ABSTRACT

Title of dissertation: ESSAYS ON
MONETARY ECONOMICS AND
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This thesis consists of two chapters. In the first chapter, I study optimal monetary policy rules in a general equilibrium model with financial market imperfections and uncertain business cycles. Earlier consensus view –using models with financial amplification with disturbances that have no direct effect on credit market conditions– suggests that financial variables should not be assigned an independent role in policy making. Introducing uncertainty, time-variation in cross-sectional dispersion of firms' productive performance, alters this policy prescription. The results show that (i) optimal policy is to dampen the strength of financial amplification by responding to uncertainty (at the expense of creating a mild degree of fluctuations in inflation). (ii) a higher uncertainty makes the planner more willing to relax 'financial stress' on the economy. (iii) Credit spreads are a good proxy for uncertainty, and hence, within the class of simple monetary policy rules I consider, a non-negligible interest rate response to credit spreads (32 basis points in response to a 1% change in credit spreads) -together with a strong anti-inflationary stance- achieves the highest aggregate welfare possible.

In the second chapter, I study global, regional and idiosyncratic factors in driving the sovereign credit risk premium (as measured by sovereign credit default swaps) for a set of 25 emerging market economies during the last decade. The results show that (i) On average, global and regional factors account for a substantial portion of the movements in sovereign risk premium (of 63% and 21%, respectively). (ii) there exists noticeable heterogeneity in the contribution of factors across the emerging markets. (iii) The (extracted) global factor is best reflected by the VIX (investors' risk sentiment) among the financial market indicators considered. (iv) There are regime changes in the relation between the global factor and the financial market indicators.

ESSAYS ON MONETARY ECONOMICS AND INTERNATIONAL
FINANCE

by

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Dedication

To my family,

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Chapter 1

Optimal Monetary Policy Rules, Financial Amplification,

and Uncertain Business Cycles

1.1   Introduction

Should financial variables *per se* be important for monetary policy making? This

question has attracted considerable attention in both policy and academic circles

during the last decade. The conventional wisdom, as stated in many central banks'

statutory mandates, is that inflation and output stability should be the central goal

of monetary policy: While financial variables (e.g. credit spreads or asset prices)

are with no doubt important ingredients for policy making, they are argued to be

useful in so far they help predicting inflation and real economic activity.[1] Intro-

ducing *uncertainty*, time-variation in cross-sectional dispersion of firms' productive

performance, alters the conventional wisdom: Optimal policy prescribes a *direct and*

systematic response to credit spreads (above and beyond what inflation and output

gap would imply).[2] Such a policy dampens distortionary effects of uncertainty, and

helps containing adverse feedback effects between financial conditions and the real

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[1]For potential channels through which fluctuations in financial variables transmit into business cycles, see Cecchetti *et al.* (2000), Gilchrist and Leahy (2002), and Gilchrist, Sim, and Zakrajsek (2010). The former two focus on asset prices, and the latter on corporate bond credit spreads.

[2]For recent studies on uncertainty, see among others Bloom (2009), Bloom, Floetotto, and Jaimovich (2010), Gilchrist, Sim and Zakrajsek (2010), Arellano, Bai and Kehoe (2010), Christiano, Motto and Rostagno (2010), Bachmann and Bayer (2011), Bekaert, Hoerova, and Duca (2011), Chugh (2011), and Basu and Bundick (2011). These shocks have also been labeled as risk or dispersion shocks in the literature.

economy.

I use a canonical New-Keynesian model with financial market imperfections to study optimality of responding to financial variables.[3] Providing a tight link between market imperfections and financial variables, the financial amplification model of Bernanke, Gertler, and Gilchrist (BGG, hereforth), a workhouse model widely used in the New-Keynesian financial frictions literature, offers a natural environment to study optimality of responding to financial variables. Existence of these imperfections, however, does not necessarily imply a direct response to financial variables as a way to mitigate the resulting distortions and improve aggregate welfare. Using traditional first-moment shocks that have no direct effect on credit market conditions, earlier consensus view suggests that it is optimal not to assign an independent role to financial variables in policy making.[4]

As an additional pulse driving the business cycles, I introduce uncertainty, exogenous time-variation in cross-sectional dispersion of firms' productive performance. Among potential channels through which uncertainty may transmit into business cycle fluctuations, here I consider credit channel owing to financial frictions

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[3]Such imperfections manifest themselves through existence of a spread, a wedge between borrowing and lending rates, that would be absent under perfect capital markets. At the heart of the mechanism lie credit spreads being linked to borrowers' indebtedness (leverage) which in turn is driven by movements in asset prices.

[4]In the presence of any sort of asset price imbalances, a gap between observed and fundamental/potential level of asset prices, it might be optimal to respond to financial variables (if the policy maker could measure these imbalances at the first place). See Bernanke and Gertler (2001), Dupor (2005), and Gilchrist and Saito (2008), among others. Here I do not consider non-fundamental movements in asset prices. Faia and Monacelli (2007), using traditional first-moment shocks, show that there might be a non-negligible marginal welfare gain of responding to (fundamental level of) asset prices under a reasonably low degree of anti-inflationary stance (roughly between one to two, as typically studied in the literature). They conclude that the policy makers should pursue a *lean-with-the-wind* policy reaction to movements in asset prices (e.g. decrease the policy rate in response to an increase in asset prices). Interested readers may refer to Gilchrist and Saito (2008) for a brief literature review on the pre-crisis consensus view.

in the model.[5] In particular, uncertainty has two direct effects on credit market conditions. First, it affects the measure of borrowers that will go bankrupt. Second, it affects net worth that will be retained by borrowers, and hence the quality of balance sheet of borrowers. Accordingly, a higher dispersion, for instance, implies a higher risk for banks' overall loan portfolio, making banks less willing to extend credit. As a result, the equilibrium level of credit spread rises and investment declines.

The main contribution of this paper is that, despite the emphasis on uncertainty as a potential driver of business cycles in the literature, whether and how monetary policy prescriptions would differ from the conventional wisdom under *uncertain business cycles* remains an open question. Moreover, in models with costly-state-verification type financial market imperfections (e.g. BGG), uncertainty, as discussed above, is primarily a 'financial' shock, directly affecting borrowers' ability to raise funds. In this regard, studying uncertainty also sheds light on normative implications of introducing disturbances that are of financial type on monetary policy.[6]

The results suggest that optimal policy is to dampen the strength of financial

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[5]Using models with financial frictions, Gilchrist, Sim and Zakrajsek (2010), Arellano, Bai and Kehoe (2010), Christiano, Motto and Rostagno (2010), and Chugh (2011) also consider a credit channel. For other potential channels, see Bloom (2009), Bloom, Floetotto, and Jaimovich (2010), Bachmann and Bayer (2011), and Basu and Bundick (2011).

[6]See, among others, Nolan and Thoenissen (2009), Gilchrist, Ortiz and Zakrajsek (2009), Espinoza *et al.* (2009), Christiano, Motto, and Rostagno (2010), Jermann and Quadrini (2011), and Gilchrist and Zakrajsek (2011) on the contribution of financial shocks (shocks that have a direct effect on credit market conditions) on business cycle fluctuations. This class of disturbances includes (but not limited to) shocks that lead to exogenous movements in borrowers' net worth -that affects efficiency of contractual relations between borrowers and lenders- (Gilchrist and Leahy, 2002; Nolan and Thoenissen, 2009; Gilchrist, Ortiz and Zakrajsek, 2010; Christiano, Motto, and Rostagno, 2010), external finance premium -that affects efficiency of financial intermediation-(Gilchrist, Ortiz and Zakrajsek, 2010), sensitivity of external finance premium to the leverage -that affects the strength of financial amplification- (Dib, 2010), or borrowers' ability to raise funds (Jerman and Quadrini, 2011).

amplification by responding to uncertainty.[7] The planner achieves so by reducing the sensitivity of external finance premium to borrowers' leverage, effectively increasing the efficiency of financial intermediation that would otherwise occur in a decentralized economy. This, however, comes at the expense of creating a mild degree of fluctuations in inflation. The intuition lies on the fact that the tension between price stickiness (which creates fluctuations in the intratemporal wedge) and financial frictions (which creates fluctuations in the intertemporal wedge) tends to be resolved in favor of the latter if uncertainty shocks come into play. Note also that the planner is endowed with a single policy tool, the short-term nominal interest rate. Introducing appropriate additional tools (e.g. macro-prudential policies) would imply a lesser role for the short-term nominal interest rate in smoothing the intertemporal wedge (or in neutralizing financial market imperfections).

