversals and large drops in asset prices, as in actual Sudden Stops. This scenario also results in increased long-run variability in consumption and asset prices, and sharply higher domestic welfare costs.

Comparing now Columns (I)-(VI) across the BMR, NSCG and SCG panels, we find that price guarantees always work to virtually eliminate the long-run probability of binding margin constraints. On the other hand, the long-run probability of executing the guarantees is high in the NSCG economy, ranging between 29 and 34 percent in all scenarios except the one with higher $sigma_{\varepsilon}$, in which it falls to 15 percent. In contrast, the probability of executing the guarantees in the SCG economy is below 1 percent in all the scenarios except those with θ =0.01 and a =2, in which it reaches 6 and 3.2 percent respectively. Thus, state-contingent guarantees are as effective as non-state-contingent guarantees at reducing the long-run probability of margin calls, with the advantage that in the SCG economy the IFO would be trading much less frequently.

A comparison of Columns (I) and (IV) shows that rising the guaranteed price 1 percent above $q^f(\varepsilon_L)$, twice as large than in the baseline, the NSCG and SCG economies dampen the Sudden Stops of the BMR economy even more than in the baseline. With the higher price guarantee in Column (IV), the fall in c is just 0.5 (0.6) percent in the NSCG (SCG), compared to 0.8 (0.9) percent in the corresponding baseline simulations. Similarly, the reversal in ca/y in the NSCG (SCG) is just 0.3 (0.4) percentage points of GDP in Column (IV), compared to 0.6 (0.7) in Column (I). On the other hand, the economies with higher guarantees prop up asset prices in the Sudden Stop state even more than in Column (I), with price increases of 0.7 (0.6) percent in the NSCG (SCG) economy. The domestic welfare gain in the high leverage Sudden Stop state increases to 2.4 (0.9) percent in Column (IV) of the NSCG (SCG) economy, compared to 1 (0.3) percent in the corresponding baseline simulations, while the long-run welfare losses remain nearly unchanged across Columns (I) and (IV). At the same time as the domestic welfare gains in the Sudden Stop state grow, the decline in the payoff of the foreign traders in the same state grows from 0.7 (0.3) percent in the NSCG (SCG) baseline to 1.4 (0.9) percent in the NSCG (SCG) with higher guarantees. In contrast, the long-run average of the traders' payoff increases with the higher guarantees. Thus, the results regarding the effects of price guarantees obtained with the baseline simulations are qualitatively similar to those obtained with higher guarantees, but quantitatively the higher guarantees induce larger moral hazard distortions, which result in weaker Sudden Stops but larger redistribution effects across foreign traders and domestic agents.

Column (VI) shows that, if the baseline level of price guarantees is applied to an economy with higher per-trade asset trading costs, the price guarantees still work to weaken the real effects of Sudden Stops relative to those in the BMR economy. With a =2, however, the guarantee set 0.5 percent above $q^f(\varepsilon_L)$ is insufficient to prevent marked reversals in c and ca/y and a sharp drop in q. Consequently, domestic agents suffer a substantial welfare loss of 1.5 (2.6) percent in the high leverage Sudden Stop state of the NSCG (SCG) economy, instead of the small gains obtained in the corresponding baseline simulations with a=0.2. Moreover, the long-run average of welfare costs increases about 5 (2) times in the NSCG (SCG) economy with a=2 relative to the same simulations with a=0.2. Interestingly, the payoff of the foreign traders in the high leverage Sudden Stop state is larger in the NSCG and SCG economies with a=2 than in their baseline counterparts with a=0.2. In fact, in the

SCG economy with a=2 the value of the foreign traders' firm in the high leverage state is even higher than that in the corresponding NFE economy.

The above results show that, for a given guaranteed price, there can be a sufficiently high value of a such that the mix of globalization hazard and international moral hazard yields outcomes in which domestic agents suffer large welfare losses at Sudden Stops, but still these losses are smaller than in the BMR economy without guarantees. Moreover, for given a, higher guarantees dampen Sudden Stops more and produce welfare gains at Sudden Stop states. These findings suggest that price guarantees should be higher the higher are trading costs. The results also show, however, that economies with higher a face higher long-run averages of welfare costs with price guarantees than without them (the cost is 1/3 of a percent in the NSCG panel of Column (VI), compared to 1/10 of a percent in the corresponding BMR). In addition, economies with higher guarantees and the baseline value of a yield larger long-run welfare losses (see Column IV). Thus, if per-trade trading costs are high, increasing price guarantees makes domestic agents better off at Sudden Stop states by weakening more the effects of globalization hazard, but the stronger effects of international moral hazard makes them worse off on average in the long run.

The findings of the sensitivity analysis suggest that the size of per-trade costs is crucial for the effectiveness of price guarantees and the globalization hazard-moral hazard tradeoff. Mendoza and Smith (2004) showed that this parameter is also crucial for the model's ability to account for asset price collapses of the magnitude observed in Sudden Stops, and documented empirical evidence of trading costs roughly in line with the model's predictions. Nevertheless, the crucial feature is not the magnitude of a per se but the elasticity of world demand for the SOE's equity, which can be influenced by factors other than trading costs. The findings of this chapter suggest that, if this elasticity is high, it is relatively easy to set up state-contingent price guarantees that reduce the probability of margin calls, undo the Sudden Stop effects of globalization hazard, and make domestic agents better off at Sudden Stop states with negligible effects on foreign traders' returns in those states, and with trivial implications for the long-run welfare of domestic agents. On the other hand, as the elasticity falls, price guarantees still weaken Sudden Stops but the globalization hazard-moral hazard tradeoff can have negative consequences for domestic welfare.

