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Putting the Brakes on Sudden Stops:
The Financial Frictions-Moral Hazard Tradeoff of Asset Price Guarantees

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The hypothesis that Sudden Stops to capital inflows in emerging economies may originate in frictions inherent to global capital markets, such as collateral constraints and trading costs, suggests that Sudden Stops could be prevented by an international organization that offers ex-ante price guarantees on the emerging-markets asset class. Providing these guarantees is a risky endeavor, however, because they introduce a moral-hazard-like incentive similar to those that are viewed as another culprit behind emerging markets crises. This paper studies this financial frictions-moral hazard tradeoff using an equilibrium asset-pricing model in which margin constraints, trading costs, and ex-ante price guarantees interact in the determination of asset prices and macroeconomic dynamics. In the absence of price guarantees, margin calls and trading costs create distortions in asset markets that produce Sudden Stops driven by occasionally binding credit constraints and Irving Fisher's debt-deflation mechanism, as in the model proposed by Mendoza and Smith (2003). Price guarantees contain the asset deflation by creating another distortion that props up the foreign investors' demand for emerging markets assets. Quantitative simulation analysis shows the strong interaction of these two distortions in determining asset prices and the dynamics of consumption and the current account. Price guarantees are shown to be effective at containing Sudden Stops but at the cost of introducing potentially large distortions leading to 'overvaluation' of emerging markets assets.

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1. **Introduction**

The Sudden Stop phenomenon of emerging markets crises is characterized by three well-defined stylized facts: a sudden reversal of private capital inflows and current account deficits, a collapse in production and private absorption, and large price corrections in domestic relative goods prices and in asset prices. A large fraction of the literature aiming to explain this phenomenon is based on the premise that international capital markets are inherently imperfect, and hence prone to contagion and overreaction in the determination of asset positions and asset prices relative to levels consistent with "fundamentals" (see Arellano and Mendoza (2003) for a short survey of this literature). The findings of this literature suggest that in principle an international financial organization (IFO) could help prevent Sudden Stops by providing explicit ex-ante price guarantees for the emerging-markets asset class. A formal proposal for creating such a credit facility was put forward by Calvo (2002).

The goal of ex-ante price guarantees is to create a trading environment in which emerging-markets asset prices can be *credibly* expected to remain above the crash levels that trigger Sudden Stops driven by international capital market frictions. Calvo views this facility as keen to an open-markets operation facility: it would commit to exchange a liquid, riskless asset (e.g., short-term 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 price recovers. The optimal response of market participants would incorporate their expectations that these guarantees would be executed if a systemic fire-sale were to crash emerging-markets asset prices, and hence a properly-designed system of price guarantees could rule out rational expectations equilibria in which Sudden Stops driven by financial frictions can take place. If these frictions are the only source of Sudden Stops and the support of the probability distribution of the events that can cause Sudden Stops is known (i.e., if there are no truly "unexpected" shocks), the facility would rarely trade.

A potentially important drawback of the above system of price guarantees is that it would strengthen moral hazard incentives among global investors. Everything else the same, the introduction of the price guarantees would increase the foreign investors' demand for emerging markets assets, since the downside risk of holding them in bad states of nature is transferred to the IFO providing the guarantees. This can be a serious drawback of the ex-ante price guarantees because the moral hazard argument itself has been forcefully put forward as a competing explanation of Sudden Stops, and has been used to propose major reforms to the international financial system (see the report of the Meltzer Commission and the article by Lerrick and Meltzer (2001)).

Proponents of the moral hazard view argue that Sudden Stops are induced by excessive indebtedness of emerging economies driven by the expectation of private capital market participants that IFOs will bail out countries in financial difficulties. Based on this premise, Lerrick and Meltzer (2001) argue for 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 defaulted asset and would require the country to commit to re-purchase the asset at its crash price (making the commitment credible by having the IFO commit itself to buy the asset at a negligible discount below the crash price if the country were unable to buy it). If the only cause of Sudden Stops is moral hazard, the announcement of this arrangement should remove the moral hazard distortion and reduce debt levels, and in practice the arrangement itself would rarely be activated.

The tension between the financial frictions and moral hazard approaches to explain Sudden Stops and their proposals for price guarantees captures an important tradeoff that ex ante price guarantees create. On one hand, ex-ante price guarantees hold the promise of endowing IFOs with an effective policy tool to prevent and manage Sudden Stops driven by frictions affecting international capital markets. On the other hand, ex-ante guarantees could end up making matters worse by strengthening moral hazard incentives (even if it were true that capital market frictions were the only cause of the Sudden Stops of the last decade).

The financial frictions-moral hazard tradeoff implies that making the case for ex ante price guarantees requires their advocates to establish the possibility of designing price guarantees so that their benefits, in terms of undoing the distortions induced by financial frictions, outweigh their costs, in terms of promoting moral hazard. The goal of this paper is to design a quantitative framework to conduct this cost-benefit analysis using a dynamic, stochastic general equilibrium model of asset pricing and current account dynamics. The model is based on the setup proposed by Mendoza and Smith (2003), in which margin constraints and asset trading costs produce outcomes consistent with some of the features of a Sudden Stop. This paper adds to their framework guarantees offered to foreign investors on the asset prices of an emerging economy by an IFO. Quantitative simulation analysis is used to study how the price guarantees affect Sudden Stops and to quantify the financial frictions-moral hazard tradeoff involved in the use of ex-ante price guarantees. We are interested in particular in studying how price guarantees affect asset positions, the volatility of asset prices, the cyclical dynamics of an emerging economy, and the magnitude and probability of Sudden Stops.

Asset price guarantees have not been widely studied in quantitative equilibrium asset pricing theory, with the notable exception of the work by Ljungqvist (2000), and they 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 financial-frictions and moral-hazard hypotheses separately. From this perspective, one contribution of this paper is that it studies the interaction between these two hypotheses in a unified dynamic equilibrium framework from which we can derive quantitative predictions.

The Mendoza-Smith model that is used as starting point for the model of this paper is a model in which two financial frictions play a central role in determining the equilibrium asset prices and the dynamics of net foreign assets of an emerging economy: a margin constraint on foreign borrowing faced by the agents of the emerging economy, and trading costs incurred by foreign securities firms specialized in trading the equity of the emerging economy. Margin constraints and trading costs are intended to capture the collateral constraints and informational frictions that have been widely studied as determinants of Sudden Stops (see, for example, Calvo (1998), Izquierdo (2000), Calvo and Mendoza (2000), Caballero and Krishnamurty (2001), Mendoza (2004), Paasche (2001) and Schneider and Tornell (1999)).

This paper introduces asset price guarantees into the Mendoza-Smith model in the form of ex-ante guarantees offered to foreign investors on the return (or equivalently, the liquidation price) of the emerging economy's assets. An IFO offers these guarantees and finances them with a lump-sum tax on foreign investors. Both the agents in the emerging economy and foreign investors are aware of the IFO's guarantees policy when formulating their optimal asset demands. Hence, forward-looking equity prices reflect the effects of the margin constraints and trading costs as well as the effects of the 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 and extended to incorporate margin constraints and trading costs.

The policy on price guarantees has different implications depending on the level at which they are set. There are levels of the guarantees so low that they effectively never bind, thus making the model yield outcomes identical to those of the Mendoza-Smith model. At the other extreme, there are levels of the guarantees so high that they would always bind and would yield prices and asset allocations dominated by moral hazard incentives. The key region for the study of the financial frictions-moral hazard tradeoff of price guarantees is therefore the region in which the guarantees are "not too high and not too low." In this region, there is a non-trivial tradeoff between using the guarantees to undo the effects of the credit-market imperfections and strengthening the incentives for foreign investors to over-invest in the small open economy (or for the emerging economy to "over-borrow" from abroad).

The paper is organized as follows. Section 2 presents the model and characterizes the competitive equilibrium in the presence of margin constraints, trading costs and ex ante price guarantees. Section 3 studies key properties of this equilibrium that illustrate the nature of the financial frictions-moral hazard tradeoff of price guarantees. Section 4 represents the competitive equilibrium as a recursive, rational expectations equilibrium and proposes a solution algorithm. Section 5 conducts the quantitative analysis and Section 6 concludes.

2. The Analytical Framework

Consider a small open economy (i.e., the emerging economy) 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 emerging economy's equity, and can also access a global credit market of one-period bonds. In addition, an IFO operates a facility that provides price guarantees to foreign traders on their holdings of the emerging economy's equity. When foreign traders wish to liquidate the emerging economy's equity they can do so at either the current market price or the IFO's guaranteed price, whichever is higher. Dividend payments on the emerging economy's equity are stochastic and vary in response to exogenous shocks to domestic productivity. Since the probability distribution of equilibrium dividend payments is public knowledge, the IFO can setup price guarantees so as to effectively guarantee a minimum rate of return to foreign traders investing in the emerging economy. Markets of contingent claims are incomplete (because trading equity and bonds does not allow domestic households to fully hedge income uncertainty), and the credit market is imperfect (because of margin constraints and trading costs). Finally, the global credit market is also subject to exogenous shocks affecting the world-determined real interest rate.

(a) The Emerging Economy

The representative firm inside the small open economy produces a single 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 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 on the part of the firm yields standard marginal productivity conditions for labor demand and the rate of dividend payments (d):

$$w_t = \exp(\varepsilon_t)F_n(k,n_t) \qquad (1)$$

$$d_t = \exp(\varepsilon_t)F_k(k,n_t) \qquad (2)$$

The small open economy is inhabited by an infinitely-lived representative household. The household chooses intertemporal sequences of consumption (c), labor supply (n), equity holdings (α), and foreign bond holdings (b) so as to maximize Epstein's (1983) stationary cardinal utility function:

$$U(c,n)=E_0\left[\sum_{t=0}^{\infty}\exp\left\{-\sum_{\tau=0}^{t-1}v\left(c_\tau-h(n_\tau)\right)\right\}u\left(c_t-h(n_t)\right)\right] \tag{3}$$

This utility function is a time-recursive, Von Neumann-Morgenstern intertemporal utility index with an endogenous rate of time preference (it is the stochastic representation of the classic Uzawa utility function with endogenous discounting). The period utility function *u(.)* is a standard, concave, twice-continuously differentiable utility function. The function *v(.)* 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(.)* is an increasing, convex continuously differentiable function. Greenwood, Hercowitz and Huffman (1988) introduced this composite good as a way to eliminate the wealth effect on labor supply. As shown in Section 3, this property of preferences plays an important role in separating the equilibrium dynamics of wages, dividends, labor and output from those driving consumption, saving and portfolio choices.

The intertemporal utility function with endogenous time preference has the property that a change in date-t consumption has not only the standard effect on date-t marginal period utility, but also an "impatience effect," by which the change in date-t consumption alters the subjective discount rate at which all future period utility flows are discounted. Epstein showed that the size of this impatience effect is constrained by the conditions required for these preferences to be consistent with consumption behaving as a normal good in all periods and savings to be an increasing function of the economy's state variables.

Utility functions with endogenous impatience are commonly used in models of small open economies in order to obtain well-defined long-run equilibria for holdings of foreign assets in which the exogenous world real interest rate equals the long-run rate of time preference (see for example, Obstfeld (1981) or Mendoza (1991)).[1] In models with credit constraints like the one studied here, these preferences have the additional advantage that they can be used to support long-run equilibria in which credit constraints can be binding (see Arellano and Mendoza (2003) and Section 3 of this paper for details).

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

$$c_t = \alpha_t k d_t + w_t n_t + q_t(\alpha_t - \alpha_{t+1})k - b_{t+1} + b_t \exp(\nu_t) R \qquad (4)$$

where α_t and α_{t+1} are beginning and end-of-period shares of the domestic capital stock owned by domestic households, q_t is the price of equity, and ν_t is a Markov shock to the ex-post world real interest rate (i.e., a shock keen to inflation or devaluation risk on a nominal risk free asset such as the U.S. T-bill). In addition, international loan contracts incorporate a collateral constraint in the form of a margin clause by which the stock of foreign debt of the small open economy cannot exceed the fraction κ of the market value of the SOE's equity holdings:

$$b_{t+1} \geq -\kappa q_t \alpha_{t+1} k, \qquad 0 \leq \kappa \leq 1 \qquad (5)$$

Margin clauses of this form are widely used in international capital markets. In some instances they are imposed by regulators as a way to limit the exposure of financial intermediaries to idiosyncratic risk of their lending portfolio, but they are also widely used by investment banks and other lenders as a mechanism to manage default risk (they can take the form of explicit margin constraints linked to the value of specific securities offered as collateral or implicit margin requirements linked to the volatility of an asset class or subclass as those

[1] Arellano and Mendoza (2003) describe other alternatives used with a similar purpose in the literature, such as the Aiyagari-Hugget setup in which a constant rate of time preference is set lower than the world interest rate (so that precautionary savings pins down a well-defined ergodic distribution of wealth), or formulations of asset markets with ad-hoc world interest rate functions that depend on debt or long-run costs of adjustment in net foreign assets.

implied by value-at-risk collateralization). Margin clauses are a particularly effective collateral constraint (compared to constraints like the well-known Kiyotaki-Moore constraint that limits debt to the discounted liquidation value of assets one period ahead) because: (a) custody of the securities that constitute the 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 value at which they were marked.