A key question then is whether simple policy rules, that include only a few observable macroeconomic variables, can attain a welfare level close to the planner's, and the optimal magnitude of response to financial variables (if not nil). As an additional input to policy making (besides inflation and output gap), I consider credit spread, the key variable that is tightly linked to financial distortions. In practice, credit spreads are easily observable to policy makers, and accordingly can be thought as a desirable input to the policy. For comparison purposes with the earlier literature, I also study (fundamental level of) asset prices as an additional

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[7]The planner maximizes aggregate welfare subject to competitive equilibrium conditions, using the short-term nominal interest rate as the policy tool. To have accurate welfare comparisons, I conduct second-order approximation to the policy and welfare functions. Note also that uncertainty, as a second-moment shock, has a first-order effect on equilibrium dynamics.

input to the policy.[8]

Confirming the conventional wisdom, if the economy is driven only by traditional first-moment disturbances, it is optimal not to respond to financial variables, and strict inflation stabilization is the welfare maximizing policy. If the economy is driven also by uncertainty shocks, the optimal rules suggest a non-negligible *lean-against-the-wind* policy reaction to credit spreads. Such a response is mainly due to spreads being driven mostly by uncertainty shocks.[9] The optimal magnitude of response to credit spreads is generally less than one-to-one. Under the benchmark scenario (when spreads fluctuate moderately), the policy rate should be reduced by 32 basis points in response to a 1% increase in credit spreads. [10] This result holds for sufficiently low level of anti-inflationary reaction (less than 3). A stronger inflationary reaction would decrease the optimal magnitude of response to credit spreads towards zero, as strict inflation stabilization welfare dominates the optimized rule (however small it is). Last but not least, the policy maker, if instead allowed to react to uncertainty directly, would choose to do so to improve aggregate welfare.

To shed further light on the results, I study how strong the planner values relaxing the 'financial constraint' from a historical perspective.[11] The results show the higher the uncertainty, the stronger the planner values relaxing the financial

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[8]I focus on the fundamental (as opposed to non-fundamental) movements in asset prices, since modeling asset price imbalances is not the immediate goal of this paper.

[9]If asset prices, which are driven mostly by productivity shocks in the model, is the financial variable included in the policy rule, then the corresponding policy response should be nil.

[10]A 1% increase in credit spreads amounts to roughly a 2- to 3-standard-deviation increase in credit spreads.

[11]The key equation in the financial amplification mechanism links external finance premium to aggregate leverage ratio. One can express this equation as a financial constraint in that firms can borrow a certain fraction of their net worth, the fraction depending on aggregate financial conditions.

constraint.[12] The planner's willingness to relax the constraint exhibits a rapid deterioration starting in mid-2002, and hits record low by the end of 2006. During recession periods, especially for the recent one, marginal benefit of relaxing the constraint rises substantially.

The main policy lesson, as hinted above, is that policy makers should closely monitor time-variation in cross-sectional dispersion of firms performance. From a practical point of view, however, the availability and the quality of information on the dispersion may not be available in real time. Yet, since credit spreads could serve as a good proxy for uncertainty, responding to the credit spreads can be used as a general policy to have better aggregate outcomes.

Closely related to my work, Gilchrist and Zakrajsek (2011) use a similar model with BGG-type financial market imperfections. They show that a spread-augmented policy rule dampens the effect of financial amplification and induces powerful stabilizing effects on real and financial variables. They, however, do not consider optimal policy problem. Angeloni and Faia (2011) introduce a banking sector in an otherwise standard New-Keynesian model, and show that containing fluctuations in asset prices (combined with mildly acyclical capital requirements) improves aggregate welfare compared to simple policy rules. Curdia and Woodford (2010), using a model with costly financial intermediation, conclude that in response to disturbances affecting efficiency of financial intermediation directly, it is optimal to respond to credit spreads, with the optimal degree generally being less than one-to-one. Our

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[12]This result can also be interpreted along the lines of Gilchrist, Sim and Zakrajsek (2010). In a richer model, they show that investment becomes more sensitive to borrowers' net worth when uncertainty is higher. Accordingly, the measure of firms which are financially constrained is higher and aggregate output declines in response to a higher uncertainty.

results suggest that it is not necessarily the credit supply channel *per se* that makes containing fluctuations in credit spreads optimal, but it is the underlying set of disturbances that has a direct effect on credit market conditions that matters.

The chapter proceeds as follows: Section 1.2 presents the model economy, Section 1.3 the functional forms and the calibration. Section 1.4 studies long-run equilibria as a function of long-run cross-sectional dispersion, and the model dynamics in the decentralized equilibrium. Section 1.5 presents how to approximate aggregate welfare, Section 1.6 the optimal monetary policy problem, and Section 1.7 the optimal simple policy rules. Section 1.8 provides the historical analysis, and Section 1.9 concludes.

1.2   The Model

This section presents a brief description of the BGG. Readers may refer to Appendix A for details. The difference is the existence of uncertainty shocks in the model environment and recursively formulating some of the equilibrium conditions.

The economy is populated by a representative household, a monetary authority and three types of producers: wholesale-good producers (entrepreneurs), capital-good producers and retailers.

Entrepreneurs play the key role in the model. They produce wholesale goods using physical capital constructed by capital producers, and labor supplied by both households and entrepreneurs. To finance capital expenditures, entrepreneurs need to rely on external financing: In excess of their own net worth, entrepreneurs borrow

from a perfectly competitive financial intermediary. The intermediary could only observe the distribution of entrepreneurs' idiosyncratic productivity at the time debt contract is made. This asymmetric information leads to a costly state verification problem as in Townsend (1979). The need for external financing induces a non-zero probability of default, which, in equilibrium, induces a positive premium over the riskless rate, the external finance premium. The premium depends positively on the aggregate leverage ratio of the entrepreneurs, the key relation that the amplification model exhibits.

The retailers are introduced solely to motivate price stickiness. They buy wholesale goods at perfectly competitive markets, and differentiate them costlessly. The final consumption goods are then demanded by households, capital producers, and the government.

Readers may find it helpful the timing of events presented in Table 1.1.

Table 1.1: Timing of Events

At the end of Period t-1:
  1. Entrepreneurs accumulate net worth.
  2. Uncertainty (of period t) is realized.
  3. Entrepreneurs decide how much capital to borrow, and state-contingent debt contract is made.
Period t:
  1. TFP shock and the idiosyncratic productivities are realized.
  2. Wholesale production is done.
  3. Threshold level of idiosyncratic productivity and contractual returns are determined.
  4. Defaulting entrepreneurs' projects are seized, and the wholesale goods are sold to the retailers.
  5. Some of the entrepreneurs leave the market exogenously.
  6. Entrepreneurs accumulate net worth.
  7. Uncertainty (of period $t+1$) is realized.
  8. Entrepreneurs decide how much capital to borrow, and state-contingent debt contract is made.

1.2.1 Households

There is an infinitely-lived representative household that derives utility from a composite final consumption good $C_t = \left[\int_0^1 c_{it}^{1-\frac{1}{\epsilon}} di \right]^{\frac{1}{1-\frac{1}{\epsilon}}}$ and leisure, $1 - H_t$, where c_{it} denotes the level of consumption for each retail good i at period t, and ϵ is the intratemporal elasticity of substitution across the retail goods.

Households supply labor H_t to the entrepreneurs and receive W_t as the real wage per labor hour. They earn a total of Π_t as dividends from the retailers, pay lump-sum taxes T_t to the fiscal authority, and receive the riskless real rate of return R_t on their deposits D_t with the intermediary. Formally, the representative household solves

$$\max_{\{C_t, H_t, D_{t+1}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, H_t\right) \tag{1.1}$$

subject to the period budget constraints

$$C_t + D_{t+1} = W_t H_t + R_t D_t - T_t + \Pi_t \tag{1.2}$$

where $\beta \in (0,1)$ is the subjective discount rate. E_t is the expectation operator conditional on the information set available at t, which includes current and past values of endogenous state variables, and distributions of shocks to total factor productivity, real government spending, and cross-sectional dispersion of entrepreneurs' idiosyncratic productivity. Following Bloom (2009), I label shocks to cross-sectional dispersion as *uncertainty* shocks.