2.6 Conclusions

This chapter shows that, in the presence of globalization hazard caused by world capital market frictions, providing ex-ante price guarantees on emerging markets assets can be an effective means to contain Sudden Stops. The same theory predicts, however, that these guarantees create a form of international moral hazard that props up the foreign investors' demand for emerging markets assets. Hence, ex-ante price guarantees create a tradeoff between the benefits of undoing globalization hazard and the costs of international moral hazard.

The chapter borrows from Mendoza and Smith (2004) a dynamic, stochastic equilibrium model of asset prices in which the sources of globalization hazard are collateral constraints and asset trading costs. Collateral constraints are modeled as margin constraints that limit the ability of domestic agents to leverage foreign debt on equity holdings. Asset trading costs are incurred by foreign traders and take the form of per-trade costs and recurrent costs. In this environment, typical realizations of productivity shocks trigger margin calls when the economy's debt is sufficiently large relative to the value of its equity. Margin calls lead to fire sales of equity and a Fisherian deflation of asset prices. If domestic asset markets are relatively illiquid, the result is a Sudden Stop with reversals in consumption and the current account and a fall in asset prices.

This chapter introduced into the Mendoza-Smith model an IFO that offers foreign traders ex-ante guarantees to buy the emerging economy's assets at pre-announced minimum prices. The resulting international moral hazard distortion increases the foreign traders' demand for the emerging economy's assets by an amount that depends on the traders' conditional expected present value of the excess of guaranteed prices over market prices.

The chapter's quantitative analysis, based on a calibration to Mexican data, showed that guaranteed prices set to 1 percent above the fundamentals price in a low productivity state reduce significantly the Sudden Stop effects of globalization hazard, and eliminate the long-run probability of margin calls. If the guarantee is non-state-contingent, however, the IFO trades often (with a long-run probability of executing the guarantee of about 1/3), and there is persistent asset overvaluation above the prices obtained without globalization hazard. The IFO trades much less often, with a long run probability below 1/100, if the same guaranteed price is offered as a state-contingent guarantee that applies only at high debt levels. These state-contingent guarantees are just as effective at containing Sudden Stops and they do not cause persistent asset overvaluation.

The effectiveness of price guarantees to prevent Sudden Stops and increase social welfare hinges on the relative magnitudes of globalization hazard and international moral hazard. The price elasticity of world demand for domestic assets, which in the model depends on the size of per-trade costs, is the key determinant of both. The Fisherian deflation that governs globalization hazard depends on how much prices have to fall for foreign traders' to accommodate the fire sales of domestic assets. The moral hazard distortion increases foreign demand for domestic assets by an amount proportional to the price elasticity of this demand. With per-trade costs that yield an elasticity of 5, guaranteed prices set to 1 percent above the low-productivity fundamentals price result in domestic welfare gains when the economy hits a Sudden Stop, with negligible changes in long-run welfare. The value of foreign traders' firms in a Sudden Stop state falls slightly but its long-run average rises sharply. Hence, in this case the benefits of price guarantees to contain globalization hazard outweigh the costs of international moral hazard.

These results are reversed when per-trade costs yield an elasticity of world demand for domestic equity of . In this case, globalization hazard causes larger Sudden Stops and higher price guarantees are needed to contain them. However, even with guarantees set at to 1 percent above the low-productivity fundamentals price, which cannot prevent reversals in consumption and the current account, the moral hazard distortion is magnified significantly. Welfare gains for the emerging economy at Sudden Stop states are smaller, and the economy suffers non-trivial welfare losses in the stochastic steady state. In this case, price guarantees yield a short-term improvement in macroeconomic indicators and welfare because they weaken globalization hazard, but international moral hazard outweighs this benefit and causes a long-run welfare loss. This outcome can be altered increasing guaranteed prices (to fully offset Sudden Stop effects) and adjusting their state-contingent structure (to weaken the moral hazard distortion) at the same time.

The challenge to the IFO is to design ex-ante price guarantees that can yield better outcomes than those obtained without an instrument to contain Sudden Stops. The findings of our quantitative analysis illustrate the complexity of this task. An effective system of price guarantees requires a "useful" quantitative model of asset prices that can explain the features of Sudden Stops and provide assessments of the effects of the guarantees taking into account how they affect the optimal plans of forward-looking agents. This challenge also applies to ex-post price guarantees. The Lerrick-Meltzer and IMF proposals assume that a "useful" model sets sustainable levels of external debt and the "normal" and crash prices of an emerging economy's assets. This chapter makes some progress towards developing models that can be used for these purposes, but clearly there is a lot left for further research.