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 have a non-trivial role. 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.

(b) 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 small open economy's equity. The securities firm maximizes its net present value discounted at the stochastic discount factors relevant for its international clients (i.e., the world interest rate). Thus, the foreign traders' problem is to choose their sequence of equity holdings α_{t+1}^*, for $t = 1,\ldots,\infty$, so as to maximize

$$D = E_0\left[\sum_{t=0}^{\infty} M_t^*\left(\alpha_t^* k\left(d_t + \max(q_t, \tilde{q}_t)\right) - q_t\alpha_{t+1}^* k - q_t k\left(\frac{a}{2}\right)\left(\alpha_{t+1}^* - \alpha_t^* + \mathrm{I}_t\theta\right)^2 - kT_t^*\right)\right] \quad (6)$$

where $M_0^* \equiv 1$ and M_t^* for $t = 1,\ldots,\infty$ is given by $M_t^* = R^{-t}\exp\left(-\sum_{i=0}^{t} v_i\right)$.

The total net return paid by the foreign securities firm to its shareholders at each date *t* is the sum of: (a) dividends collected on its share of the small open economy's capital ($\alpha_t^* k d_t$), plus

(b) proceedings from the sale of equity holdings ($\alpha_t^* k \max(q_t, \tilde{q}_t)$), which are executed at either the market price q_t or at the guaranteed price $\tilde{q}_t$, whichever is greater, minus (c) new equity purchases ($q_t \alpha_{t+1}^* k$), minus (d) total trading costs, which in turn include a cost that depends on the size of net trades ($\alpha_{t+1}^* - \alpha_t^*$) and a recurrent trading cost ($I_t \theta$), minus (e) lump sum taxes paid to the IFO (kT_t^*) . Trading costs are specified in quadratic form, as is typical in the equilibrium asset pricing literature on trading costs, so a is a standard adjustment-cost coefficient. I_t is an indicator variable such that $I_t = 1$ if $\max(q_t, \tilde{q}_t) = q_t$ and $I_t = z$, for $0 \leq z \leq 1$, otherwise. This indicator variable is introduced to capture the possibility that price guarantees could affect the foreign traders' recurrent costs (as foreign traders relying on price guarantees may, for example, cut expenses in acquiring and processing country-specific information).

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:

$$kT_t^* = \max\left(0, \left(\tilde{q}_t - q_t\right)\alpha_t^* k\right) \tag{7}$$

If the price 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 price guarantee (i.e., the extra income that foreign traders earn by selling equity to the IFO instead of selling it in the equity market).

Notice that since the return on equity is $R_t^q \equiv [d_t + q_t]/q_{t-1}$, and the vector of possible realizations of dividends at t and the value of q_{t-1} are known at each date t, the IFO's offer to guarantee the date-t price implies a guaranteed minimum *return* on the emerging economy's equity. The implied guaranteed rate of return is defined as: $\tilde{R}_t^q = \left[\tilde{q}_t + d_t\right]/q_{t-1}$. Alternatively, the IFO could fix a guaranteed return and foreign traders could then determine the implied schedule of implicit price guarantees that is consistent with the guaranteed return.

(c) Equilibrium

A competitive equilibrium for this model economy is made of the stochastic intertemporal sequences for the allocations $\left[c_t, n_t, b_{t+1}, \alpha_{t+1}, \alpha^*_{t+1}, T^*_t\right]_{t=0}^{\infty}$ and prices $\left[w_t, d_t, q_t\right]_{t=0}^{\infty}$ such that: (a) the household maximizes the utility function (3) subject to the constraints (4) and (5) and the short-selling constraint, taking prices, wages and dividends as given, (b) domestic firms maximize profits by satisfying equations (1) and (2), taking wages and dividends as given, (c) the foreign securities firm maximizes (6) taking the price of equity, the price guarantees and lump-sum taxes as given, (d) the budget constraint of the IFO in equation (7), holds and (e) the equity market clears (i.e., $\alpha_t + \alpha_t^* = 1$ for all t). In Section 4, the recursive representation of this rational expectations equilibrium is exploited to design a numerical solution algorithm.

3. Characterizing the Financial Frictions-Moral Hazard Tradeoff

The tradeoff between the distortions introduced by margin constraints and trading costs and those introduced by the price guarantees can be illustrated by studying the conditions that determine the optimal decisions of domestic households and foreign traders. Consider first the domestic households. The first-order conditions of their maximization problem are:

$$U_{C_t}(c,n) = \lambda_t \tag{8}$$

$$h'(n_t) = w_t \tag{9}$$

$$q_t\left(\lambda_t - \eta_t \kappa\right) = E_t\left[\lambda_{t+1}(d_{t+1} + q_{t+1})\right] + \upsilon_t \tag{10}$$

$$\lambda_t - \eta_t = E_t\left[\lambda_{t+1} \exp(\nu_{t+1}) R\right] \tag{11}$$

In these expressions, $U_{c_t}(c,n)$ is the derivative of the stationary cardinal utility 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 (8) has the standard interpretation: at equilibrium, the marginal utility of wealth equals the lifetime marginal utility of consumption. Condition (9) equates the marginal disutility of labor with the real wage. This is the case because the Greenwood-Hercowitz-Huffman 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 (9) together with (1) and (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 neutrality of the financial frictions with regard to the "supply side" of the domestic economy follows from strong assumptions but it simplifies significantly the solution of the model by separating the equilibrium path of dividends from the savings and portfolio decisions. Mendoza (2004) studies the business cycle implications of margin constraints in a small-open-economy model with endogenous investment in which the credit constraints affect dividends, investment and the Tobin Q, but abstracting from international equity trading.

Conditions (10) and (11) are Euler equations for the accumulation of equity and bonds respectively. Following Mendoza and Smith (2003), 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:

$$q_t = E_t\left(\sum_{i=0}^{\infty}\left[\prod_{j=0}^{i}\left(1-\frac{\eta_{t+j}}{\lambda_{t+j}}\kappa\right)^{-1}\right]M_{t+1+i}\,d_{t+1+i}\right) \qquad (12)$$

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

$$E_t\left[R^q_{t+1}\right] - R_{t+1} = \frac{\eta_t(1-\kappa) - \dfrac{\upsilon_t}{q_t} - COV_t(\lambda_{t+1}, R^q_{t+1})}{E_t[\lambda_{t+1}]} \tag{13}$$

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

$$q_t = E_t\left(\sum_{i=0}^{\infty} \left[\prod_{j=0}^{i} \left(E_t\left[R^q_{t+1+j} \right] \right)^{-1} \right] d_{t+1+i} \right) \tag{14}$$

Expressions (12)-(14) show the *direct* and *indirect* effects that margin calls have on the demand for equity of the small open economy, and thus on its valuation of equity and excess returns. The direct effect of a date-*t* margin call is represented by the term $\eta_t(1-\kappa)$ in (13), or the term $\eta_t\kappa$ in (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). The 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.

If domestic agents facing margin calls trade assets in a frictionless, perfectly-competitive market in which the world demand for the emerging economy's assets is infinitely-elastic at the level of the fundamentals price, the margin call would trigger a small portfolio reallocation effect without any price movement. However, if the world demand for the emerging economy's assets is less than infinitely-elastic, the equilibrium asset price would fall. Since households were already facing a binding margin constraint at the initial price, the price decline would tighten further the margin constraint triggering a new round of margin calls. This downward spiral in equity prices is a variant of Fisher's debt-deflation mechanism. The Fisherian deflation magnifies the direct and indirect effects of the margin constraint.

The world demand for assets of the emerging economy is less than infinitely-elastic because of the trading costs incurred by the foreign securities firm. Define the fundamentals asset price q_t^f as the conditional expected value of the stream of dividends discounted using the stochastic world interest rate, $q_t^f \equiv E_t\left(\sum_{i=0}^{\infty} M^*_{t+1+i} d_{t+1+i}\right)$. The first-order condition for the optimization problem of the foreign traders implies then the following asset demand function:

$$\left(\alpha^*_{t+1} - \alpha^*_t\right) = \frac{1}{a}\left(\frac{q_t^f}{q_t} - 1 + \frac{E_t\left[\sum_{i=1}^{\infty} M_{t+i}{}^*\left(\max(q_{t+i}, \tilde{q}_{t+i}) - q_{t+i}\right)\right]}{q_t}\right) - I_t\theta \tag{15}$$

This expression states that the foreign traders demand for the emerging economy's assets is an increasing function of (a) the percent deviation of q_t^f relative to q_t (with an elasticity equal to $1/a$) and (b) the expected present discounted value of the price guarantees in units of today's equity price.[2] The first effect reflects the influence of the per-trade trading costs. If trading were costless and recurrent costs were zero, the foreign traders' demand function would be infinitely-elastic at the fundamentals price and, as explained earlier, margin calls could not

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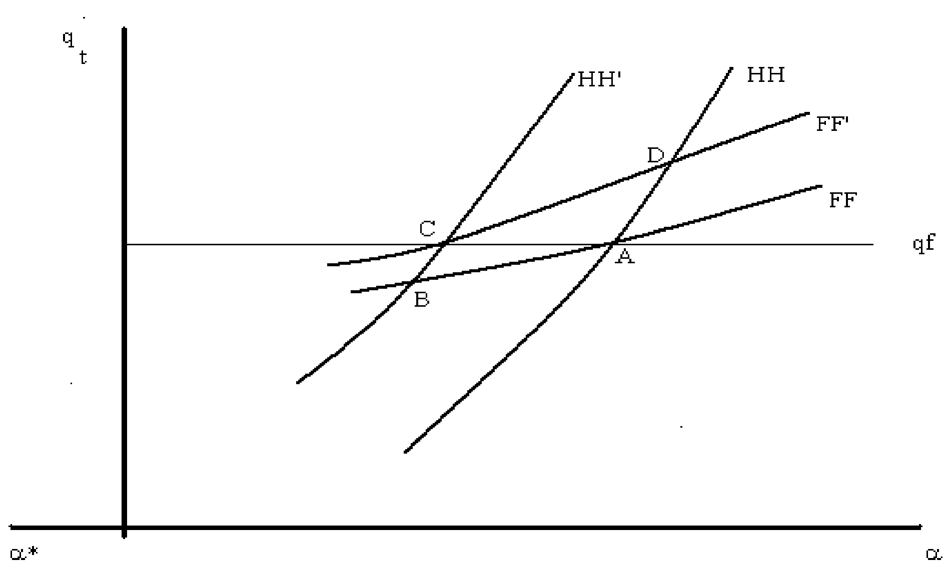
[2] The present value of the price guarantees has an equivalent representation in terms of the present value of the implied guaranteed returns $E_t\left[\sum_{i=1}^{\infty} M_{t+i}{}^* s_{t+i}\left(q_{t+i}\left[\tilde{R}_{t+i} - R^q_{t+i}\right]\right)\right]$, with $s_{t+i}=1$ if the guaranteed price exceeds the market price and $s_{t+i} = 0$ otherwise.

distort asset prices. The second effect represents the "moral hazard effect" of the price guarantees, which acts as a "demand shifter" in 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 the emerging economy's assets at date *t* than they would in a market without price guarantees. The recurrent trading costs are also a demand shifter (the foreign trader's demand function is lower the higher is θ).

Putting together the previous results, the tradeoff between the distortions created by the financial frictions and those induced by the moral hazard effect 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 1.

Figure 1. Equilibrium in the Date-t Asset Market



The demand function of foreign traders is simply the reduced form solved for in (15), shown as an upward-sloping curve because the horizontal axis measures α, which is the complement of α*. There is no closed-form solution for *HH*, so the depicted curve is intended only to facilitate intuition. We follow Aiyagari and Gertler (1999) in plotting *HH* as an upward-sloping curve because domestic agents respond to wealth, intertemporal-substitution and portfolio-composition effects in choosing their equity holdings. Depending on which effect dominates, *HH* can be downward or upward slopping.