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The riskless real rate of return is defined as $R_t = \frac{1+r_t^n}{1+\pi_{t+1}}$, where r_t^n is the (net) nominal interest rate and π_{t+1} is the (net) price inflation of the final good from t to $t+1$. The nominal interest rate is set by the monetary authority as an operating target, and affects real allocations due to existence of price stickiness in the model environment.

The household's optimality conditions imply standard consumption-savings and labor supply conditions:

$$\frac{\partial U(t)}{\partial C_t} = \beta R_t E_t \left[\frac{\partial U(t+1)}{\partial C_{t+1}} \right] \qquad W_t = -\frac{\frac{\partial U(t)}{\partial H_t}}{\frac{\partial U(t)}{\partial C_t}} \tag{1.3}$$

where $U(t)$ denotes the period-t utility function. One-period stochastic discount factor, which is taken as given by the sector(s) owned by the household, is then given by $\Xi_{t+1|t} = \beta E_t \left[\frac{\partial U(t+1)}{\partial C_{t+1}} / \frac{\partial U(t)}{\partial C_t} \right]$. A no-Ponzi condition on households, $\lim_{T\to\infty} E_t \beta^T \Xi_{t+T|t} D_{t+T} \geq 0$ completes the household's problem.

1.2.2 Entrepreneurs

The entrepreneur i starts each period t with physical capital K_{it} that is purchased from capital producers at the end of period $t-1$ at a real price Q_{t-1}. They produce wholesale goods Y_{it} with labor and capital. The labor used in the production, L_{it}, is composed of household labor H_{it} and the entrepreneurial labor H_{it}^e such that $L_{it} = H_{it}^\Omega (H_{it}^e)^{(1-\Omega)}$ where Ω is the share of households' income in total labor income.[13]

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[13]Entrepreneurs are allowed to supply labor not only for their own projects but also for other entrepreneurial projects. This helps to aggregate the entrepreneurial sector. The share of labor income accruing to the entrepreneur, $1 - \Omega$, is assumed to be very small (of an order of .01). Hence, including entrepreneurial labor in the standard production function does not affect the results significantly.

The wholesale production of entrepreneur i is done via a constant returns to scale (CRTS) technology given by $Y_{it} = \omega_{it} A_t K_{it}^\alpha L_{it}^{1-\alpha}$ where A_t is total factor productivity common across all entrepreneurs, and ω_{it} is the idiosyncratic productivity level of the entrepreneur i.

The idiosyncratic level of productivity, ω_{it}, is assumed to be $i.i.d$ across entrepreneurs and time, with a continuous at least once-differentiable cdf $F(.)$, with $E[\omega] = 1$ and variance σ_t.[14] The cross-sectional dispersion of entrepreneurial idiosyncratic productivity at time t is given by σ_t, and exogenous movements in σ are due to *uncertainty* shocks. Note that shocks to σ_t is a mean-preserving spread for the distribution of idiosyncratic productivity ω_i.[15]

Given the level of capital acquired at the end of $t-1$ (K_{it}), the entrepreneur chooses the demands for labor at the beginning of t to maximize real profits. The entrepreneur earns revenues from selling the wholesale goods to the retailers, and from selling non-depreciated capital to the capital producers, $\omega_{it} Q_t (1-\delta) K_{it}$.[16] Then, the entrepreneur determines how much capital to demand (or in other words, how much to borrow).[17] Hence, the entrepreneur's optimization problem can be analyzed in two stages, first labor demand is determined at the beginning of the current period, and second capital demand is determined at the end of the period.

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[14]Assuming ω_{it} to be i.i.d over entrepreneurs and time is to have an *ex-post* representative entrepreneurial sector.

[15]In particular, let $F(.)$ be a log-normal distribution. Then, $E[\omega] = 1$ implies $\ln(\omega) \sim N(\frac{-1}{2}\sigma^2, \sigma^2)$ since $E[\omega] = e^{\frac{-1}{2}\sigma^2 + \frac{1}{2}\sigma^2}$. Now consider an exogenous change in σ to $\widetilde{\sigma}$ due to uncertainty. Then, $\ln(\omega) \sim N(\frac{-1}{2}\widetilde{\sigma}^2, \widetilde{\sigma}^2)$, and that implies $E[\omega] = e^{\frac{-1}{2}\widetilde{\sigma}^2 + \frac{1}{2}\widetilde{\sigma}^2} = 1$.

[16]Hence, ω_{it} is assumed to affect not only the level of entrepreneurial production, but also the effective level of capital holdings. In this regard, ω_{it} also affects the quality of capital held by the entrepreneurs (see the discussions in Gertler et al., 2003; and Gilchrist and Saito, 2008).

[17]The entrepreneurs are assumed to be more impatient than the ultimate lenders (households) which ensures that external borrowing exists in the model.

The entrepreneur's maximization problem at the beginning of t is:

$$\max_{H_{it}, H_{it}^e} \frac{1}{X_t} \omega_{it} A_t K_{it}^\alpha \left(H_{it}^\Omega (H_{it}^e)^{(1-\Omega)} \right)^{(1-\alpha)} - W_t H_{it} - W_t^e H_{it}^e \tag{1.4}$$

where $X_t = \frac{P_t}{P_t^W} > 1$ is the average mark-up of retail goods over wholesale goods in gross terms. The solution to the above problem yields standard optimal labor demand decisions for both types of labor: $W_t = (1-\alpha)\Omega \frac{Y_{it}}{H_{it}} \frac{1}{X_t}$, and $W_t^e = (1-\alpha)(1-\Omega)\frac{Y_{it}}{H_{it}^e} \frac{1}{X_t}$. Each equation equates the marginal products with the respective real wages paid to each labor input.

For the entrepreneur to be able to repay his debt, the revenue from the wholesale production (after labor is paid), $\alpha \frac{1}{X_t} Y_{it} + \omega_{it} Q_t (1-\delta) K_{it}$, should exceed the ex-post value of debt to the financial intermediary. In particular, denote the total external financing need of the entrepreneur by $B_{it} = Q_{t-1} K_{it} - N_{it}$, where N_{it} is the entrepreneur's (own) net worth. Then, the entrepreneur is able to repay his debt at period t if

$$\alpha \frac{1}{X_t} Y_{it} + \omega_{it} Q_t (1-\delta) K_{it} \geq Z_{it}(\overline{\omega_t}; \sigma_t) B_{it} \tag{1.5}$$

where $Z_{it}(\overline{\omega_t}; \sigma_t)$ is the (state-contingent) contractual rate which depends on the aggregate macroeconomic state of the economy at t.[18]

Second stage of the entrepreneur's problem is to determine optimal capital demand. The capital demand depends on (i) the expected marginal return to holding

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[18]This notation is to emphasize that debt contract is state-contingent. It should be understood that all other endogenous variables are state-contingent as well, e.g. $Y_{it} \equiv Y_{it}(\overline{\omega_t}; \sigma_t)$, $X_t \equiv X_t(\overline{\omega_t}; \sigma_t)$, $Q_t \equiv Q_t(\overline{\omega_t}; \sigma_t)$, etc. I suppress this notation for brevity.

capital; and (ii) the expected marginal cost of financing capital expenditures.

(i) The ex-post marginal (real) return to holding capital from $t-1$ to t, $R_t^k(\overline{\omega_t}; \sigma_t)$, depends on the marginal profit from wholesale production at t plus the capital gain accrued from $t-1$ to t. Hence, $R_t^k(\overline{\omega_t}; \sigma_t) = \frac{\frac{1}{X_t}\frac{\alpha \overline{Y_t}}{K_{it}} + Q_t(1-\delta)}{Q_{t-1}}$, where $\overline{Y_t}$ is the average wholesale output across the entrepreneurs.[19] Then equation (1.5) can be equivalently represented as:

$$\omega_{it} R_t^k(\overline{\omega_t}; \sigma_t) Q_{t-1} K_{it} \geq Z_t^i(\overline{\omega_t}; \sigma_t) B_t^i \qquad (1.6)$$

Hence, there exists a threshold level of productivity $\overline{\omega_{it}}$, that satisfies $\overline{\omega_{it}} R_t^k(\overline{\omega_t}; \sigma_t) Q_{t-1} K_{it} = Z_t^i(\overline{\omega_t}; \sigma_t) B_t^i$. Accordingly, an entrepreneur i with $\omega_{it} > \overline{\omega_{it}}$ repays the loan and keeps the equity $(\omega_{it} - \overline{\omega_{it}}) R_t^k(\overline{\omega_t}; \sigma_t) Q_{t-1} K_{it}$. If, on the other hand, $\omega_{it} < \overline{\omega_{it}}$, the entrepreneur declares bankruptcy, the intermediary monitors the entrepreneurial production and seizes $(1-\mu)\omega_{it} R_t^k(\overline{\omega_t}; \sigma_t) Q_{t-1} K_{it}$.[20] The defaulting entrepreneur receives nothing.