Figure 2.1: Equilibrium in the Date t Equity Market

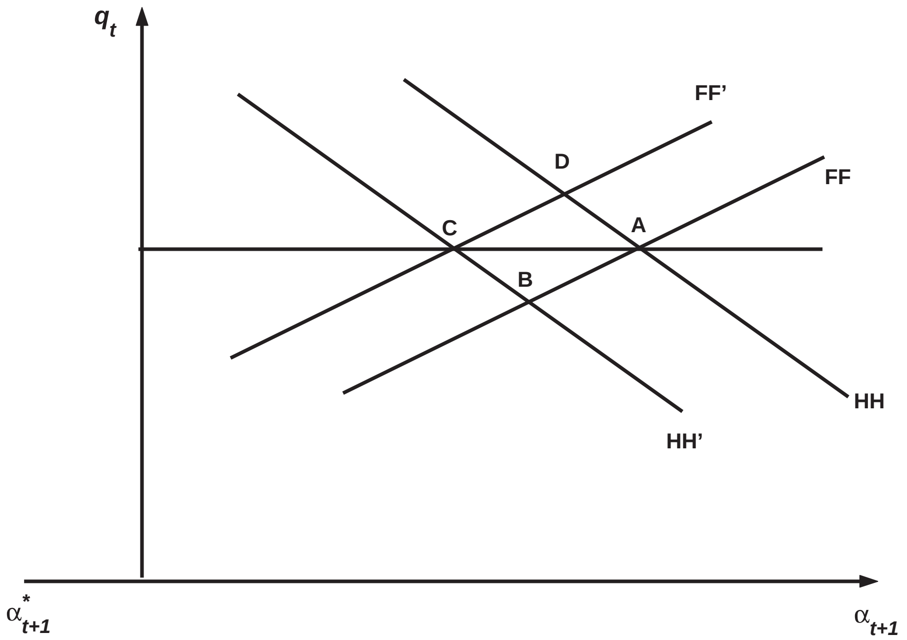