Suppose that a margin call hits domestic agents because an adverse shock hits the economy when their level of debt is "sufficiently high" relative to the value of their asset holdings. As a result, the *HH* curve shifts to *HH'*. In Figure 1, *HH'* represents the "final" demand function, including the magnification effects 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 a decline in asset prices and adjustments in the current account and consumption.

Enter now an IFO that sets a price guarantee higher than the market price at B. Since the guarantee is triggered, the foreign traders' demand curve shifts to *FF'* and the new date-*t* 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. If the guarantee is "too low" (i.e., below the price at B) it would have no effect on the equilibrium price implied by the financial frictions, and thus price guarantees would be irrelevant. If the guarantee is "too high" it could lead to a price higher than the fundamentals price with the "overpricing" even larger than the "underpricing" that occurs at C.[3] Hence, ex-ante price guarantees do not necessarily reduce the volatility of asset prices (as the numerical analysis of Ljungqvist (2000) shows).

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[3] This is under the assumption that the guarantees are used to stabilize asset prices. If the aim is to stabilize portfolio holdings (i.e., portfolio flows) then the IFO would want to set price guarantees to yield prices higher than at C.

Interestingly, Figure 1 illustrates an outcome in which, even tough the moral hazard effect props up the foreign traders' asset demand for any given price, at equilibrium domestic agents are the ones that end up owning more domestic assets relative to the equilibrium without price guarantees. Domestic agents hold more equity at C (with binding margin constraints and price guarantees) than at B (with binding margin constraints and no guarantees), or at D (with price guarantees and non-binding margin constraints) than at A (without price guarantees and non-binding margin constraints). This is the case because the demand function of domestic agents is upward-slopping and steeper than the foreign traders' demand curve, so when foreign traders increase their demand for equity bidding up the price, domestic agents have a lower demand elasticity and thus end up buying more equity. In this case, and if the margin constraint binds, this higher level of domestic equity holdings also means that the domestic economy's foreign debt would be higher than in the absence of the guarantees. Thus, the model can predict that price guarantees offered to *foreign traders* lead to excessive holdings of equity and excessive borrowing by *domestic agents*.

From the perspective of the full dynamic stochastic general equilibrium model, Figure 1 is just 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. Hence, determining the effects of the price guarantees on the dynamics of consumption, bond holdings, equity holdings and equity prices is a difficult task. Moreover, assessing the net benefit of trading off the potential gain of containing Sudden Stops caused by financial frictions for the potential loss resulting from the distortion of the moral hazard effect of price guarantees requires mapping these outcomes into welfare effects. The latter can be measured by the standard compensating variations in consumption that reflect changes in lifetime utility under alternative equilibrium outcomes. Given the lack of closed-form solutions for the model's equilibrium dynamics, the only way to deal with these issues is by exploring the quantitative implications of the model via numerical simulation.

4. The 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 observed values of the shocks to productivity and the world interest rate listed in the vector $x = [\varepsilon, \nu]$. The state space of asset positions spans the discrete grid of NA elements $A=\{\alpha_1<\alpha 2<\ldots<\alpha_{NA}\}$ with $\alpha_1=\chi$, and the state space of bonds spans the discrete grid of NB elements $B=\{b_1<b_2<\ldots<b_{NB}\}$. The endogenous state space is thus defined by the discrete set $Z = \mathrm{A} \times \mathrm{B}$ of NA×NB elements. Productivity and interest-rate shocks follow asymptotically-stationary, two-point Markov chains with realizations $\mathrm{E}=\{\varepsilon_\mathrm{L} < \varepsilon_\mathrm{H}\}$ and $\mathrm{V}=\{\nu_\mathrm{L}<\nu_\mathrm{H}\}$. The exogenous state space is thus defined by $\mathrm{X}= \mathrm{E}\times\mathrm{V}$ and consists of the 4 combinations of the values that the two shocks can take.

Equilibrium wages, dividends, labor and output are determined by solving the supply-side system given by equations (1), (2), (9) and the production function. The solutions can be represented as functions of the state space that depend only on the realizations of ε. To simplify notation, these equilibrium outcomes are expressed as functions of the vector of realizations of the two shocks, $w(x)$, $d(x)$ and $n(x)$, even though they are independent of interest-rate shocks.

Assume a continuous, nonnegative asset pricing function that is taken as given by foreign traders and agents in the emerging economy. This conjectured pricing function maps the state space into equity prices $\hat{q}(\alpha,b,x): X \times Z \rightarrow R^{+}$. Take as given also conjectured decision rules for assets and bonds: $\hat{\alpha}'(\alpha,b,x), \hat{b}'(\alpha,b,x): X \times Z \rightarrow R^{+}$. For any initial state *(α,b,x)*, the conjectured pricing function must satisfy $\hat{q}(\alpha,b,x) \in \left[q^{\min}(\alpha,b,x), q^{\max}(\alpha,b,x)\right]$, where:

$$q^{\min}(\alpha,b,x) = \left[q^{f}(x) + G(\alpha,b,x)\right] \Big/ \left[1 + a\left(\alpha - \chi + I(\alpha,b,x)\theta\right)\right] \quad (16)$$

$$q^{\max}(\alpha,b,x) = \left[q^{f}(x) + G(\alpha,b,x)\right] \Big/ \left[1 + a\left(\alpha - \alpha_{NA} + I(\alpha,b,x)\theta\right)\right] \quad (17)$$

and *G(α,b,x)* represents the expected present discounted value of the price guarantees as a function of the state (which can computed via backward recursion using $\hat{\alpha}'(\alpha,b,x)$, $\hat{b}'(\alpha,b,x)$ and $\hat{q}(\alpha,b,x)$). The above prices are the maximum and minimum asset prices along the foreign traders' demand curve for a state (*α,b,x*). These bounds of the pricing function follow from the fact that when domestic agents hit either the short-selling constraint or the upper bound α_{NA}, the foreign traders are at the "short side" of the market.

Given the above conjectured decision rules and pricing function, the recursive equilibrium can be characterized in two ways. One approach is an extension of the setup of iterations on the asset pricing function "outside" the optimization problem of the small open economy proposed by Arellano and Mendoza (2003) and Mendoza and Smith (2003). This approach uses the foreign trader's demand function and the market-clearing condition in the asset market to construct a conjectured law of motion of equity holdings, and solves a dynamic programming problem only on bond holdings for the small open economy given that law of motion and the conjectured pricing function. This dynamic programming problem yields optimal consumption plans for domestic agents and these plans are used to compute an "actual" pricing function that can be compared with the conjectured pricing function. The conjectured is then updated with a Gauss-Siedel rule and the process repeated until the conjectured and actual pricing functions satisfy a convergence criterion.

Iterations on the pricing function "outside" the optimization problem of the small open economy have the disadvantage that they take several hours to compute and may not converge to small errors. This is because the algorithm is solving for a fixed point by seeking stable convergence to equilibrium prices that clear the equity market starting from an arbitrary starting pricing function. Hence, the second approach to represent the equilibrium of the model in recursive form appeals to a quasi-planning problem that yields a more efficient solution method in which asset prices are computed without error and the contraction-mapping properties of the Bellman equation are exploited to speed convergence.

The quasi-planning-problem approach starts with the same conjectured function representing the expected present value of price guarantees, $G(\alpha,b,x)$, computed as indicated earlier. Given this, the optimal plans of domestic agents are represented as the solution to the following dynamic programming problem:

$$V(\alpha,b,x)=\max_{\alpha',b'}\left\{u\left(c-h\left(n(x)\right)\right)+\exp\left(-v\left(c-h\left(n(x)\right)\right)\right)E\left[V\left(\alpha',b',x'\right)\right]\right\} \tag{18}$$

subject to:

$$c=\alpha k d(x)+w(x)n(x)+\frac{q^{f}(x)+G(\alpha,b,x)}{1+a\theta+a(\alpha-\alpha')}k\left(\alpha-\alpha'\right)-b'+b\exp(\nu)R \tag{19}$$

$$b'\geq-\kappa\frac{q^{f}(x)+G(\alpha,b,x)}{1+a\theta+a(\alpha-\alpha')}\alpha' k \tag{20}$$

In this formulation, domestic agents choose both equity and bond positions. Equity prices have been displaced with the prices along the demand curve of foreign traders by imposing market clearing in the equity market and solving for the equity prices implied by equation (15).

Once the above dynamic programming problem is solved, the resulting optimal plans for equity holdings are combined with the foreign traders' demand function to derive the "actual" asset pricing function for the given initial conjecture of *G(.)*. The decision rules for bonds and equity and this "actual" asset pricing function are then used to solve for the "actual" price guarantees function $G(\alpha,b,x)$ (i.e., the function that returns the expected present discounted value of the difference between "actual" and guaranteed prices conditional on any initial triple (α,b,x)). The conjectured and actual price guarantees functions are then combined to create a new conjecture of $G(\alpha,b,x)$ using a Gauss-Siedel rule and the procedure starts again with the Bellman equation. The process is repeated until the actual and conjectured price guarantees functions converge, so that the conjectured price guarantees function $G(\alpha,b,x)$ that is taken as given in the dynamic programming problem is consistent with the actual price guarantees function implied by the asset price and policy functions that are the endogenous outcomes of that problem.

The drawback of the quasi-planning-problem method is that in principle it represents the equilibrium of a market in which the emerging economy is keen to a Stackelberg leader that internalizes the demand function of foreign traders. Analysis of the Benveniste-Sheinkman equations of the dynamic programming problem shows that, comparing the Euler equations for bonds and equity of the competitive equilibrium with those of the quasi planning problem, this feature does not distort the Euler equation for bonds but it does distort the one for equity. The distortion has an ambiguous sign and depends on how much the equity price along the foreign traders' demand curve varies with α and α'. However, the distortion can be quantified and compared with the residual pricing error of the pricing-function-iterations algorithm. There is therefore a tradeoff between a method that solves the competitive equilibrium with error in the pricing function and a method that yields a pricing function without error but does so by deviating from the competitive equilibrium. For small values of a (i.e., when the price elasticity of the foreign traders' demand function is high), the quasi planning problem yields optimal plans that are a closer match to the Euler equations of the competitive equilibrium. Since this method is also considerably faster, we chose to use the quasi-planning-problem method.

The optimal decision rules obtained after the solution method converges constitute a recursive, rational expectations equilibrium for the model. At this recursive equilibrium, the decision rules determining asset holdings, bond holdings, consumption, labor, wages, dividends, the foreign traders' asset holdings and the asset prices are such that: (a) given wages and dividends, the policy functions for c, b', α' and n maximize household utility and firm profits in the small open economy subject to the relevant constraints, (b) given asset prices and dividends, the choices for α'^* solve the maximization problem of foreign traders, (c) the IFO's budget constraint holds and (e) the market-clearing conditions for assets, goods and labor markets hold.[4]

5. Quantitative Analysis

The functional forms adopted to represent preferences and technology are the same as in Mendoza and Smith (2003):

$$F\left(k,n_t\right)=k^{1-\gamma}n_t^{\gamma}, \qquad 0\leq\gamma\leq1 \tag{21}$$

[4] These properties are easy to prove noting that: (i) the Benveniste-Sheinkman equations of the Bellman equation in (18) yield the Euler equation for bond holdings of the competitive equilibrium and ensure that the Euler equation for asset holdings is satisfied up to the error implied by the distortion that depends on the price elasticity of the foreign trader's demand curve, (ii) the wage, dividend and labor functions reflect optimal decisions by households and domestic firms, (iii) the optimality condition for the maximization problem of foreign traders holds (i.e., prices and allocations satisfy the foreign trader's demand curve), and (iv) the constraints (19) and (20) combined with results (i)-(iii) ensure that the market clearing conditions, the households' budget constraint, and the margin constraint hold.

$$u\left(c_t - h\left(n_t\right)\right) = \frac{\left[c_t - h\left(n_t\right)\right]^{1-\sigma} - 1}{1-\sigma}, \quad \sigma > 1 \tag{22}$$

$$v\left(c_t - h\left(n_t\right)\right) = \beta\left[Ln\left(1 + c_t - h\left(n_t\right)\right)\right], \qquad 0 < \beta \leq \sigma \tag{23}$$

$$h\left(n_t\right) = \frac{n_t^{\delta}}{\delta}, \qquad \delta > 1 \tag{24}$$

The parameter γ is the share of output allocated to labor payments, 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 determines the elasticity of the supply of labor with respect to the real wage (which is equal to $1/(\delta\text{-}1)$). The condition $0<\beta\leq\sigma$ comes from Epstein (1983).