(ii) The expected marginal cost of financing is characterized by the debt contract problem between the entrepreneur and the intermediary. The intermediaries are assumed to operate in perfectly competitive markets, earning zero profits in equilibrium and perfectly diversifying any idiosyncratic risk. Hence, the debt contract problem is characterized by maximizing expected return to capital to the entrepreneur given that the intermediary earns his opportunity cost of funding (the riskless rate) in expected terms. The solution to the problem determines how the

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[19]Details are provided in Appendix A1.

[20]The debt contract problem is incentive compatible in that an entrepreneur has no gain from misreporting the project outcome.

expected gross payoff from the contract, $R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}$, is split between the two parties, pinning down the desired capital stock K_{it}, and the state-contingent threshold level $\overline{\omega_{it}}$.

The entrepreneurial sector can be aggregated given two assumptions: (i) The fraction of entrepreneurs that remains alive at the end of each period is constant. (ii) The wholesale production technology exhibits CRTS. Given CRTS, the leverage ratio does not depend on firm-specific factors (the idiosyncratic productivity). That is, regardless of the idiosyncratic productivity level, each entrepreneur chooses the same level of leverage, $\frac{Q_{t-1}K_t}{N_t}$, hence face the same level of EFP. Similarly, aggregate wholesale production can be represented by $Y_t = A_t K_t^\alpha \left(H_t^\Omega (H_t^e)^{(1-\Omega)}\right)^{(1-\alpha)}$, where K_t denotes the aggregate capital purchased in $t-1$, H_t is the aggregate labor supplied by the households, and H_t^e is the aggregate entrepreneurial labor. Moreover, the optimal labor demands can be read without firm-specific subscripts. Since the bankruptcy costs are proportional to the wholesale output, the supply of capital can be aggregated as well.

As shown in Appendix A2, the debt contract problem implies that the external finance premium (EFP), defined as the ratio of cost of external funds to that of internal funds, is an increasing function of the aggregate leverage ratio ($\frac{Q_t K_{t+1}}{N_{t+1}} - 1$),

$$EFP_t \equiv \frac{R_{t+1}^k}{R_t} = \left(1 - \frac{N_{t+1}}{Q_t K_{t+1}}\right)\left[[1 - F(\overline{\omega_{t+1}})] + (1 - \mu)\int_0^{\overline{\omega_{t+1}}} \omega_{t+1} dF(\omega_{t+1})\right]^{-1}$$

$$(1.7)$$

where the term in square brackets is the net contractual share going to the lender,

and decreasing in $\bar{\omega}$ for $Q_t K_t > N_t$.[21] Intuitively, as the external borrowing need increases, it is more likely that the entrepreneur declares default. This, in turn, induces an increase in expected monitoring costs, and hence a higher equilibrium level of premium over the riskless rate. The amplification mechanism is driven mainly by this key equation, the EFP being positively related with the aggregate leverage ratio.

The aggregate net worth of entrepreneurs at the end of period t consists of the net worth of entrepreneurs who survived from $t-1$ to t and the period-t entrepreneurial wage. That is, the evolution of aggregate net worth satisfies

$$N_{t+1} = \gamma [R_t^k(\overline{\omega_t}; \sigma_t) Q_{t-1} K_t - \left(R_t + \frac{\mu * \int_0^{\bar{\omega}} \omega F(\omega) R_t^k(\overline{\omega_t}; \sigma_t) Q_{t-1} K_t}{Q_{t-1} K_t - N_t} \right)$$

$$* (Q_{t-1} K_t - N_t)] + W_t^e H_t^e \tag{1.8}$$

The first term in square brackets is the real gross return to holding K_t amount of capital from $t-1$ to t, and the second term is the total payment to the financial intermediaries. Note that the ratio of default costs to quantity borrowed, $\frac{\mu * \int_0^{\overline{\omega}(\overline{\omega_t}; \sigma_t)} \omega F(\omega) R_t^k(\overline{\omega_t}; \sigma_t) Q_{t-1} K_t}{Q_{t-1} K_t - N_t}$, reflects the EFP. The term inside the square brackets is the net payoff from capital investment, part of which is lost due to exogenous survival probability $\gamma < 1$. The last term, $W_t^e H_t^e$, is the total wage received by the entrepreneurs.

Finally, the entrepreneurs who exogenously leave the market at the end of t

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[21]The debt contract problem is presented in Appendix A2.

consumes the residual net worth:

$$C_t^e = (1-\gamma)\left[R_t^k Q_{t-1}K_t - \left(R_t + \frac{\mu_t * \int_0^{\overline{\omega}} \omega F(\omega)R_t^k(\overline{\omega_t};\sigma_t)Q_{t-1}K_t}{Q_{t-1}K_t - N_t}\right) * (Q_{t-1}K_t - N_t)\right]$$

(1.9)

Capital Producers. They purchase final goods I_t and use existing capital stock K_t to produce new capital goods K_{t+1}. The new capital good is then sold to the entrepreneurs.[22] They face capital adjustment cost $\Psi\left(\frac{I_t}{K_t}\right)$, with $\Psi(0) = 0$, $\Psi'(.) > 0$, and $\Psi''(.) < 0$. Hence, the law of motion for aggregate capital stock is

$$K_{t+1} = (1-\delta)K_t + K_t\Psi\left(\frac{I_t}{K_t}\right)$$

(1.10)

Capital producers' problem of choosing I_t to maximize their profits, $Q_tK_{t+1} - Q_t(1-\delta)K_t - I_t$, subject to the evolution of aggregate capital stock yields the standard *Q-relation* for the price of capital:

$$Q_t = \left[\Psi\left(\frac{I_t}{K_t}\right)'\right]^{-1}$$

(1.11)

1.2.3   Retailers

A measure-one continuum of retailers operate in monopolistically competitive markets and face implicit costs of adjusting prices. The price stickiness is of standard Calvo (1983) and Yun (1996) type. Retailers purchase wholesale goods from the

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[22]The capital producers lease capital stock of entrepreneurs (K_t) at period t before the production of K_{t+1}.

entrepreneurs at the marginal cost (P_t^W), and differentiate them costlessly.

The retailers' maximization of expected discounted real profits given iso-elastic demands for each retail good yields the standard optimality condition that a retailer who is able to change its price at t sets the price such that the expected discounted difference between the real marginal cost $(\frac{P_t^W}{P_t})$ and real marginal revenue $(\frac{P_t^*}{P_t})$ is zero, given the environment that the firm is unable to change its price with probability θ in future periods. Formally,

$$E_t \sum_{s=t}^{\infty} \Xi_{t,t+s} \theta^{s-t} \left(\frac{P_t^*}{P_s}\right)^{-\epsilon} Y_s^f \left(\frac{P_t^*}{P_s} - \frac{\epsilon}{\epsilon-1} \frac{P_s^w}{P_s}\right) = 0 \tag{1.12}$$

where P_t^* denote the price set by retailers who are allowed to change their price at t, P_t is the aggregate price level, and $Y_t^f = \left[\int_0^1 y_t(j)^{1-\frac{1}{\epsilon}}\right]^{\frac{1}{1-\frac{1}{\epsilon}}}$ is the Dixit-Stiglitz aggregate of retail goods $y_t(j)$.[23] The conventional approach in most New-Keynesian literature is to log-linearize this equation around a non-inflationary steady state, and proceed to the standard New-Keynesian Phillips curve. However, since I employ second-order approximation to the policy functions, I represent eq. (1.12) in a recursive format.