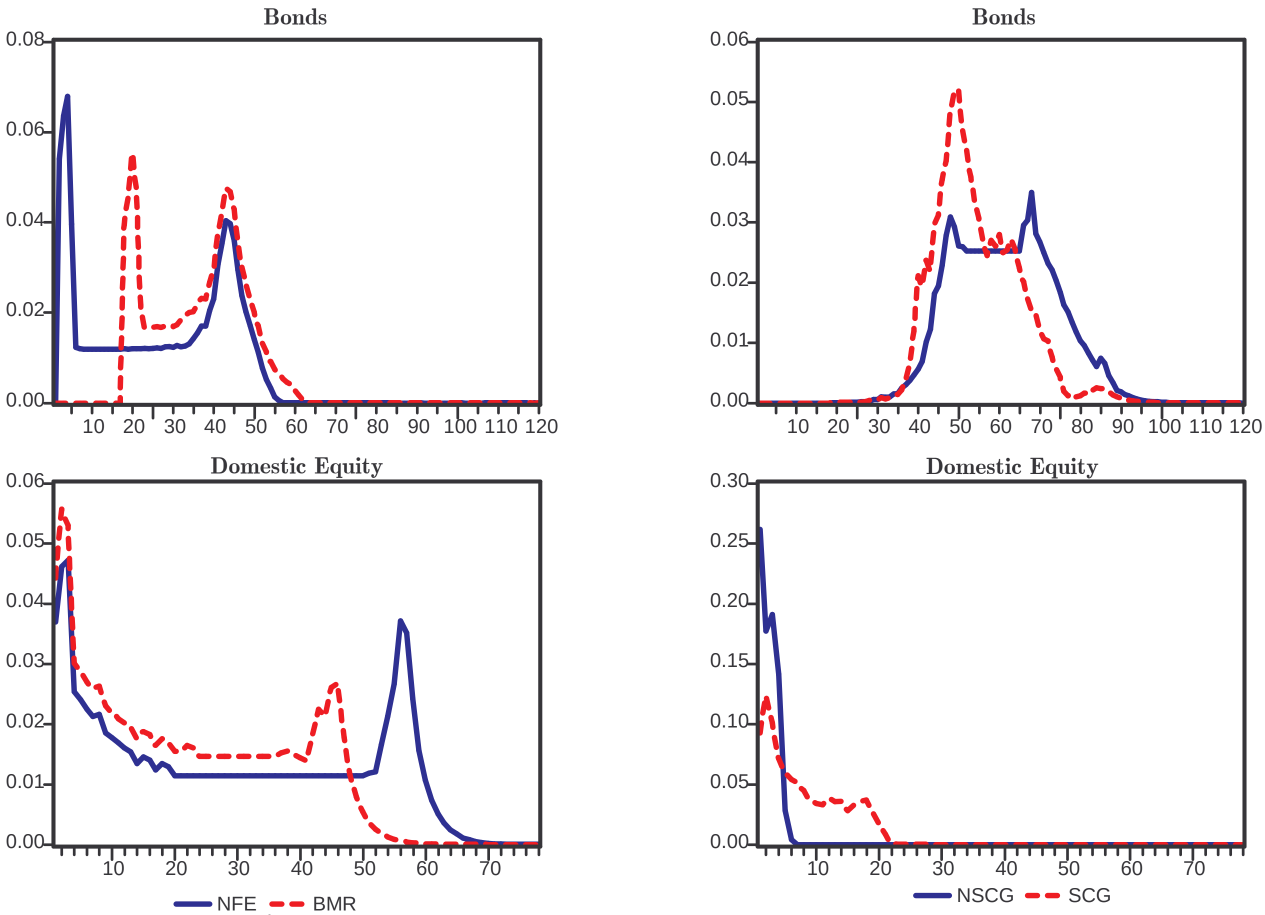
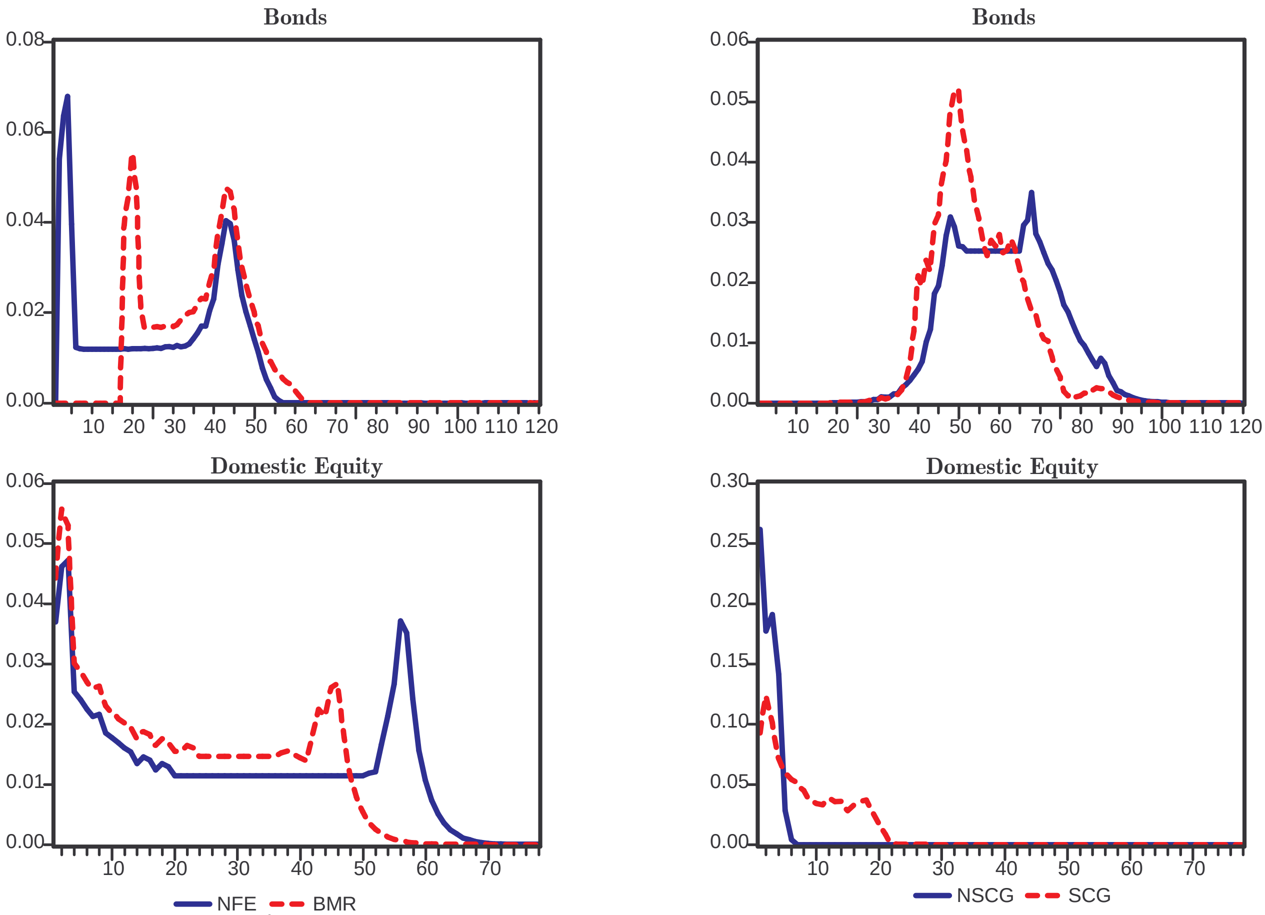