Calibration to Mexican Data

The calibration strategy differs from the one adopted by Mendoza and Smith (2003). Their calibration normalizes the capital stock to $k=1$ and lets the steady-state equity price adjust to the value implied by the asset pricing condition given a set of parameter values that were directly inferred from the data or set to enable the model to match key ratios of national accounts statistics. Here, we normalize the steady-state equity price so that the capital stock matches the deterministic, steady-state capital stock of a typical RBC small open economy model calibrated to Mexican data (as in Mendoza (2004)). The details of this calibration procedure are provided below.

The risk aversion parameter does not appear in the model's deterministic steady-state conditions. This parameter is set at $\sigma=2$ to be in line with values often used in RBC studies of small open economies.

The parameter values that enter into the supply-side system are determined as follows. The labor share is set at $\gamma=0.65$, which is 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 do a poor job at measuring proprietors income and other forms of labor income (for further details on the controversy regarding labor shares in Mexico see Mendoza (2004)). The real interest rate is set at 6.5 percent, which is the value widely used in the RBC literature. Since the model is set to a quarterly frequency, this implies that the gross real interest rate is $R=1.065^{1/4}$. The labor disutility coefficient is kept at the same value as in Mendoza and Smith (2003), $\delta=2$, which implies a unitary wage elasticity of labor supply.

As in the typical calibration exercise of RBC analysis, the calibration is designed to yield a set of parameter values such that the model's deterministic steady state matches the time-series averages of the GDP shares of consumption (*sc*), investment (*si*), government purchases (*sg*) and net exports (*snx*) from the data. 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 endogenous 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 exogenous expenditures constant at 28.2 percent of steady state output.

The typical RBC model of the small open economy features a standard steady-state optimality condition that equates the marginal product of capital net of depreciation to the world interest rate, and a standard law of motion for 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 can be combined to yield implied 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 the value of *sk* is about 2.5 (or 10.08 on a quarterly basis).

In a deterministic steady state of the model of this paper in which the credit constraint does not bind and there are no price guarantees, the steady-state equity price is $q = q^f = d/(R-1)$. Given the calibration criterion that the steady-state marginal product of capital net of depreciation equals the net world interest rate, q^f can be written as $F_k(k,n) / (F_k(k,n)-dep)$. With the Cobb-Douglas form of the production function this reduces to $q^f = (1-\gamma) / (1-\gamma - si)$. Thus, if the model is to be consistent with a dividend rate that matches the long-run predictions of a typical RBC small open economy model, the steady state equilibrium price of equity is pinned down once the values of the labor income share and the investment rate are set. In this case, $q^f=2.19$.

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 (1), (2), (9) and (21). In particular, the level of the capital stock consistent with these supply-side conditions and the calibrated parameter values is $k=79$. Note that, 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 β and the financial frictions parameters a, θ and κ. The time-preference elasticity coefficient is derived from the consumption Euler equation as follows: In a deterministic stationary state in which the margin constraint does not bind, the endogenous rate of time preference equals the real interest rate:

$$\left(1+(sc)F(k,n)-\frac{n^{\delta}}{\delta}\right)^{\beta} = R \tag{25}$$

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 β = 0.0118. The total stock of domestic savings follows then from the resource constraint as $s = [c-F(k,n)(si+sg)-wn] / (R-1)$.

Mendoza and Smith (2003) showed that the above deterministic steady state with a non-binding margin constraint has the unappealing feature that, while there is a well-defined, unique steady-state equilibrium for savings, the allocation of the savings portfolio across bonds and equity is undetermined. As noted earlier, the steady-state price of equity equals its fundamentals level $q = q^f = d/(R-1)$ and therefore the return on equity equals the world interest rate. At this price and return, any portfolio of equity and bonds is consistent with the steady state as long as it satisfies the accounting identity for steady-state saving, $\alpha q^f k+b = s$, and the resulting (α,b) pair is such that $b > -\kappa\alpha q^f k$ and $\alpha \geq \chi$. Notice in addition that, within this range of portfolios and given the value of q^f, it is difficult to support portfolios in which the emerging economy is actually borrowing in the bond market (i.e., portfolios with $b<0$). Debt portfolios require $\alpha >$ 0.9. If domestic agents own less than 90 percent of the capital stock, their bond position is always positive and grows larger the smaller is α.

The above results showing that there is a small range of debt positions in a deterministic steady state with non-binding credit constraints, and that these debt positions require a high degree of "home bias" in equity holdings, also imply that it will take relatively strong margin coefficients (i.e., low values of κ) to make the margin constraint bind. In particular, ruling out short positions by foreign traders, so that the largest share of domestic equity holdings is 100 percent, it takes $\kappa \leq 0.10$ for the margin constraint to bind for at least some of the feasible steady-state pairs of (α, b). These low values of κ can be rationalized considering that the margin constraint is intended to represent the fraction of domestic capital that is *useful* collateral for international debt contracts. Several studies in the literature on Sudden Stops provide different arguments suggesting that this fraction may be far less than 1. The models proposed by Caballero and Krishnamurty (2001), Paasche (2001), Mendoza (2002), Scheneider and Tornell (2000) and others show how frictions like limited enforcement, default risk, "liability dollarization," and low international liquidity of shares of domestic physical capital of different sectors are frictions that can hamper the ability of domestic borrowers to leverage foreign debt on domestic assets.

The stochastic economy with non-binding margin constraints has the additional unappealing feature that it can lead to a degenerate long-run distribution of equity and bonds in which domestic agents hold the smallest possible fraction of equity (χ) and use only bonds to engage in consumption smoothing and precautionary savings. The reason is that, without credit constraints and zero recurrent asset-trading costs, risk-averse domestic agents demand a risk premium to hold equity (for standard equity-premium reasons) while the risk-neutral foreign traders do not. Hence, domestic agents end up selling all the equity they can to foreign traders. This process takes time because the per-trade trading costs slow the speed at which foreign traders adjust their equity holdings.

To circumvent the above problems of indeterminacy of the portfolio composition in a deterministic steady state and full downloading of domestic equity holdings in the stochastic steady state of the economy with frictionless financial markets, the calibration sets the values of the financial frictions parameters (a, θ and κ) so that the allocations and prices obtained for the deterministic steady with non-binding margin constraints can also be supported as the deterministic steady state of an economy with negligible (but positive) recurrent trading costs and a margin constraint that is just slightly binding (maintaining the assumption of zero price guarantees). This calibration scenario is therefore labeled the "nearly frictionless economy."

As Mendoza and Smith (2003) showed, the deterministic steady state of the model when $\theta > 0$ and the margin constraint binds has well-defined, unique solutions for the allocation of savings across bonds and equity. 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 $R^q > R$ at steady state. The ratio of the Lagrange multipliers of the margin constraint and the budget constraint can then be found to be: $\mu/\lambda = (R^q-R)/(R^q-R\kappa)$.

With the domestic agent's debt given by $b = -\kappa\alpha\, q\, k$, a unique stationary equity position can then be obtained from the steady-state consumption Euler equation when the credit constraint binds. This is the value of α that solves the following expression:

$$\left(1+\alpha kd+wn-\kappa q\alpha k(R-1)-\frac{n^{\delta}}{\delta}\right)^{\beta}=\frac{R}{1-(\mu/\lambda)} \tag{26}$$

This expression illustrates the key role that the endogenous rate of time preference plays in supporting stationary equilibria with binding credit limits. It allows the rate of time preference to adjust so as to make the higher long-run level of consumption of an economy in which agents were not allowed to build as much debt as they desired in the transition to the steady state to be consistent with the higher effective long-run real interest rate implied by the credit constraint. Notice that the recurrent trading cost is also critical. With $\theta=0$, the equity price equals the fundamentals price and the return on domestic equity equals the real interest rate, and the latter would imply that $\mu/\lambda=0$, so the borrowing constraint could not bind.

In this nearly frictionless economy, the values of κ, a and θ are set to yield a deterministic stationary state with a binding borrowing constraint in which the following conditions hold: (1) the debt-GDP ratio is in line with the empirical evidence for Mexico, (2) the allocations, factor payment rates and the equity price are nearly identical to those in the model without binding credit limit, and (3) the elasticity of the foreign trader's demand curve is relatively high. The values of the parameters are: $\kappa = 0.03$, $\theta = 0.001$ and $a = 0.2$. These parameter values, and the values set earlier for γ, δ, β, and R, yield values of c, s, n, w, d, q, and R^q nearly identical to those obtained without a binding debt constraint, and the unique steady-state portfolio allocations are now α=0.931 and b =-4.825. The debt-GDP ratio implied by the latter is about 62 percent.

Stochastic Simulation Framework

The stochastic simulations are solved over a discrete state space with 62 evenly-spaced nodes in the equity grid and 152 evenly-spaced nodes in the bonds grid. The lower bound for domestic equity positions is set at 84 percent of the capital stock ($\chi=0.84$), so the equity grid spans the interval [0.84,1]. These bounds for domestic equity holdings, together with the "plausible" maximum equity price in equation (17) and the margin constraint, set the lower bound of the bond grid as $-\kappa q^{max} k$ =-5.2. This is the largest "feasible" debt that the domestic economy can leverage by holding the largest possible equity position at the highest possible price for the given grid of equity holdings. The upper bound of bonds is found by solving the model repeatedly starting with an upper bound on bonds that supports the steady state stock of 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 [-5.2,34.1]. This grid of bonds includes a relatively small region of debt positions, reflecting the fact that, despite the frictions induced by asset trading costs, domestic agents still have a preference for substituting equity for bonds as a vehicle to smooth consumption and build their buffer stock of savings.

A limit on domestic equity holdings of 84 percent is much higher than the conventional short-selling limit set at 0. However, the result from the calibration exercise showing that bond positions become positive and unrealistically large when the domestic economy owns less than 90 percent of its capital argues in favor of a high value of χ. Moreover, at the aggregate level of an emerging country it is hard to argue that the entire physical capital stock has a liquid international market. In Mexico, the average ratio of stock market capitalization to output for the period 1988-2000 is 27.6 percent. Since the calibration yields an estimate of the capital-output ratio of about 2.5, the total value of the shares of the capital stock of all publicly-traded firms constitutes just 11 percent of Mexico's capital stock. A large fraction of Mexico's capital stock is owned by non-publicly-traded private and government firms and by owners of residential property, and thus does not have a liquid market in which to trade shares with foreign residents.

Simulation Results

In this version of the paper we report a set of preliminary results in which productivity shocks are the only stochastic driving force of the model. The productivity shocks are modeled as a two-point, symmetric Markov process that follows the simple persistence rule. This Markov process is calibrated in the same way as in Mendoza and Smith (2003) by setting the two points of the Markov chain and the Markov transition probability matrix so that the moments of the limiting distribution of the process match the standard deviation and first-order autocorrelation of the quarterly cyclical component of Mexico's tradables GDP reported in Mendoza (2002). The standard deviation of the shocks is 3.36 percent and their first-order autocorrelation is 0.553.

Three sets of simulation results are obtained. The first set is for the "nearly frictionless economy" in which the financial frictions have negligible effects. The second set tightens the margin coefficient to κ=*0.005* and is compared with the first set so as to examine the effects of the financial frictions in the absence of price guarantees. The third set introduces a simple price guarantees policy that introduces two minimum prices, one for each state of productivity.

Financial Frictions & Sudden Stops without Prcie Guarantees

Consider first the comparison between the nearly frictionless economy and the economy in which financial frictions are at work in the absence of price guarantees. Figure 1 shows the ergodic probability distributions of equity and bonds in these two economies. The effect of the binding borrowing constraints is clear in the bonds distribution. The distribution has a marked bias to the left in the two economies but the distribution shifts markedly to the right when margin constraints bind. The opposite occurs with the distribution of equity. The distribution of equity is biased to the left in both economies, reflecting the inherent incentive that the risk-averse domestic agents have to sell equity to the risk-neutral foreign lenders as explained earlier. However, the binding margin constraints shift the equity distribution to the left. This is the result of the "fire sales" of equity in which domestic agents engage to meet margin calls.