First define

$$x_t^1 = E_t \sum_{s=t}^{\infty} \Xi_{t,s} \theta^{s-t} \left(\frac{P_t^*}{P_s}\right)^{-\epsilon} Y_s^f \left(\frac{P_t^*}{P_s}\right) \tag{1.13}$$

and

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[23]See Appendix A3 for details.

$$x_t^2 = E_t \sum_{s=t}^{\infty} \Xi_{t,s} \theta^{s-t} \left(\frac{P_t^*}{P_s}\right)^{-\epsilon} Y_s^f \left(\frac{P_s^w}{P_s}\right) \tag{1.14}$$

As shown in Appendix A4, x_t^1 and x_t^2 can represented in a recursive format as

$$x_t^1 = \widetilde{p}_t^{\,1-\epsilon} Y_t^f + E_t \Xi_{t,t+1} \theta (1+\pi_{t+1})^{\epsilon-1} \left(\frac{\widetilde{p}_t}{\widetilde{p_{t+1}}}\right)^{1-\epsilon} x_{t+1}^1 \tag{1.15}$$

where $\widetilde{p}_t = \frac{P_t^*}{P_t}$; and

$$x_t^2 = \widetilde{p}_t^{\,-\epsilon} Y_t^f \frac{1}{X_t} + E_t \Xi_{t,t+1} \theta (1+\pi_{t+1})^{\epsilon} \left(\frac{\widetilde{p}_t}{\widetilde{p_{t+1}}}\right)^{-\epsilon} x_{t+1}^2 \tag{1.16}$$

I focus on the symmetric equilibrium such that optimizing retailers at a given time choose the same price. Then, the evolution of aggregate price satisfies $P_t^{1-\epsilon} = \theta(P_{t-1})^{1-\epsilon} + (1-\theta)(P_t^*)^{1-\epsilon}$. Dividing this expression by $P_t^{1-\epsilon}$ yields

$$1 = \theta(1+\pi_t)^{\epsilon-1} + (1-\theta)\widetilde{p}_t^{\,1-\epsilon} \tag{1.17}$$

1.2.4 Monetary Authority and the Government

The monetary authority sets the short-term nominal interest rate *via* a simple monetary policy rule.[24] The rule, in its most general version, prescribes potential reactions to inflation, and output (as in the standard Taylor rule), as well as financial variables (all in deviations from their respective long-run values). Formally,

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[24]A rule is simple if it includes only a few observable macroeconomic variables and ensures a unique rational expectations equilibrium (and hence implementable). Second, a rule is optimal if it minimizes the welfare distance between the decentralized economy and the planner's economy. For further discussion, see Schmitt-Grohe and Uribe (2006).

$$log\left(\frac{1+r_t^n}{1+\overline{r^n}}\right) = \rho_r log\left(\frac{1+r_{t-1}^n}{1+\overline{r^n}}\right) + (1-\rho_r)\left[\varphi_\pi log\left(\frac{1+\pi_t}{1+\overline{\pi}}\right) + \varphi_Y log\left(\frac{Y_t}{\overline{Y}}\right) + \varphi_F log\left(\frac{F_t}{\overline{F}}\right)\right]$$

(1.18)

where F stands for Financial and denotes either asset price (Q) or external finance premium (EFP), and overlined variables denote the corresponding deterministic steady state values. The policy can also exhibit some inertia/smoothing $(\rho_r \geq 0)$. Note that the authority follows such a policy rule only under a decentralized economy. In planner's economy, the planner does not follow a rule, but instead uses the short-run interest rate as the policy tool to maximize aggregate welfare.

The fiscal policy is assumed to be non-distortionary that the exogenous stream of government expenditures G_t is financed by lump-sum taxes, $G_t = T_t$.[25]

1.2.5 Equilibrium and Aggregation

Each retailer faces a downward-sloping demand from the households $(c_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\epsilon} C_t)$, the capital producers $(i_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\epsilon} I_t)$, and the government $(g_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\epsilon} G_t)$.[26] Moreover, entrepreneurial consumption (c_{jt}^e) and monitoring costs (amc_{jt}) soke up some of the retail good supply j. Hence, supply should be equal to demand at the firm-level implies

$$y_t(j) = c_{jt} + i_{jt} + g_{jt} + c_{jt}^e + amc_{jt}$$

(1.19)

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[25]Assuming away fiscal policy is to simplify the analysis and to focus on monetary policy prescriptions.

[26]See Appendix A5 for details.

for each j. Given the demand curves for each retail good, the above equation can be expressed as

$$y_t(j) = (C_t + I_t + G_t) \left(\frac{P_{jt}}{P_t} \right)^{-\epsilon} + c_{jt}^e + amc_{jt} \tag{1.20}$$

for each j. Note that the retailers are not a productive unit in the economy, implying that the aggregate amount of retail goods should be equal to the aggregate wholesale production $Y^f \equiv Y = F(K, H, H^e)$. Hence, aggregating over all the retail goods implies an aggregate market clearing for the final goods market:

$$Y_t = (C_t + I_t + G_t) \int_0^1 \left(\frac{P_{jt}}{P_t} \right)^{-\epsilon} dj + C_t^e + AMC_t \tag{1.21}$$

where $C_t^e = \int_0^1 c_{jt}^e dj$ and $AMC_t = \int_0^1 amc_{jt} dj$.

To represent the goods-market clearing condition in a tractable way, I represent $S_t \equiv \int_0^1 \left(\frac{P_{jt}}{P_t} \right)^{-\epsilon} dj$ in a recursive format. As details are shown in Appendix A6,

$$S_t \equiv \int_0^1 \left(\frac{P_{it}}{P_t} \right)^{-\epsilon} di$$

$$= (1 - \theta) \left(\frac{P_t^*}{P_t} \right)^{-\epsilon} + \theta \left(\frac{P_{t-1}}{P_t} \right)^{-\epsilon} S_{t-1}$$

$$= (1 - \theta) \tilde{p}_t^{-\epsilon} + \theta \pi_t^\epsilon S_{t-1} \tag{1.22}$$

Hence, the aggregate resource constraint is represented by the following three conditions:

$$Y_t = C_t + C_t^e + I_t + G_t + AMC_t \quad \text{(Aggregate Demand)} \tag{1.23}$$

$$Y_t - C_t^e - AMC_t = \frac{1}{S_t}(F(K_t, H_t, H_t^e) - C_t^e - AMC_t) \quad \text{(Aggregate Supply)} \tag{1.24}$$

$$\sigma_t = (1 - \theta)\widetilde{p}_t^{-\epsilon} + \theta \pi_t^\epsilon S_{t-1} \tag{1.25}$$

I leave the definition of stationary competitive equilibrium of this economy to Appendix B.[27]

1.3   Functional Forms and Calibration

I calibrate the model to match the US economy for the period 1989Q1-2009Q1. This sample choice is mainly for calibration purposes which will be clear below. For some parameters, I use conventional estimates reported in the literature. Table 1.2 summarizes the parameter values.

I choose the period utility function of the form

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[27]The definition of equilibrium includes optimality conditions of the debt contract problem -not shown for brevity in Section 2.2-. These optimality conditions are derived in Appendix A2.

$$U\left(C_t, H_t\right) = log(C_t) - \xi\frac{H^{1+\nu}}{1+\nu} \tag{1.26}$$

which is typically studied in the New-Keynesian literature. I set ν at 0.55 which implies a Frisch labor supply elasticity $(\frac{1}{\nu})$ of 1.80.[28] Then I set ξ at 6.05 so that the household spends $\frac{1}{3}$ of her time working at the deterministic steady state.

The aggregate production of wholesale goods is governed by a CRTS technology given by

$$Y_t = A_t K_t^\alpha \left(H_t^\Omega (H_t^e)^{(1-\Omega)}\right)^{(1-\alpha)} \tag{1.27}$$

where $\alpha = 0.35$, $\Omega = \frac{0.64}{0.65}$, and $H^e = 1$, following BGG. Setting $\alpha = 0.35$ ensures that wages constitute 65% of the total production cost in the model, in accordance with the US economy. $\Omega = \frac{0.64}{0.65}$ implies that entrepreneurial labor earns approximately 1% of the total income. Moreover, the entrepreneurial labor is assumed to be supplied inelastically and normalized to unity.

The subjective discount factor, β, is taken to be 0.9902, in line with the observed 4% annual real rate of interest in the US economy. The quarterly depreciation rate is assumed to be fixed at 0.025. Following Klenow and Malin (2010), I set the Calvo price stickiness parameter, θ, equal to 0.66. This value implies an average frequency of price changes of approximately 3 quarters.[29] Moreover, ϵ is set at 11,

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[28]This level of elasticity is well in the range studied in the macro- business cycle literature. For recent discussions on the labor supply elasticity, see Rogerson and Wallenius (2009), and Christiano, Trabandt, and Walentin (2010) and references therein. I take the average of νs studied by Christiano, Trabandt, and Walentin (2010) as two extreme cases (ν=1 and ν=0.1).