Figure 2.2: Ergodic Distributions of Domestic Equity and Bond Holdings



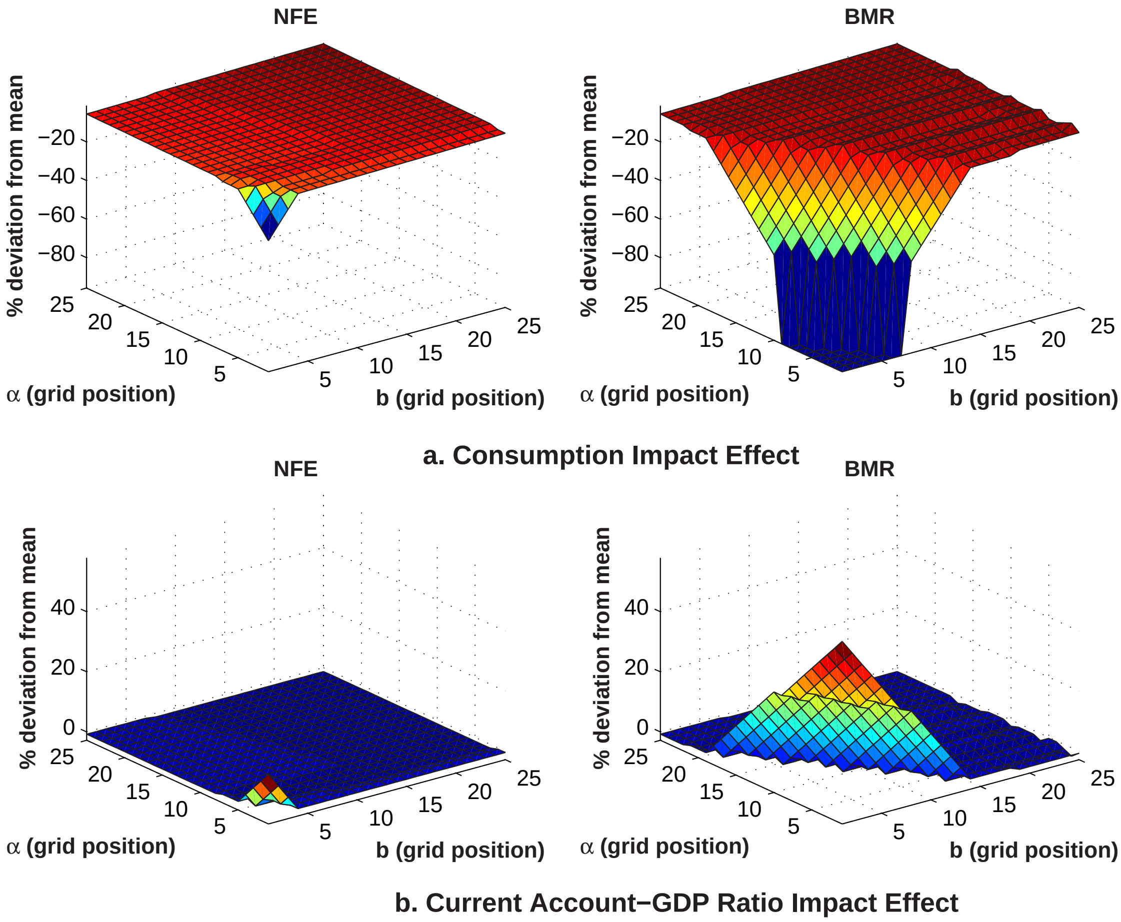
Note: NFE is nearly frictionless economy, BMR is economy with binding margin requirements, NSCG is economy with binding margin requirements and non-state-contingent guarantees, and SCG is economy with binding margin requirements and state-contingent guarantees.

Figure 2.3: Ergodic Distributions of Domestic Equity and Bond Holdings



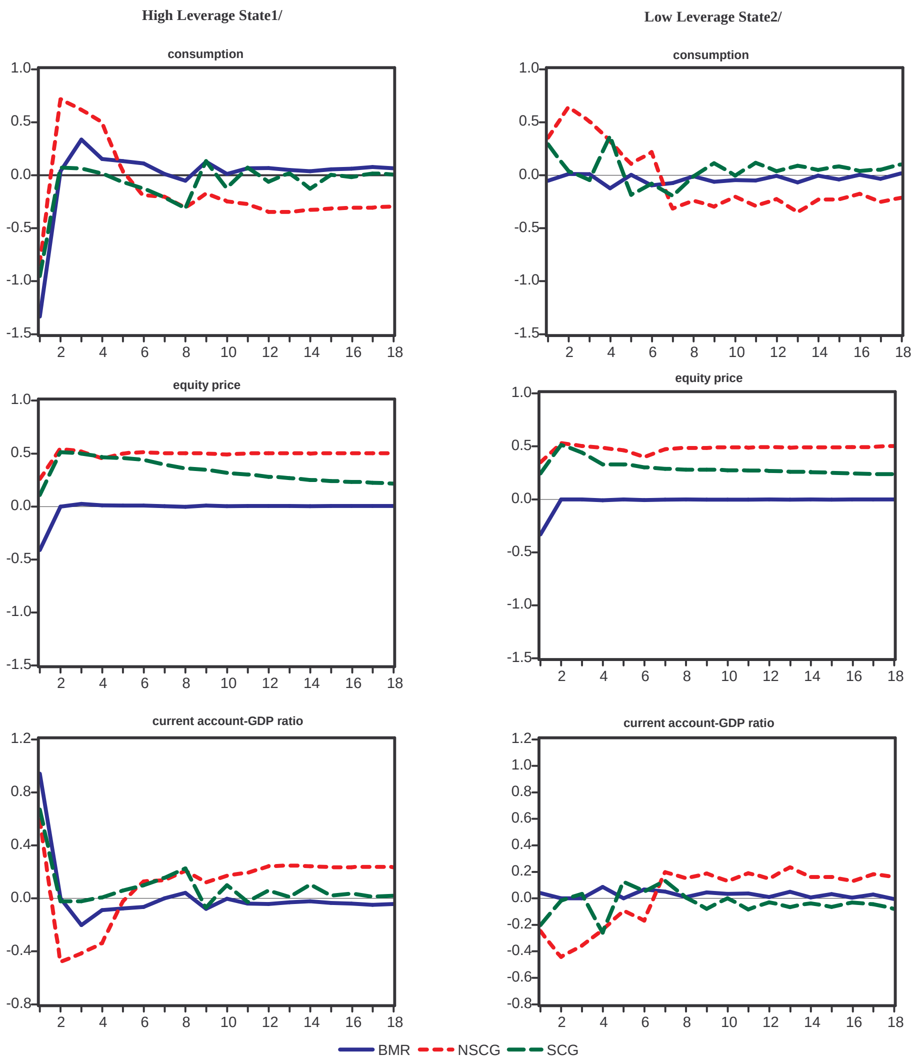
Note: NFE is nearly frictionless economy, BMR is economy with binding margin requirements, NSCG is economy with binding margin requirements and non-state-contingent guarantees, and SCG is economy with binding margin requirements and state-contingent guarantees.