The shifts in the ergodic distributions of equity and bonds also reflect the outcome of the precautionary savings effect. Domestic agents aware of the imperfections of financial markets and the possibility of hitting binding borrowing limits have an incentive to build up a buffer stock of savings in order to minimize the risk of being forced into abrupt drops in the argument of utility (i.e., consumption minus the disutility of labor). Hence precautionary savings leads them to increase their average holdings of risk-free bonds. The average bonds-output ratio increases from 24 in the nearly frictionless economy to 55 percent in the economy in which domestic agents cannot borrow more than 0.5 percent of the value of their equity holdings.

Precautionary savings behavior also leads agents to accumulate enough savings in the long run to lower the risk of facing states in which margin constraints actually bind. While it is possible for the domestic economy to go though any of the states of equity and bonds in the horizontal axis of the ergodic distributions along the stochastic transitional dynamics of the competitive equilibrium, the long-run distribution with binding margin constraints clearly rules out the states with the largest debt positions (in which a binding margin constraint would force the largest adjustments in consumption and the current account). Still, the long-run probability of facing a state of nature in which the margin constraint binds is about 2 percent. Thus, as Mendoza (2002) argued, the precautionary savings effect implies that Sudden Stops driven by occasionally binding credit constraints are rare but non-zero probability events in the long run. This result implies, however, that the effects of these constraints are unlikely to be noticeable in the business cycle moments derived from ergodic distributions, and that hence to analyze the model's ability to explain Sudden Stops we should study the short-run dynamics in the high-debt region of the state space in which the margin constraint binds (the "Sudden Stop" region).

The three-dimensional plots in Figures 2-4 are useful for identifying the Sudden Stop region of the state space. These plots show the percent deviations from the long-run means in consumption, the current account-GDP ratio and equity prices across a large region of the discrete state space over which the model was solved. The Sudden Stop region of debt positions (i.e., values of b low enough for the constraint to be triggered) is easy to identify by comparing the plots for the nearly frictionless economy and the economy with binding margin constraints. Examining the responses of the variables across different levels of equity holdings for the

Sudden Stop region of bonds, we can also notice that the leverage ratio (i.e. the ratio of debt to equity) also makes a difference. As Mendoza and Smith (2003) argued, Sudden Stops with large consumption collapses and large corrections in the current account-GDP ratio occur when debt is high relative to equity holdings. If domestic agents have little equity, the fire-sales in which they can engage are limited. This yields small asset price collapses but large corrections in consumption and the current account. On the other hand, if the leverage ratio is low (i.e., if equity holdings are large relative to debt within the Sudden Stop region of debt), domestic agents liquidate more equity and trigger larger asset price collapses, but they do so in their effort to swap their limited borrowing ability for equity sales in order to minimize the correction in consumption. Thus, the resulting drop in consumption and current account reversal are smaller.

Mendoza and Smith showed that this pattern of larger current account corrections with smaller asset price collapses fits the observations of some emerging markets crises. In Mexico the current account reversal in the first quarter of 1995 was 5.2 percentage points of GDP but the drop in real equity prices was nearly 29 percent. By contrast, in Korea, the current account reversal in the first quarter of 1998 was about twice as large at 11 percentage points of GDP but the asset price correction was just 10 percent.

To examine in more detail the short-run dynamics produced by Sudden Stops, we examine the forecasting functions (or conditional impulse response functions) of the equilibrium processes of consumption, the current account-GDP ratio, and equity prices in response to a negative, one-standard-deviation productivity shock conditional on initial positions of equity and bonds within the Sudden Stop region. Two sets of forecasting functions are plotted in Figures 5-6, one for α=0.898 and b=-1.3, which is a debt position of about 17 percent of mean GDP, and one for the same debt but α=0.889. The first case is labeled the "low leverage state" and the second one is the "high leverage state."

As the charts in Figures 5-6 show, the initial effects of the adverse productivity shock differ sharply across the economies with and without borrowing constraints. The pattern of these initial effects is consistent with the message of the three-dimensional plots: in the high-leverage case, domestic agents have a harder time liquidating assets to meet margin calls, since their equity holdings are smaller relative to their debt, and thus a larger portion of the adjustment is reflected in consumption and the current account. In contrast, in the low-leverage case domestic agents are better positioned to try to keep consumption smooth by substituting debt for equity as a way to finance the current account deficit. Hence the decline in consumption and the current account reversal are smaller, but the equity price correction is larger.

Figures 5-6 also show that Sudden Stops in this model are short-lived. In the high-leverage case, consumption and the current account fall sharply initially, but recover to the path of the frictionless economy very quickly. In the low-leverage case the same happens with equity prices. It may be possible to obtain stronger persistence effects by increasing the trading costs faced by foreign traders, so that they adjust their demand for equity more slowly. Another alternative not considered in the model could be to introduce endogenous capital accumulation. Mendoza (2004) shows that margin constraints can generate strong persistence effects in an environment in which firms incur adjustment costs in capital accumulation and the margin constraint links the ability to borrow to the valuation of capital determined by Tobin's Q.

Kocherlakota (2000) showed that in analyzing the effects of credit constraints it is important to separate persistence from amplification. The forecasting functions are useful for illustrating persistence but they can be misleading as a measure of amplification, since they show deviations from the mean that do not take into account the second moments of the business cycle. Kocherlakota thus proposed to measure the amplification effect of a once-and-for-all, unanticipated linear income shock that triggers a credit constraint as the difference observed on impact as the shocks hits in a variable under the influence of the credit constraint relative to its frictionless steady state in percent of the size of the shock. Here we take Mendoza's (2004) modification of this measure for a stochastic model in which the shocks follow a known Markov process (and hence in this sense, and in contrast to Kocherlakota's experiment, the shocks are "anticipated" and "recurrent"). The modified measure is the difference of a variable in the equilibrium with occasionally binding margin constraints relative to its level in the nearly frictionless economy in percent of the standard deviation of the variable in the frictionless economy. For example, if the amplification coefficient of consumption for a negative productivity shock is 50 percent, it indicates that the fall in consumption in the economy with margin constraints exceeds that of the frictionless economy by an amount equal to ½ the magnitude of an "average" consumption cycle in the frictionless economy (i.e., the margin constraint amplifies business cycles in consumption by 50 percent).

Columns 2 and 4 in Table 1 report the amplification effects of a negative productivity shock for the high and low-leverage states in the Sudden Stop region of the economy with margin constraints. These amplification effects display a similar pattern as the forecasting functions. In the high-leverage case, the amplification effects on consumption and the current account-GDP ratio are very large at 78 and 57 percent respectively. In contrast, the amplification effect on domestic equity holdings is small at about 10 percent. The opposite occurs in the low leverage case, in which the amplification effects on consumption and the current account are both below 10 percent, while the amplification effect on equity holdings is nearly twice as large as in the high leverage case. The amplification effect on equity prices is also twice as large in the low leverage case, but amplification is high in both cases (100 percent in the high leverage case, 201 percent in the low leverage case). Note that while Figures 5-6 suggest that the asset price effects of the margin constraint in terms of percent deviations from the mean are small, they are very large when measured relative to the variability of asset prices in the ergodic distribution of the nearly frictionless economy.

Introducing Price Guarantees (Incomplete)

Consider now the model with ex ante price guarantees. The guarantee is set first at a level higher than the crash price of the low-leverage case of the economy with binding margin constraints but lower than the fundamentals price (both for the low productivity state). The guaranteed price is set at 2.1845 for all triples (α, b, ε) in the state space. The fundamentals price in the low productivity state (i.e., the expected present discounted value of dividends discounted at the risk-free rate conditional on starting at date 0 with a 1-standard-deviation negative shock to productivity) is 2.1855. The comparable price in the low-leverage case of the economy with margin constraints is 2.1805. Thus, the guaranteed price represents a discount of 0.05 percent relative to the fundamentals price, but is also 0.18 percent above the "crash" price.

Figure 1 shows the ergodic distributions of equity and bonds for the economy with price guarantees together with the previous two distributions for the nearly frictionless economy and the economy with financial frictions. Relative to the economy with financial frictions, the guarantees shift the distributions slightly in the direction of those that pertain to the nearly frictionless economy. The long-run unconditional average of the conditional expected present value of the excess of guaranteed over market prices (i.e., the long-run average of the $G(.)$

function) is 0.002, which is equivalent to 0.09 percent of the mean equity price in the stochastic stationary state.

Overall, the long-run moments of the model's endogenous variables vary little across the three ergodic distributions, but there are some interesting changes introduced by the price guarantees. The long-run probability of hitting a state in which the margin constraint binds falls from 2 percent in the economy with binding margin constraints and no price guarantees to 1.43 percent in the same economy with price guarantees. The long-run variability of consumption falls slightly from 3.19 percent to 3.16 percent. However, the variability of asset prices increases slightly (from 0.1 percent to 0.12 percent). The results from the closed-economy analysis by Ljungqvist (2000) showed similar results indicating the possibility that price guarantees can increase the volatility of equilibrium asset prices. Price guarantees do alter sharply the persistence and GDP-correlation of asset prices. Their first-order autocorrelation increases from about 0.5 to 0.62 and the correlation with output falls sharply from 0.93 to 0.72.

The effects of the price guarantees on Sudden Stop dynamics for the high and low leverage cases are shown in Figures 5 and 6 and in Table 1. Price guarantees result in a sizable reduction of the collapse in consumption and the reversal of the current account in the high-leverage case, and an almost negligible change in the low-leverage case. Equilibrium asset prices show the opposite pattern. The guarantees have a smaller effect on the size of the fall in prices in the high leverage case than in the low leverage case. In fact, with the price guarantee at 2.1845, the guarantee is executed in the low leverage case (with the equilibrium price at 2.1834) but not in the high leverage case (with the equilibrium price at 2.1849). This reflects in part the fact that the guaranteed price was targeted to the price decline obtained in the low leverage case of the economy without price guarantees, and since the equilibrium price had a smaller decline in the high leverage case, a guarantee targeted to the low leverage case is less relevant for this case. Still, the smaller price decline in the high leverage case is enough to result in a much smaller consumption collapse and current account reversal. Thus, as suggested by the forward-looking assessment of future price guarantees and margin constraints reflected in the foreign traders' demand function and the asset pricing condition of domestic agents, the expectations of the effects resulting from *future* price guarantees have significant implications for the *initial* consumption and current account responses of the high leverage case (even if on the initial date the equilibrium price does not trigger the guarantees).

Figure 7 compares asset prices in the low productivity state for the economy with binding margin constraints and no price guarantees and the same economy with price guarantees. As the plots show, the price guarantees not only result in higher prices in the Sudden Stop region with high debt (i.e., low b values), but they actually result in higher asset prices in most of the state space. In fact, price guarantees have their most significant effects on equilibrium asset prices in states in which agents have a stock of savings above the long-run average (i.e., high values of α and b). Asset prices in this region are significantly higher in the economy with margin constraints and price guarantees than in either the nearly frictionless economy or the economy with margin constraints and no guarantees. This result reflects one aspect of the tradeoff between financial frictions and price guarantees. The guarantees can result in significant asset price distortions in states of nature that are not exposed to the risk of Sudden Stops. One alternative to avoid some of these distortions would be to consider state-contingent price guarantees, instead of the time- and state-invariant guarantee that produced Figure 7. We explore this alternative in the next experiment.

(To be added: state-contingent guarantees, "excessive" guarantees, welfare implications, sensitivity analysis)

6. Conclusions

The equilibrium asset pricing theory presented in this paper suggests that, if global capital markets are distorted by the kind of financial frictions reflected in collateral constraints and asset trading costs, an arrangement to provide ex ante price guarantees on the emerging markets asset class could be an effective means to contain Sudden Stops in emerging economies. The same theory predicts, however, that introducing these guarantees creates an additional distortion that induces a moral hazard effect propping up the demand for emerging markets assets of foreign investors. Hence, the provision of ex ante price guarantees creates a tradeoff between the benefits that can be gained by undoing the distortions caused by imperfections in world capital markets and the costs that result from the moral hazard effect. This cost-benefit analysis involves quantitative comparisons of equilibrium outcomes across distorted economies with incomplete asset markets that can only be performed via numerical simulation analysis.

The model studied in this paper borrows from Mendoza and Smith (2003) the setup of a dynamic, stochastic general equilibrium model of the pricing of the assets of an emerging economy in which financial frictions generate Sudden Stops. Asset trading between domestic agents and specialized foreign securities firms is affected by collateral constraints on domestic agents (in the form of a margin constraint that limits their ability to leverage foreign debt on their equity holdings) and asset trading costs faced by foreign traders (per-trade costs as well as recurrent trading costs that are incurred each period regardless of trading activity). In this environment, adverse real shocks that hit an emerging economy with a sufficiently high stock of debt relative to equity values trigger margin calls that lead to a fire sale of equity by domestic agents and a Fisherian deflation of asset prices. Thus, the Mendoza-Smith model makes the case for price guarantees by producing outcomes in which margin constraints and asset trading costs cause Sudden Stops.