[29]Klenow and Malin (2010) reports that the mean (non-sale) price duration of non-durable goods is 8.3 months, and it is 9.6 months for services goods. Weighting these price durations by their

implying a 10% long-run price mark-up over the marginal cost (under zero long-run inflation).

The capital adjustment cost function takes the following quadratic form

$$\Psi \left(\frac{I_t}{K_t} \right) = \frac{I_t}{K_t} - \frac{\Psi_k}{2} \left[\frac{I_t}{K_t} - \delta \right]^2 \tag{1.28}$$

I set $\Psi_k = 10$ so that the elasticity of price of capital with respect to investment to capital ratio is 0.25 at the deterministic steady state.[30]

The monetary authority is assumed to have a perfect control over the short-term nominal interest rate, and targets an (annual) inflation rate of $\overline{\pi}=2.66\%$ (the average CPI-based inflation rate).[31] Following BGG, I assume that the monetary authority reacts only to the inflation.[32] The (long-run) inflation feedback coefficient, φ_π, is set at 1.77, and the policy persistence parameter, ρ_r, is set at 0.84, following Smets and Wouters (2007).

The remaining three parameters, the bankruptcy cost (μ), the long-run cross-sectional dispersion of idiosyncratic productivity ($\overline{\sigma}$), and the entrepreneur's survival

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shares in the CPI gives out 2.93 quarters. This level of duration in turn implies $\theta = 0.66$. This value is well in the range calibrated/estimated in the New-Keynesian DSGE literature (for a list of studies, see Schmitt-Grohe and Uribe, 2010).

[30]BGG argues that a reasonable calibration for Ψ_k should imply an elasticity in the range of 0 to 0.50. I simply follow BGG, taking the average of these values. Recent estimates imply an elasticity up to 0.60 (see for instance Christensen and Dib, 2008). A larger elasticity would imply a stronger reaction of asset prices to disturbances, leading to larger movements in entrepreneurs' net worth and in turn a stronger financial amplification. I, however, take a conservative stand, and set the parameter as in BGG.

[31]Following Rudebusch (2006), I calculate π_t using the price index for consumption expenditures *excluding* food and energy. Denoting the index by P_t, $\pi_t=400log(P_t/P_{t-1})$.

[32]In Section 7 where I study optimal simple policy rules, I consider the most general case in which the monetary authority is allowed to react to inflation, output gap, and financial variables. The reason of not including the latter two under the benchmark economy is mainly for comparison purposes with the BGG and to elicit in Section 6 the planner's motive to mitigate the degree of financial amplification that would prevail under the benchmark economy.

Table 1.2: Parameters

Description	Parameter	Value	Target/Source
Households			
The quarterly subjective discount rate	β	0.9902	4% Real rate
Preference Parameter	ξ	6.05	1/3 working time
(Inverse) Frisch labor supply elasticity	ν	0.55	CTW (2010)
Firms			
Share of capital in production	α	0.35	RBC
Share of HH's labor income	Ω	0.64/0.65	BGG
Depreciation rate of capital	δ	0.025	RBC
Calvo price stickiness parameter	θ	0.66	Klenow & Malin (2010)
Intra-temporal elasticity of substitution	ϵ	11	BGG
Capital adjustment cost parameter	Ψ_k	10	BGG
Financial Variables			
Bankruptcy Rate	μ	0.13	Bankruptcy rate (3%)
Survival Rate	$1-\gamma$	0.982	Leverage ratio (1.05) [a]
L-R Cross-sectional Dispersion	$\overline{\sigma}$	0.261	EFP (227 BP) [b]
Exogenous Processes			
Persistence Parameter, log(TFP)	ρ_A	0.95	RBC
Persistence Parameter, log(G)	ρ_G	0.87	SGU (2007)
Persistence Parameter, log(σ)	ρ_σ	0.83	Chugh (2010)
Stdev. of innovations to log(TFP)	$\wp_{\varepsilon^A}$	0.0082	Cyclical volatility of GDP
Stdev. of innovations to log(G)	$\wp_{\varepsilon^G}$	0.0076	Cyclical volatility of G
Stdev. of innovations to log(σ)	$\wp_{\mathcal{U}}$	0.0151	Cyclical volatility of EFP [c]
Monetary Policy Rule			
Policy rate persistence	ρ_r	0.84	Smets & Wouters (2007)
Inflation feedback coefficient	φ_π	1.77	Smets & Wouters (2007)

(a) Chugh (2011).
(b) Long-run average of (i) prime-lending rate and 6-month constant maturity treasury bill, (ii) prime-lending rate and 3-month constant maturity treasury bill, (iii) Moody's BAA-rated and AAA-rated corporate bonds, (iv) Moody's BAA-rated corporate bond and 10-year constant maturity treasury bill.
(c) Average cyclical volatility of these credit spreads. Sensitivity analysis is performed as well.

rate (γ) are jointly calibrated to match three long-run financial targets: An annual

bankruptcy rate of 3% (following BGG), the aggregate leverage ratio of non-financial

firms of 1.05 (following Chugh, 2011), and the long-run level of external finance

premium of 227 basis points.[33][34]

The first-moment shocks that I consider are those typically studied in the literature, the innovations to aggregate TFP and real government expenditures.[35] They both follow a first-order autoregressive (AR(1)) process in logs:

$$log(A_t) = \rho_A * log(A_{t-1}) + \varepsilon_t^A \tag{1.29}$$

$$log(G_t) = (1 - \rho_G)log(\overline{G}) + \rho_G log(G_{t-1}) + \varepsilon_t^G \tag{1.30}$$

where ρ_A, ρ_G are the respective persistence parameters, $\overline{G}$ is the long-run level of real government expenditures, and ε_t^A and ε_t^G are the respective i.i.d Gaussian innovations. I set $\rho_A = 0.95$ following the real business cycle literature, and $\rho_G = 0.87$ following Schmitt-Grohe and Uribe (2006). I set $\overline{G}$ equal to 19.56% of the real

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[33]To obtain the long-run average of external finance premium, I use the average of credit spreads that are generally used as an aggregate measure for the spread: two paper-bill spreads, and two corporate bond spreads, i.e. (i) prime-lending rate and 6-month constant maturity treasury bill, (ii) prime-lending rate and 3-month constant maturity treasury bill, (iii) Moody's BAA-rated and AAA-rated corporate bonds, (iv) Moody's BAA-rated corporate bond and 10-year constant maturity treasury bill; all taken from the Fed St. Louis Database. The long-run average of these premia, which I take as the calibration target, is 227 basis points. An annual bankruptcy rate of 3% is within the range of recent estimates for the bankruptcy rates of US non-financial firms (see Gilchrist, Yankov and Zakrajsek, 2010). Chugh (2011) establishes business cycle statistics of aggregate financial variables of the US non-financial firms, and use the sample period 1989Q1-2009Q1.

[34]Note that these financial targets are aggregate measures, and their empirical counterparts are not clear. The level of premium, for instance, depends on the maturity structure of underlying instruments, borrowing firms' characteristics like age, equity, loan size etc., and hence is firm-specific. Use of heterogeneity in these financial targets in a general equilibrium model, however, requires a heterogenous-agent framework, and the BGG, as most agency-cost general equilibrium models, assumes no heterogeneity in this dimension mainly for computational ease. For empirical studies based on micro-level data on EFP and default frequencies, see Levin, Natalucci, and Zakrajsek (2004), and Gilchrist, Yankov and Zakrajsek (2010).

[35]By minimizing the set of first-moment shocks (one for supply and one for demand), I keep the analysis simple. Moreover, the studies that closely resemble this paper, Schmitt-Grohe and Uribe (2006) and Faia and Monacelli (2007), use these disturbances to drive fluctuations in the economy.

GDP in the long run, inline with the US economy for the sample period.

The uncertainty shock, $\mathcal{U}_t$, is defined as disturbances to cross-sectional dispersion of entrepreneur's idiosyncratic productivity. In particular, the cross-sectional dispersion follows an AR(1) process in logs:

$$log(\sigma_t) = (1 - \rho_\sigma)log(\overline{\sigma}) + \rho_\sigma log(\sigma_{t-1}) + \mathcal{U}_t \qquad (1.31)$$

where ρ_σ is the persistence parameter, and $\mathcal{U}_t$ is an i.i.d. Gaussian innovation. I set ρ_σ equal to 0.83, the estimate reported by Chugh (2010) using firm-level data.