Figure 2.4: Consumption & Current Account-GDP Ratio Impact Effects of a Negative Productivity Shock in the Sudden Stop Region of Equity & Bonds



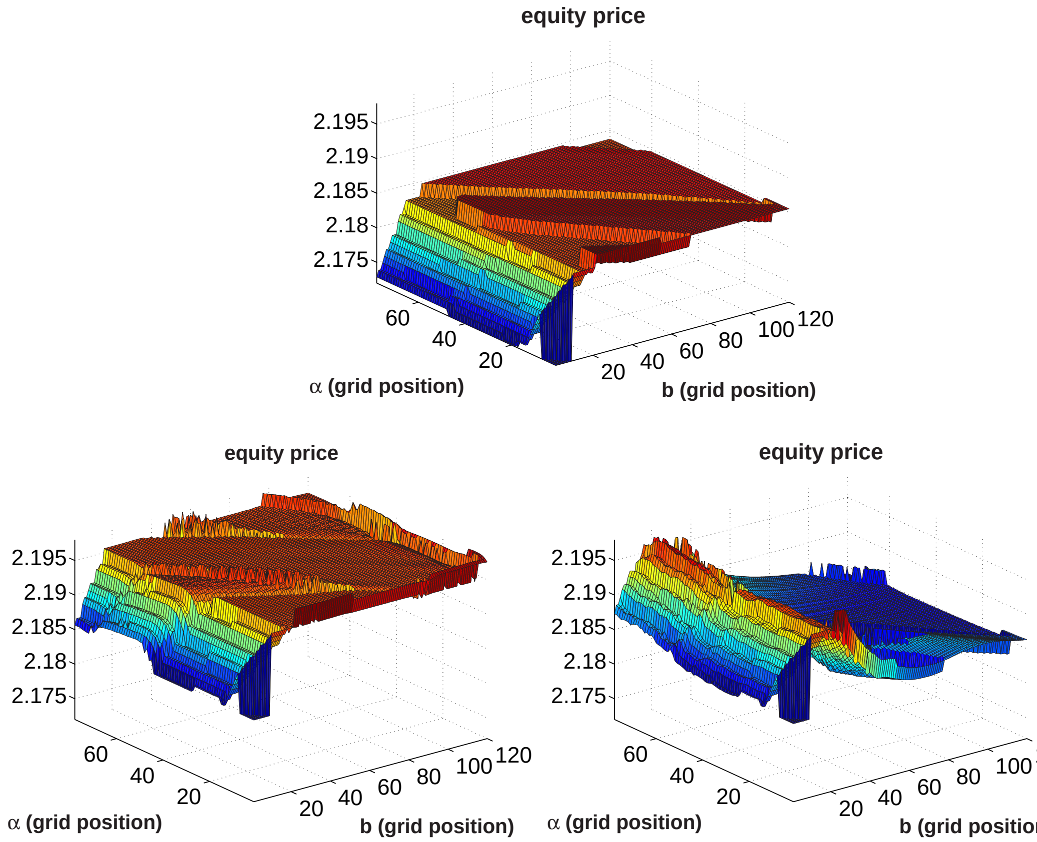
Note: The values are in percent deviations from long run average for consumption impact effects, and percentage point difference for current account-GDP ratio impact effects.

Figure 2.5: Conditional Responses to a Negative, One-Standard-Deviation Productivity Shock



1/ Forecasting functions of each variable's equilibrium Markov process conditional on initial states α=0.938 and b=-4.68, which imply a leverage ratio of 0.029 and a debt/GDP ratio of 0.597.
2/ Forecasting functions of each variable's equilibrium Markov process conditional on initial states α=0.938 and b=-3.38, which imply a leverage ratio of 0.021 and a debt/GDP ratio of 0.43

Figure 2.6: Equity Pricing Function in the Low Productivity State



Note: The top graph is the Economy with Binding Margin Requirements. The bottom left graph is the Economy with Non-State-Contingent Guarantees. The bottom right graph is the Economy with State-Contingent Guarantees