The Mendoza-Smith model is modified in this paper to introduce an IFO that offers foreign traders ex ante guarantees on the price of the equity of the emerging economy, financing the cost of any realized guarantees by levying a lump sum tax on foreign traders. These guarantees introduce a distortion that leads foreign traders to increase their demand for emerging markets assets. This distortion can be interpreted as a valuation effect that adds to the "fundamentals price" the conditional expected present discounted value of the excess of guaranteed prices over market prices that traders expect in the future along the stochastic equilibrium path.

The challenge to the IFO is to design the price guarantees so that they can result in an equilibrium outcome that improves over the outcome obtained when there is no policy in place to contain Sudden Stops triggered by the financial frictions. Our quantitative analysis applied to the case of Mexico illustrates the complexity of this task. Part of the challenge is that an effective system of ex ante price guarantees requires a good model of asset prices (i.e., a model that can start by explaining the observed features of Sudden Stops without price guarantees and that can be used to assess the effects of the guarantees). The model we proposed in this paper is consistent with the features of Sudden Stops but its ability to match some of the quantitative features of the data, particularly the magnitude of the collapse in asset prices, is limited. Yet, the quantitative results suggest that a basic, non-state-contingent system of price guarantees can go a long way in containing the collapse in absorption and current account reversals of Sudden Stops, but at the cost of inducing distortions on asset prices that can lead to significant "over-valuation" of an emerging economy's assets.

Non-trivial difficulties would remain in designing an ideal schedule of ex ante price guarantees even if the model could mimic the observed quantitative features of Sudden Stops. In particular, and in line with the findings of Ljungqvist (2000), price guarantees do not necessarily reduce the volatility of asset prices. Moreover, the effects of price guarantees are driven by important forward looking elements that depend on agents' expectations of the likelihood of executing price guarantees and/or hitting Sudden Stop states in the future (even if at present no price guarantees are executed and the economy has normal access to foreign financing). Hence, to be effective at providing price guarantees to contain Sudden Stops without creating strong moral hazard effects, the IFO needs to be able to determine the range of debt and equity values at which Sudden Stops occur and the crash prices on assets that Sudden Stops produce, as well as the "normal" levels of asset prices that would prevail in a frictionless world without margin constraints and trading costs. This information would allow the IFO to set guarantees "high enough" to make a difference relative to the environment in which there are no guarantees, and at the same time "low enough" to avoid large deviations from the outcome that would be obtained in a frictionless environment. The analysis undertaken in this paper makes some progress in reaching these objectives, but clearly there is a lot left for further research.

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Table 1. Initial Amplification of a Negative Productivity Shock

Variable	low leverage state (alpha=0.897, b=-1.30) financial frictions	low leverage state (alpha=0.897, b=-1.30) financial frictions & guarantees	high leverage state (alpha=0.889, b=-1.30) financial frictions	high leverage state (alpha=0.889, b=-1.30) financial frictions & guarantees
Consumption	0.073	0.059	0.776	0.052
Equity Holdings	0.191	0.191	0.096	0.191
Bond Holdings	0.650	0.524	0.813	0.524
Current Account-GDP ratio	0.054	0.043	0.572	0.038
Equity Price	2.011	0.715	1.007	0.083

Note: b=-1.30 state has a debt to GDP ratio of -0.166

Figure 1a. Ergodic Distributions of Domestic Equity Holdings

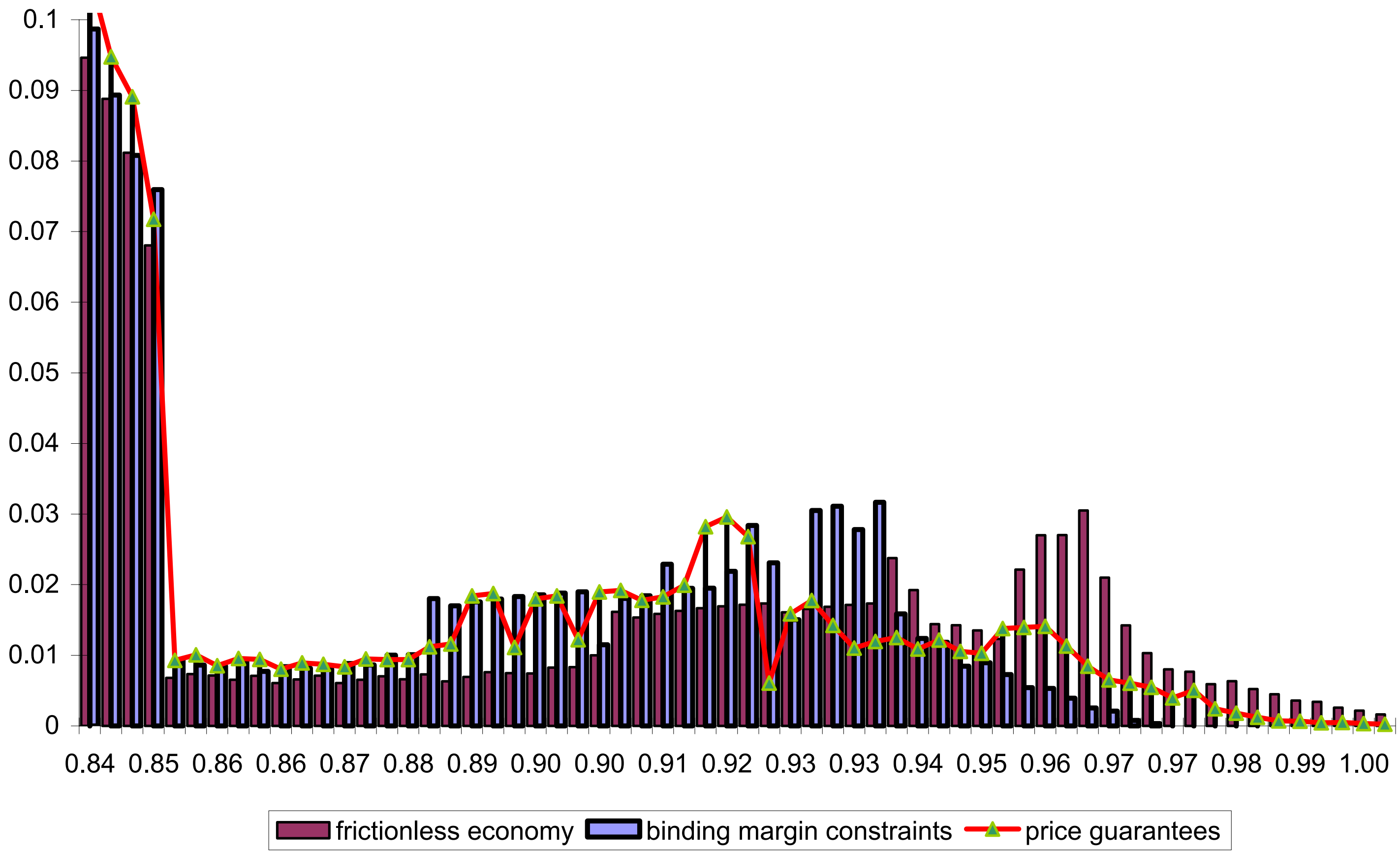
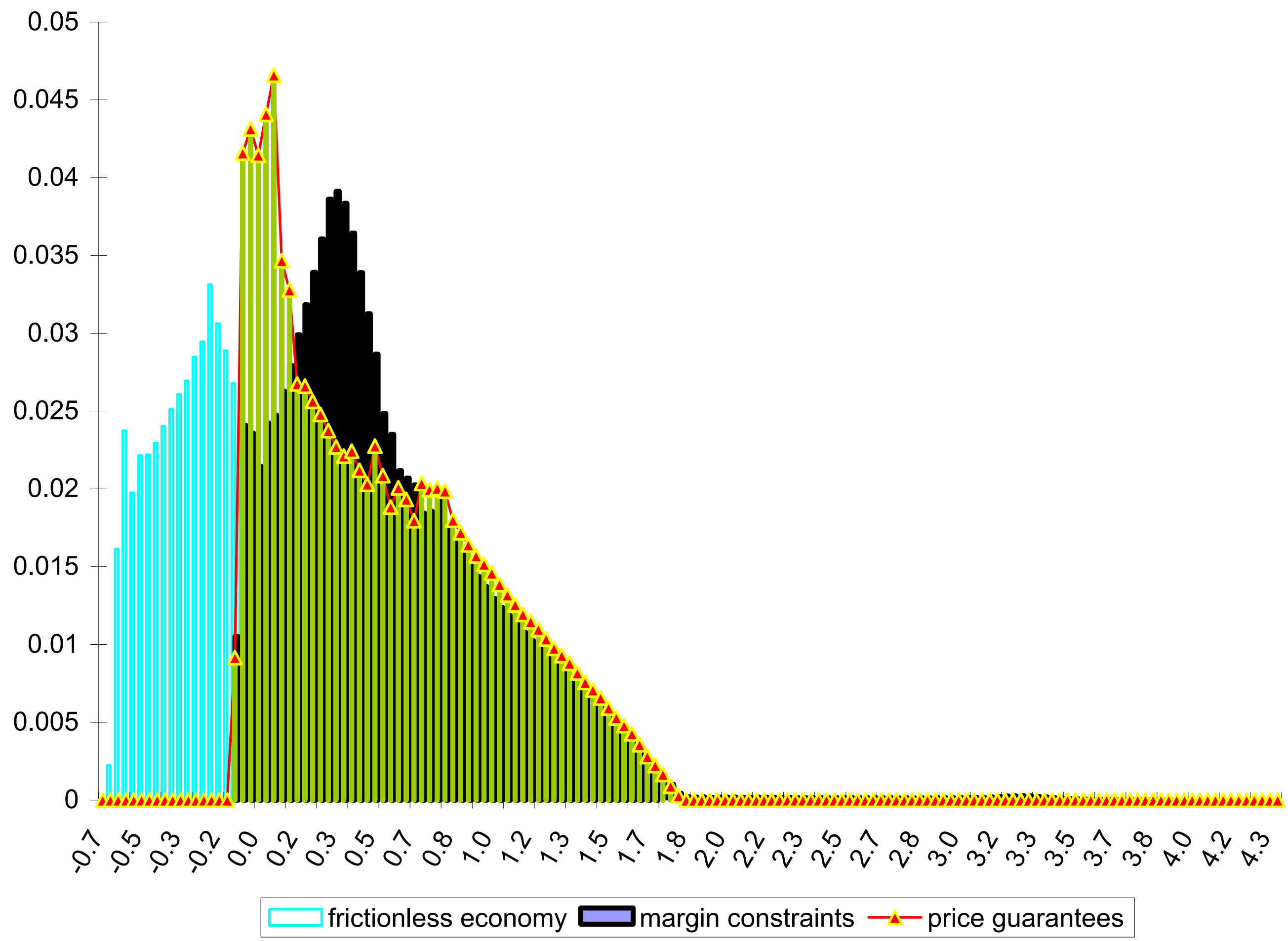
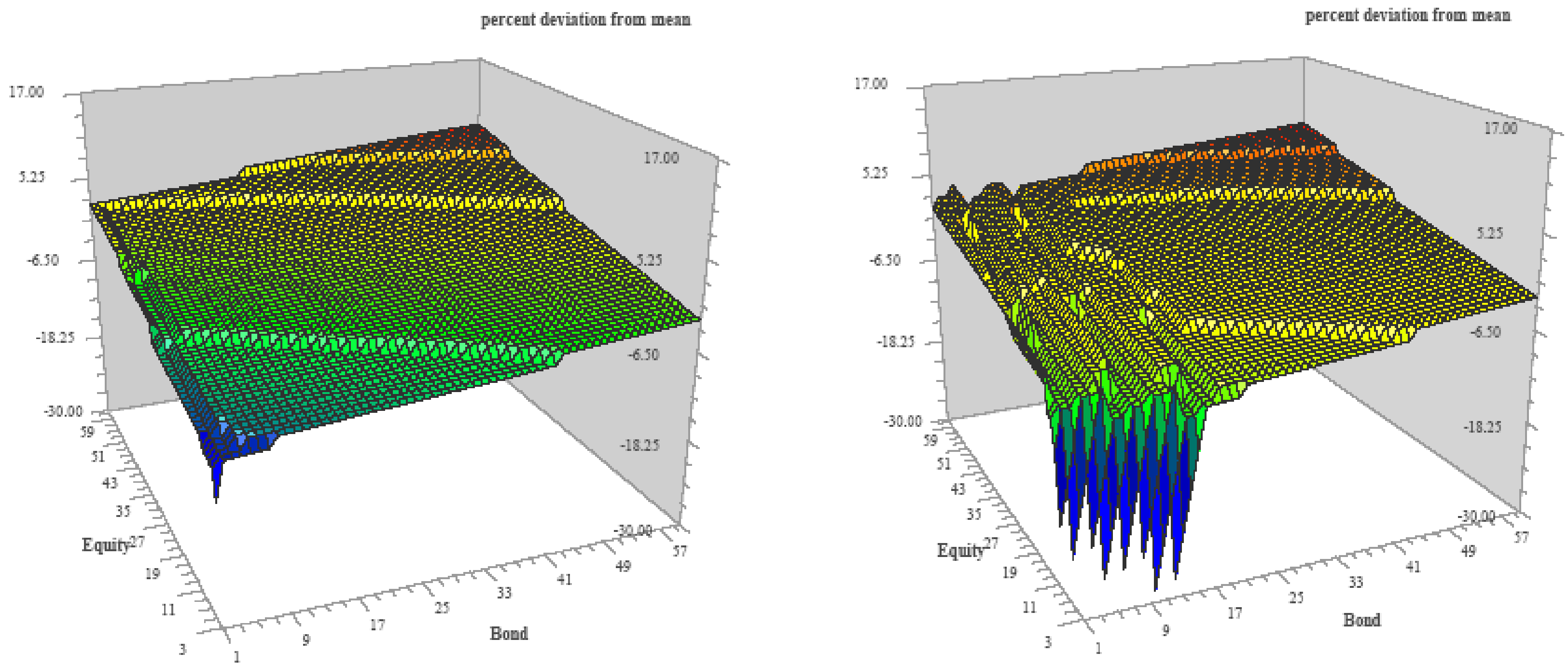