Given the structural parameters set so far, I jointly calibrate standard deviations of innovations ε_t^A, ε_t^G, and $\mathcal{U}_t$ to match the observed cyclical volatilities of real GDP, real government expenditures, and the credit spread in the data.[36] The resulting parameter values are $\wp_{\varepsilon^A} = 0.0082$, $\wp_{\varepsilon^G} = 0.0074$, and $\wp_{\mathcal{U}} = 0.0151$ respectively.

1.4 Decentralized Equilibrium and Cross-Sectional Dispersion

I first study the long-run deterministic equilibrium as a function of long-run cross sectional dispersion, $\overline{\sigma}$. This analysis provides a *step-en-route* to discuss how credit frictions affect model dynamics and interlinked with the monopolistic competition and the long-run inflation. Second, I present model dynamics in response to productivity, government spending and uncertainty shocks, and the relative importance of

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[36]The cyclical volatility of the aforementioned credit spreads are, in respective order, .2805, .2195, .2497, and .4812. The average, which I take as the calibration target, is 0.308. In Section 7, I consider sensitivity of the normative results with respect to using a different credit spread. For data definitions, see Appendix C.

uncertainty shocks in driving the business cycles.

1.4.1 Long-run equilibrium and long-run cross sectional dispersion

Figure 1.1 plots the long-run equilibria as a function of long-run cross-sectional dispersion.[37] As the dispersion reduces to zero, the idiosyncratic entrepreneurial project outcomes become a common knowledge. In other words, the asymmetric information between the lender and the entrepreneurs dissipates. As a result, external finance premium, bankruptcies as well as aggregate monitoring costs shrink to zero.[38] Moreover, long-run capital accumulation rises as the dispersion fades away.[39] Similarly, aggregate investment, consumption and output rise as the dispersion dissipates. Moreover, households' welfare is monotonically decreasing in cross-sectional dispersion (not shown for brevity).

Nevertheless, investment and output displays a non-monotonic behavior, that they begin to rise for values of dispersion above a certain level. This is not due to any sort of non-monotonicity in contractual terms (as suggested by the monotonic path of financial variables). This is rather due to entrepreneurs' relying much less on external borrowing: total debt and leverage shrink to zero as the dispersion rises. Hence, *effectively*, the strength of financial frictions starts to decrease in the deterministic long-run equilibrium as the dispersion rises substantially.

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[37]All other parameters are held fixed at those presented in Table 1.2.

[38]When the dispersion is exactly equal to zero, the entrepreneurial sector becomes managed by the intermediary. Hence, neither leverage nor the loan amount can be identified when the dispersion is exactly zero.

[39]Note that aggregate investment at the deterministic steady state is equal to stock of depreciated capital. Hence, an equivalent diagram for total capital stock would be just a scaled-up version of the diagram for investment.

Figure 1.1: Long-run equilibria as a function of long-run cross-sectional dispersion
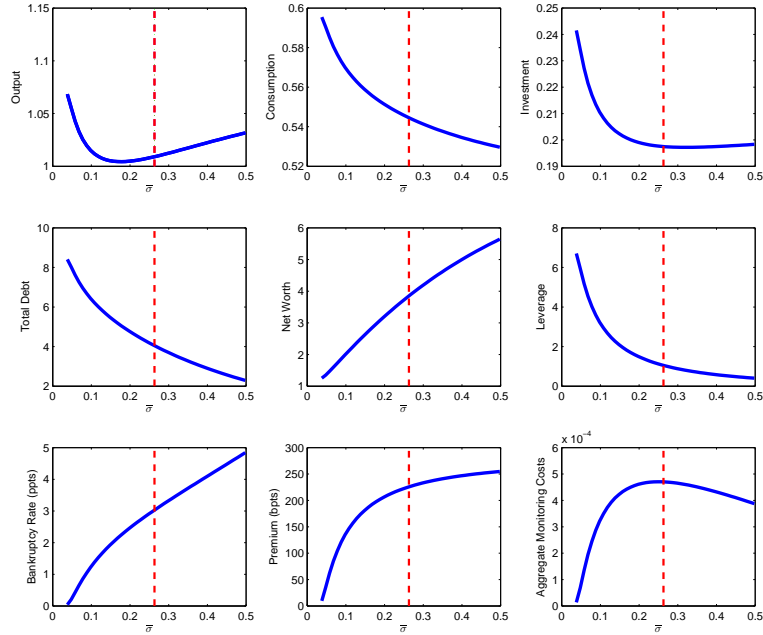
Notes. All other parameters are held fixed at those presented in Table 1.2.

These comparative statics bear the question of whether the responses are driven solely by the agency-cost framework, or affected by specified degrees of long-run inflation ($\overline{\pi} > 0$) and monopolistic competition (captured by ϵ). Since financial variables in the absence of aggregate shocks are determined within partial equilibrium, financial frictions are (almost) independent from the degree of monopolistic competition and the level of long-run inflation at the deterministic steady state. Nevertheless, as we elaborate below, financial frictions are interlinked with the other two features in the model dynamics.

1.4.2 Dynamics of the model and cross-sectional dispersion

I simulate the model economy around the deterministic steady-state using second-order approximation to the policy functions. All statistics are based on HP-filtered cyclical components (with a smoothing parameter 1600). Impulse responses refer to how endogenous variables react to an unexpected one-time one-standard-deviation increase in the underlying exogenous state. All responses are in percentage deviations from respective deterministic steady state values unless otherwise noted.

1.4.2.1 Productivity and Government Spending Shocks

For comparison purposes with the literature, I present the equilibrium responses of real and financial variables in response to a favorable productivity shock (Figure 1.2). Dashed lines show the dynamics under no financial amplification. To shut off the amplification, I set the external finance premium fixed at its deterministic long-run value (227 basis points).[40]

An exogenous increase in total factor productivity leads to an unexpected rise in ex-post marginal real return to capital, which, due to capital adjustment costs, raises the price of capital, Q_t. For a given level of net worth, a rise in Q_t induces an increase in borrowing needs. However, the rise in Q_t drives the net worth up more than proportionately, leading to a decrease in the leverage.[41] EFP then falls on

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[40]I should make the following distinction between shutting financial amplification off and shutting financial frictions off. The former refers to fixing the EFP at its deterministic long-run value (so that the amplification is turned off), whereas the latter refers to no financial frictions in the economy, EFP being zero at all times. For presentation purposes, I choose to shut the amplification off, since the former and the benchmark model then share the same deterministic equilibrium.

[41]One can algebraically show that how sensitive the net worth is to unexpected changes in ex-post return to capital depends on the leverage ratio: Net worth rises more than proportionately to the extent entrepreneurs are leveraged (see BGG, p. 1359).

impact, generating an amplified response of asset prices and aggregate investment.

An exogenous increase in aggregate supply of wholesale goods drives the nominal marginal costs down that the retailers face. Hence, the retailers that are able to set prices chooses a price lower than the average price level in the economy. Average price level, P_t, then decreases, but, due to sticky prices, not as much as the decrease in P_t^W. As a result, average mark-up in the economy, $\frac{P_t}{P_t^W}$, rises and inflation goes below its long-run value.[42]