Table 2.1: Long Run Business Cycle Moments

Variable	mean	std. dev. (in %)	std. dev. rel. to GDP	correlation with GDP	first order autocorr.
I. NFE					
GDP	7.833	2.644	1.000	1.000	0.683
consumption	5.366	2.185	0.826	0.853	0.770
current account/GDP	0.000	1.347	0.509	0.979	0.660
trade balance/GDP	0.315	0.948	0.358	0.564	0.811
equity price	2.187	0.121	0.046	0.961	0.606
foreign debt-GDP ratio	0.177	56.694	21.442	-0.076	0.997
debt-equity ratio	0.010	2.888	1.092	0.000	0.001
II. BMR Economy (probability of binding margin constraints = 3.973%)					
GDP	7.833	2.644	1.000	1.000	0.683
consumption	5.365	2.186	0.827	0.856	0.771
current account/GDP	0.000	1.324	0.501	0.982	0.664
trade balance/GDP	0.315	0.940	0.355	0.565	0.823
equity price	2.187	0.121	0.046	0.962	0.609
foreign debt-GDP ratio	0.499	37.964	14.358	-0.118	0.994
debt-equity ratio	0.026	2.007	0.759	0.000	0.001
III. NSCG Economy (probability of binding margin constraints = 0.001%)					
GDP	7.833	2.644	1.000	1.000	0.683
consumption	5.362	2.052	0.776	0.790	0.724
current account/GDP	0.000	1.487	0.562	0.968	0.660
trade balance/GDP	0.315	1.111	0.420	0.631	0.750
equity price	2.198	0.099	0.037	0.891	0.384
foreign debt/GDP	1.336	41.053	15.526	0.001	0.992
debt-equity ratio	0.071	2.186	0.827	0.000	0.006
IV. SCG Economy (probability of binding margin constraints = 0.001%)					
GDP	7.833	2.644	1.000	1.000	0.683
consumption	5.364	2.121	0.802	0.834	0.765
current account/GDP	0.000	1.380	0.522	0.974	0.660
trade balance/GDP	0.315	1.000	0.378	0.599	0.788
equity price	2.188	0.121	0.046	0.903	0.630
foreign debt/GDP	1.114	34.141	12.912	-0.067	0.991
debt-equity ratio	0.059	1.810	0.685	0.000	0.004

Note: NFE is nearly frictionless economy, BMR is economy with binding margin requirements, NSCG is economy with binding margin requirements and non-state-contingent guarantees, and SCG is economy with binding margin requirements and state-contingent guarantees.

Table 2.2: Payoffs of Domestic Agents and Foreign Traders in Baseline Simulations

	NFE	BMR	NSCG	SCG
I. Long-run averages				
Domestic Agents				
Welfare cost 1/		0.017	0.062	0.057
Foreign Traders				
Present value of traders' returns	17.920	20.519	27.350	25.529
percent change w.r.t. NFE		14.499	52.621	42.460
Returns	0.280	0.321	0.427	0.399
(a) dividend earnings	0.280	0.320	0.427	0.399
(b) trading costs	1.1E-05	2.3E-05	8.8E-05	1.6E-04
II. High leverage Sudden Stop State				
Domestic Agents				
Welfare cost 1/		0.367	-1.036	-0.317
(a) short-run cost 2/		1.376	0.862	0.978
(b) long-run cost 3/		-1.010	-1.899	-1.295
Date-1 rate of time preference	1.58	1.56	1.57	1.57
Foreign Traders				
Present value of traders' returns	10.931	10.940	10.858	10.901
percent change w.r.t. NFE		0.082	-0.670	-0.276
Returns at date 0	-0.192	-3.770	-3.796	-3.791
(a) dividend earnings	0.166	0.166	0.166	0.166
(b) value of trades	0.359	3.927	3.953	3.948
(c) trading costs	1.6E-04	9.8E-03	9.8E-03	9.8E-03
III. Low leverage Sudden Stop State				
Domestic Agents				
Welfare cost 1/		0.215	-1.194	-0.393
(a) short-run cost 2/		0.055	-0.356	-0.293
(b) long-run cost 3/		0.160	-0.838	-0.100
Date-1 rate of time preference	1.59	1.59	1.59	1.59
Foreign Traders				
Present value of traders' returns	10.931	10.937	10.854	10.901
percent change w.r.t. NFE		0.055	-0.707	-0.272
Returns at date 0	-0.192	-3.056	-3.077	-3.074
(a) dividend earnings	0.166	0.166	0.166	0.166
(b) value of trades	0.359	3.215	3.237	3.234
(c) trading costs	1.6E-04	6.7E-03	6.7E-03	6.7E-03

1/ Compensating variation in date-0 consumption that equates expected lifetime utility obtained in the BMR, NSCG and SCG economies with that of the NFE.
2/ Compensating variation in date-0 consumption that equates date-0 period utility obtained in the BMR, NSCG and SCG economies with that of the NFE.
3/ Difference of total welfare cost minus short-run cost.