Figure 1b. Ergodic Distributions of Bonds



Note: Bonds are measured as a share of average GDP.

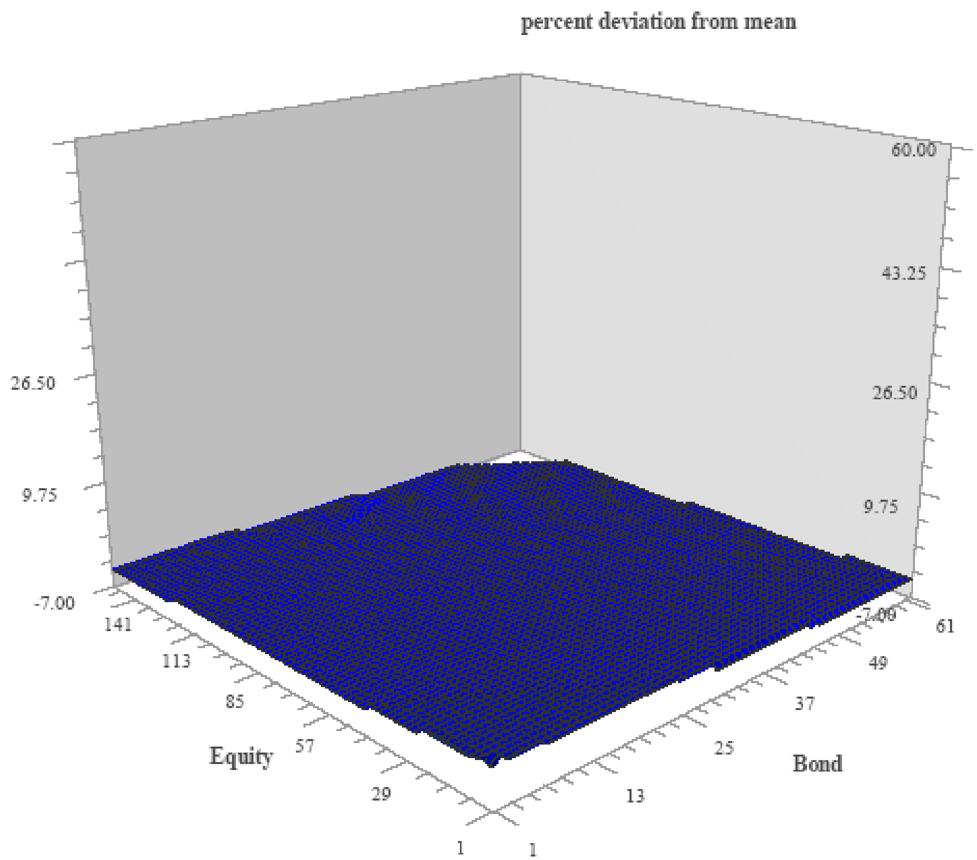
Figure 2. Consumption Impact Effects of a Negative Productivity Shock for the Universe of Initial Equity & Bond Positions (percent deviations from long run average)



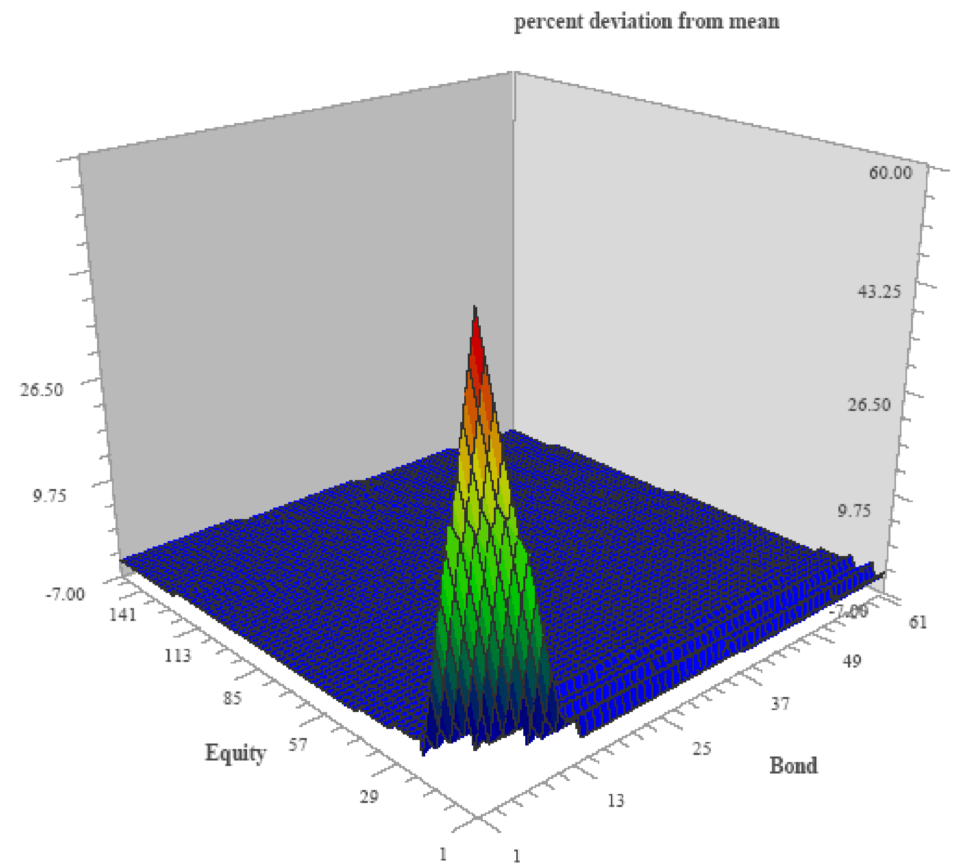
a. Nearly Frictionless Economy

b. Economy with Financial Frictions

Figure 3. Current Account-Output Ratio Impact Effects of a Negative Productivity Shock for the Universe of Initial Equity & Bond Positions (percent deviations from long run average)

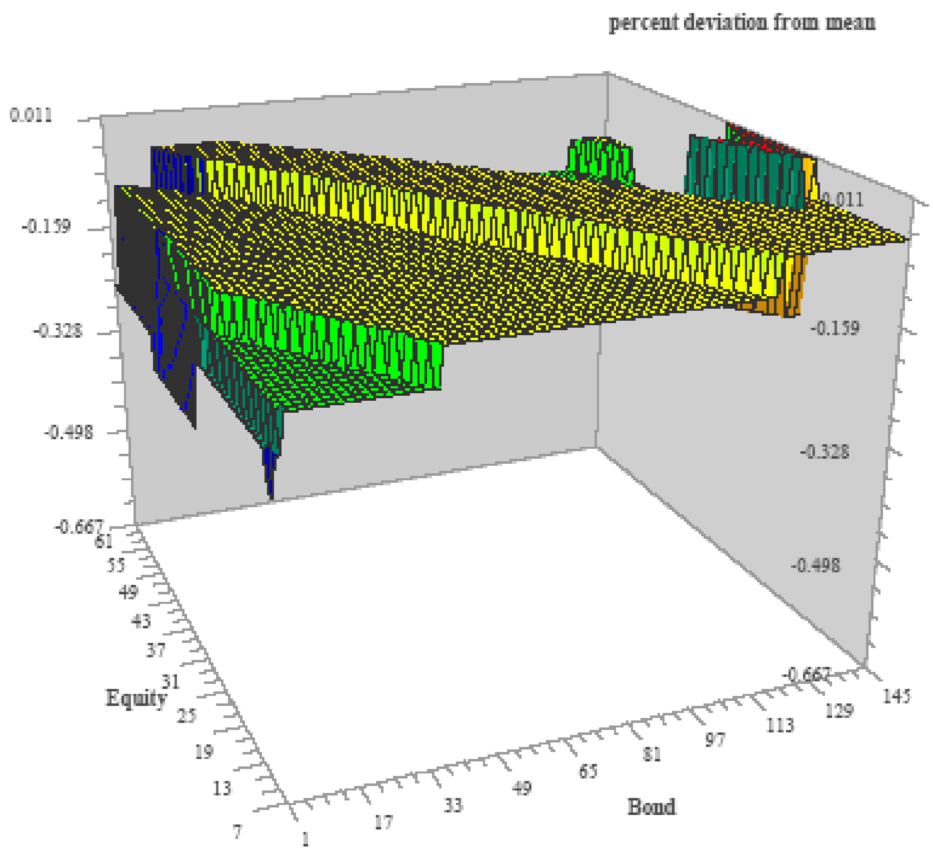


a. Nearly Frictionless Economy

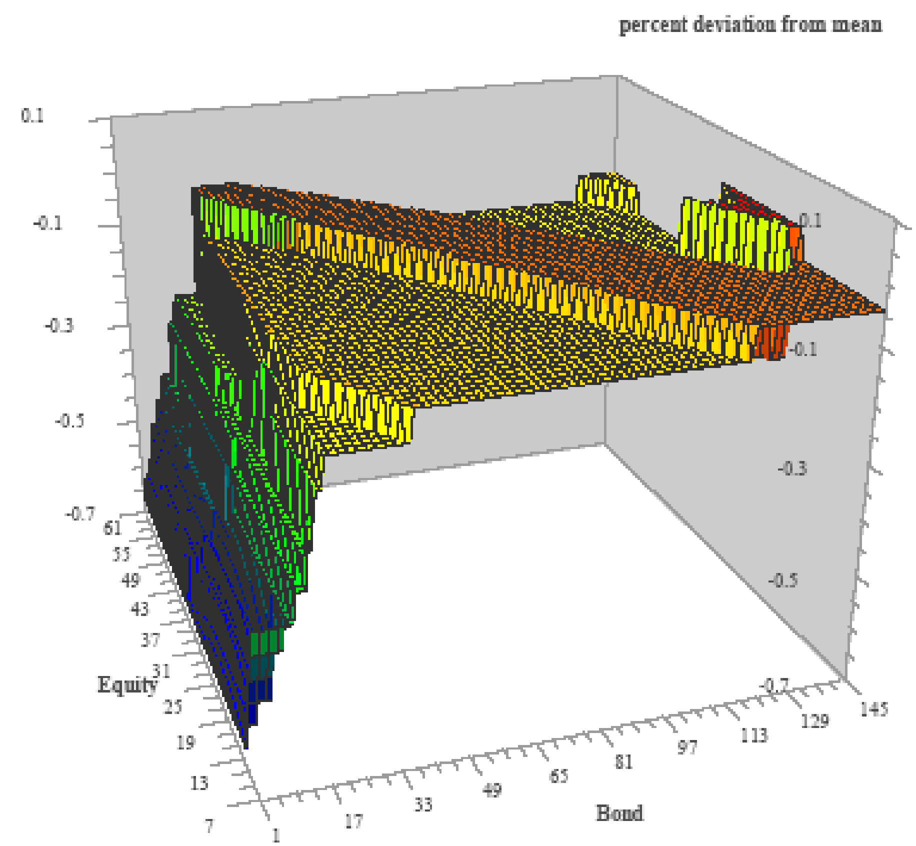


b. Economy with Financial Frictions

Figure 4. Equity Price Impact Effects of a Negative Productivity Shock for the Universe of Initial Equity & Bond Positions (percent deviations from long run average)

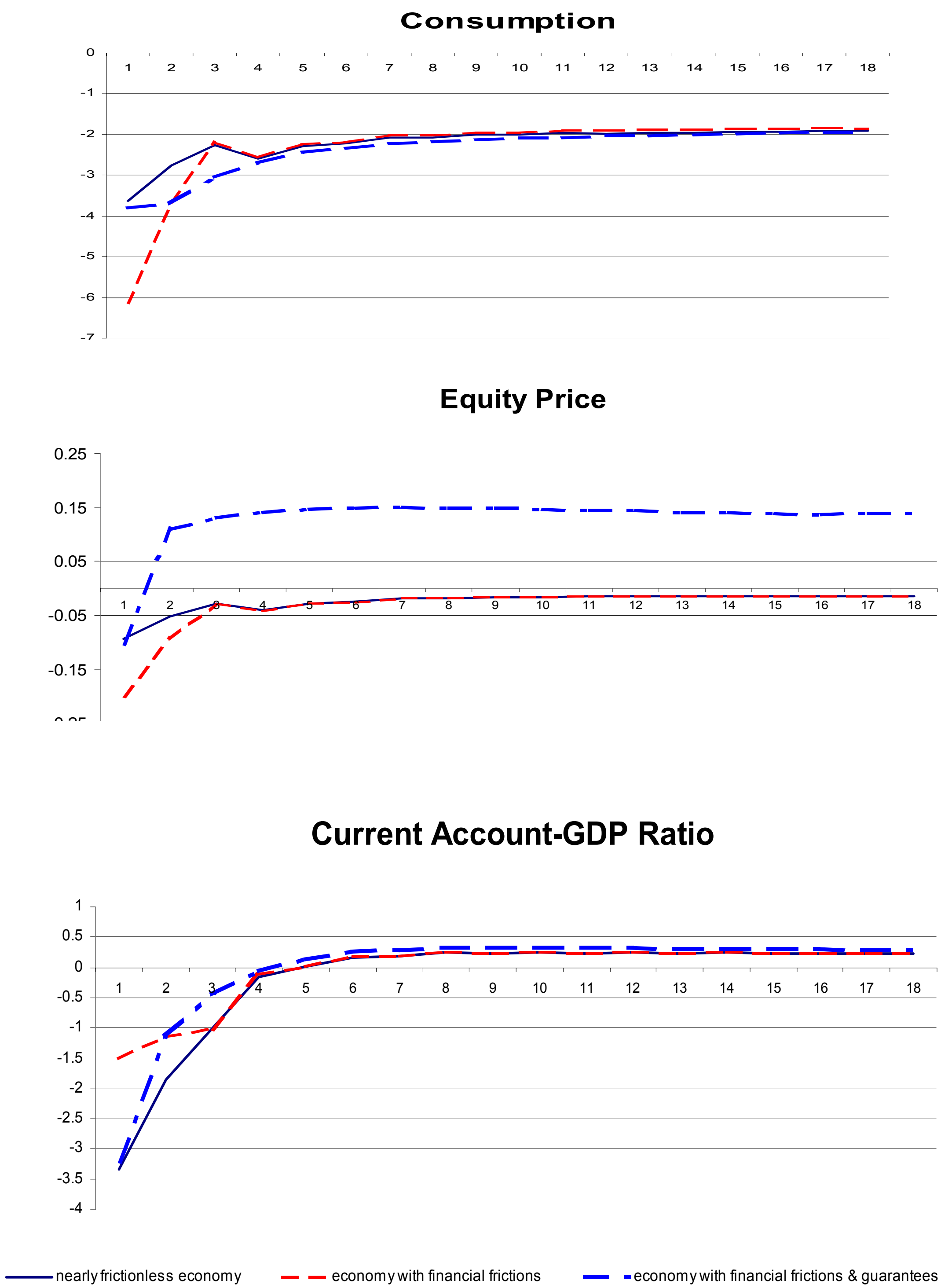


a. Nearly Frictionless Economy



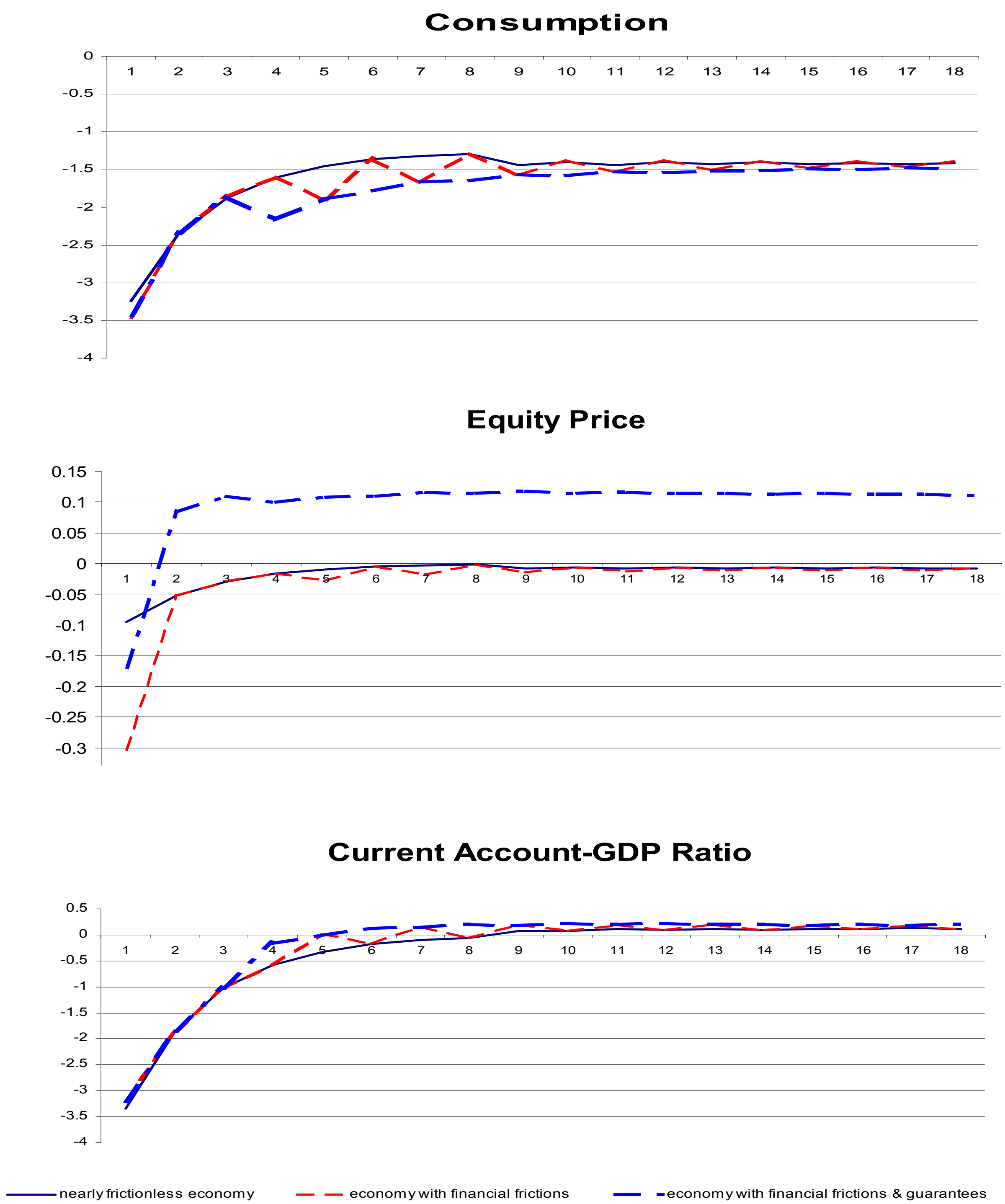
b. Economy with Financial Frictions

Figure 5. Conditional Forecasting Functions in Response to Low Productivity Shock in High Leverage State



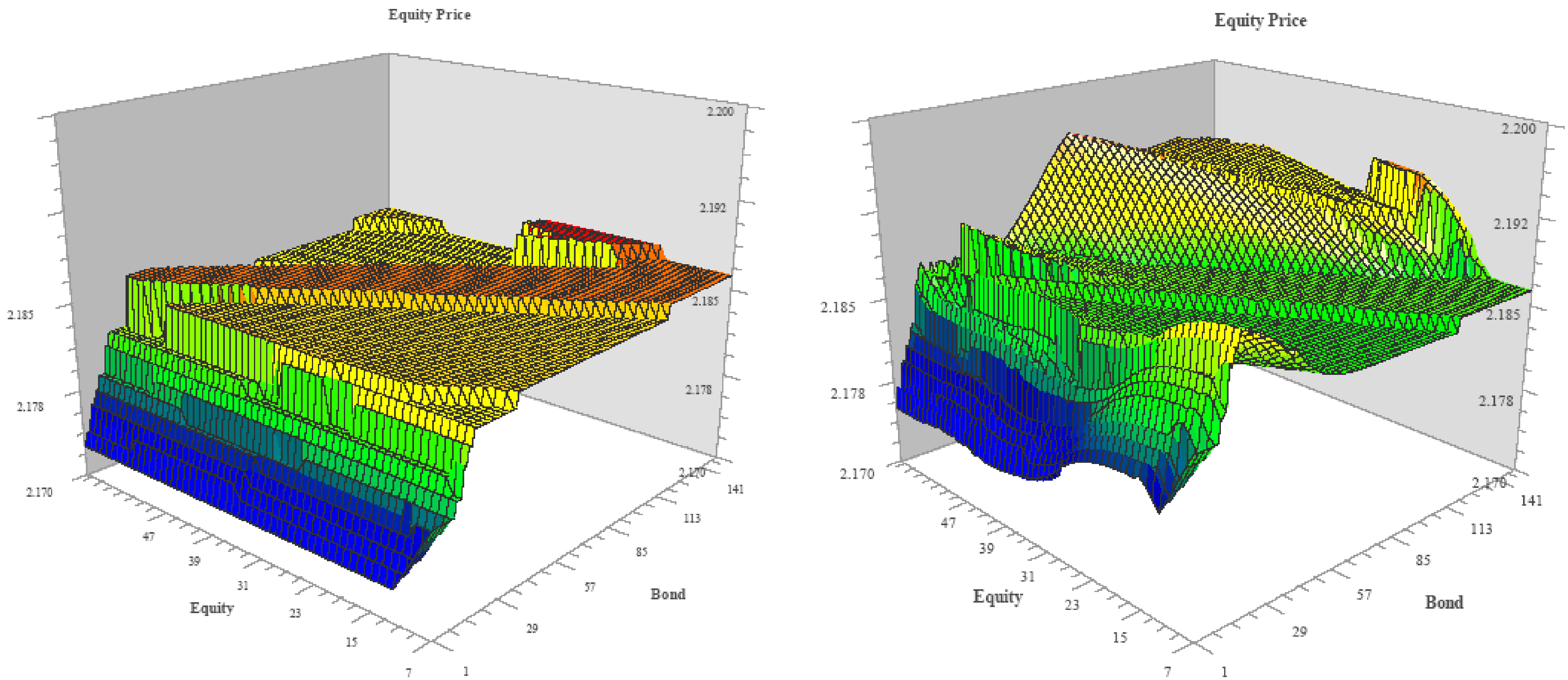
Note: forecasting functions are conditional on initial states alpha=0.889, b=-1.30 (debt to GDP ratio of -0.166)

Figure 6. Conditional Forecasting Functions in Response to Low Productivity Shock in Low Leverage State



Note: forecasting functions are conditional on initial states alpha=0.897, b=-1.30 (debt to GDP ratio of -0.166)

Figure 7. Equity Price in the Low Productivity State



a. Economy with Financial Frictions

b. Economy with Financial Frictions & Price Guarantees