Table 2.3: Sensitivity Analysis

	Baseline	Prod. Shocks		Guarantees	Trading Costs	
	(I)	(II)	(III)	(IV)	(V)	(VI)
		$\rho = 0.8$	$\sigma_\varepsilon = 2.4\%$	1% above q^f	$\theta = 0.01$	$a = 2$
I. BMR Economy						
In. responses in high lev. st.						
consumption	-1.335	-1.380	-1.404	n.a.	-1.453	-3.059
current account/GDP	0.939	0.972	0.997	n.a.	1.023	2.157
equity price	-0.413	-0.413	-0.413	n.a.	-0.412	-4.324
traders' return	-4.529	-4.526	-4.526	n.a.	-4.522	-4.866
Moments of the ergodic dist.						
Prob. of bind. mar. cons. (%)	3.973	4.200	2.331	n.a.	16.740	19.444
Averages						
consumption	5.365	5.369	5.366	n.a.	5.369	5.378
equity price	2.187	2.187	2.187	n.a.	2.183	2.183
equity holdings	0.883	0.885	0.861	n.a.	0.906	0.907
Standard deviations (%)						
consumption	2.186	2.382	2.721	n.a.	2.169	2.454
current account/GDP	1.324	1.325	2.020	n.a.	1.432	1.428
equity price	0.121	0.184	0.100	n.a.	0.114	0.463
Domestic welfare loss1/						
high leverage state	0.367	0.361	0.389	n.a.	0.490	4.074
long-run average	0.017	0.013	0.012	n.a.	0.099	0.110
ΔPDV of traders' returns1/						
high leverage state	0.083	0.082	0.095	n.a.	3.448	0.924
long-run average	14.502	12.163	4.354	n.a.	34.519	27.531
II. NSCG Economy						
In. responses in high lev. st.						
consumption	-0.840	-0.875	-0.901	-0.503	-0.885	-2.205
current account/GDP	0.591	0.616	0.640	0.354	0.623	1.554
equity price	0.259	0.274	0.214	0.718	0.362	-3.256
traders' return	-4.562	-4.560	-4.561	-4.586	-4.561	-4.926
Moments of the ergodic dist.						
Prob. of bind. mar. cons. (%)	0.001	0.017	0.024	0.002	0.002	0.000
Prob. of executing guar.(%)	34.290	32.892	15.434	29.650	34.068	28.925
Averages						
consumption	5.362	5.365	5.360	5.361	5.362	5.362
equity price	2.198	2.199	2.198	2.208	2.198	2.206
equity holdings	0.844	0.844	0.844	0.842	0.844	0.842
expected PDV of excess prices	0.012	0.013	0.011	0.022	0.015	0.023
Standard deviations (%)						
consumption	2.052	2.269	2.615	2.014	2.047	2.191
current account/GDP	1.487	1.473	2.035	1.567	1.490	1.584
equity price	0.099	0.149	0.104	0.091	0.100	0.429
expected PDV of excess prices	2.083	3.913	4.235	1.375	1.368	1.466
Domestic welfare loss1/						
high leverage state	-1.036	-1.137	-1.033	-2.359	-1.025	1.506
long-run average	0.062	0.063	0.132	0.086	0.286	0.332
ΔPDV of traders' returns1/						
high leverage state	-0.670	-0.732	-0.660	-1.372	2.501	-0.459
long-run average	52.621	51.867	17.567	54.696	122.862	116.646

Table 2.3: Sensitivity Analysis (Continued)

	Baseline	Prod. Shocks		Guarantees	Trading Costs	
	(I)	(II)	(III)	(IV)	(V)	(VI)
		$\rho = 0.8$	$\sigma_\varepsilon = 2.4\%$	1% above q^f	$\theta = 0.01$	$a = 2$
III. SCG Economy						
In. responses in high lev. st.						
consumption	-0.952	-0.878	-0.988	-0.626	-0.920	-2.182
current account/GDP	0.670	0.618	0.702	0.440	0.648	1.538
equity price	0.107	0.270	0.105	0.550	0.313	-3.227
traders' return	-4.555	-4.560	-4.555	-4.586	-4.558	-4.928
Moments of the ergodic dist.						
Prob. of bind. mar. cons. (%)	0.001	0.014	0.042	0.009	0.013	0.000
Prob. of executing guar.(%)	0.035	0.261	0.391	0.502	6.063	3.245
Averages						
consumption	5.364	5.369	5.363	5.363	5.358	5.355
equity price	2.188	2.188	2.189	2.190	2.190	2.191
equity holdings	0.855	0.855	0.855	0.850	0.879	0.874
expected PDV of excess prices	0.002	0.002	0.011	0.003	0.007	0.009
Standard deviations (%)						
consumption	2.121	2.317	2.709	2.095	2.061	2.298
current account/GDP	1.380	1.369	2.028	1.420	1.466	1.536
equity price	0.121	0.187	0.120	0.137	0.154	0.469
expected PDV of excess prices	42.186	62.894	4.235	52.202	37.543	51.111
Domestic welfare loss1/						
high leverage state	-0.317	-0.481	-0.297	-0.869	-0.385	2.596
long-run average	0.057	0.053	0.033	0.054	0.086	0.121
ΔPDV of traders' returns1/						
high leverage state	-0.276	-0.359	-0.246	-0.567	2.985	0.167
long-run average	42.460	41.196	9.446	47.217	72.049	73.680

Note: The guaranteed price is 0.5 percent (1 percent for column (IV)) above the fundamentals price in the low productivity state of the baseline simulation. Welfare costs are compensating variations in initial consumption that equalize lifetime utility in each simulation with that of the corresponding NFE. Initial responses are in percent of the corresponding NFE and detrended as described in the text (except the response for traders' returns which is in percent of the capital stock and the response for the current account-output ratio which is the difference in percentage points relative to the corresponding NFE).
1/Percentage change relative to NFE

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