Figure 1.2: Impulse Responses to a 1 sd. increase in total factor productivity
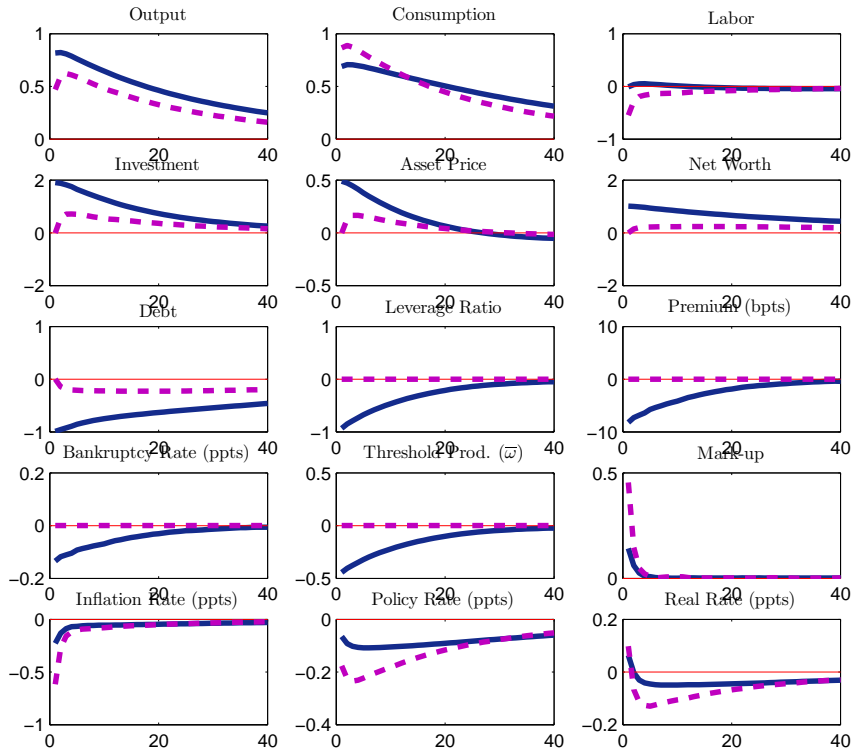
Notes. Solid line: Financial amplification, Dashed line: No financial amplification (EFP is fixed). Unless otherwise noted, the responses are in terms of percentage deviation from the respective deterministic steady states.

Note that existence of financial amplification dampens the response of infla-

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[42]These responses are by and large in line with the literature. See BGG, Faia and Monacelli (2005), and Christiano, Motto and Rostagno (2010).

tion to a rise in productivity. For an economy without amplification (the dashed lines), the rise in aggregate supply of wholesale goods is lower, which dampens the decrease in nominal marginal costs. Average mark-up in the economy then rises less than what would be without financial amplification. As a result, inflation decreases much less on impact. Hence, there exists a relative deflationary effect of financial amplification in response to productivity shocks.[43]

An unexpected expansionary government spending serves as a typical favorable demand shock. A rise in demand for wholesale goods leads to a rise in output and entrepreneurial net worth, and eventually a decrease in premium and the bankruptcy. A higher demand for wholesale goods pushes wholesale prices (nominal marginal costs) up. Retailers that are able to set their prices set a higher price, which leads to an increase in inflation. The average price, P_t, though, does not increase as much as the increase in P_t^W, and hence, average mark-up in the economy, $\frac{P_t}{P_t^W}$ falls.[44]

1.4.2.2 Uncertainty Shocks

Before presenting the corresponding model dynamics, it might be useful to discuss briefly how an exogenous increase in the cross-sectional dispersion affect financial variables in partial equilibrium. Figure 1.3, in particular, shows the effect of a two-standard deviation increase on the cross-sectional dispersion, based on the benchmark values of $\overline{\sigma}$ and $\wp_{\mathcal{U}}$. If the threshold level of productivity, $\overline{\omega}$, were to remain unchanged in response to an increase in the dispersion, the measure of entrepreneurs

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[43]See Faia and Monacelli (2005) for a similar result.

[44]See Figure 1.15 in the Appendix for impulse responses of real and financial variables in response to the government spending shock.

whose productivity is below the threshold level ($\omega_i < \overline{\omega}$) rises. Since the distribution of ω is known at the time the debt contract is made, lenders now understand that there will be fewer firms who will be able pay their debts. Since the lenders should be compensated for the increase in the associated expected monitoring costs, this in turn induces a higher equilibrium level of EFP. The threshold level of productivity is endogenous though, and the general equilibrium effect of an exogenous increase in σ_t is quantitative in nature.

Figure 1.3: An increase in the cross-sectional dispersion of entrepreneurs' idiosyncratic productivity
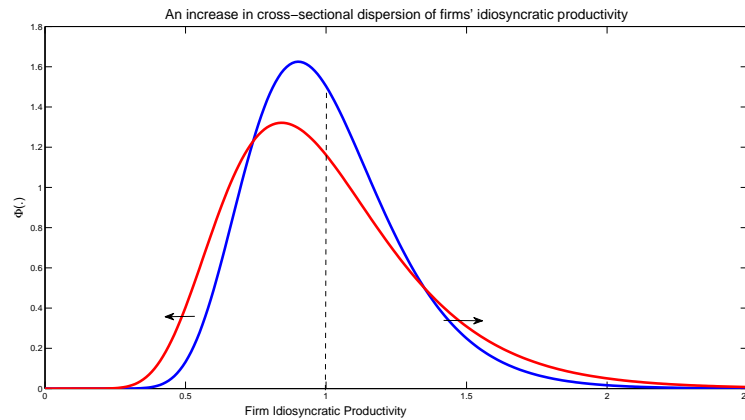
Figure 1.4 provides the impulse responses of real and financial variables to an unfavorable uncertainty shock (an unexpected rise in the cross-sectional dispersion). It is evident that it serves as a prototypical aggregate demand shock. An increase in the dispersion implies a higher risk for the overall loan portfolio of the lenders. Hence, expected monitoring costs rise for which lenders should be compensated. Moreover, due to decrease in expected return to capital, aggregate net worth of the entrepreneurs goes down. These eventually lead to an equilibrium increase in the

leverage and in the premium. The rise in the premium tightens the financing terms, which lowers aggregate investment and in turn aggregate demand.

Figure 1.4: Impulse Responses to a 1 sd. increase in uncertainty
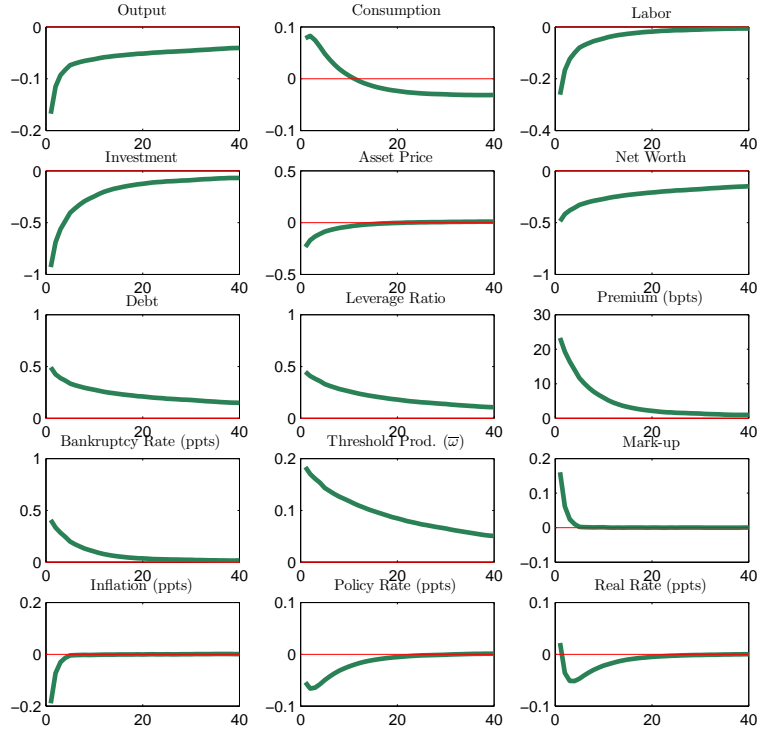
Notes. Unless otherwise noted, the responses are in terms of percentage deviation from the respective deterministic steady states.

A reduction in aggregate demand for the retail goods leads to a lower demand for wholesale goods, pushing wholesale prices (nominal marginal costs) down. Retailers that are able to set their prices set a lower price, which leads to a decrease in inflation. The average price, P_t, though, does not decrease as much as the decrease in P_t^W, and hence, average mark-up in the economy, $\frac{P_t}{P_t^W}$ rises.

Although the model is rather simplistic, equilibrium responses are by and large inline with the data. Gilchrist, Sim and Zakrajsek (2010) show in a VAR

framework that the real GDP declines by .2% after 2 quarters and exhibits a hump-shaped response due to an unexpected one-standard-deviation (an approximately 8%) increase in the uncertainty.[45] We are able to generate this magnitude of decline, but not the hump-shape response. Similarly for aggregate investment, the model is able to generate the documented magnitude of decline yet misses the hump-shape response. Moreover, although the impact effect on the premium seems to be somewhat larger than that documented, it is hard to draw a conclusive picture in this dimension, since the empirical counterpart of the model-based premium is not clear.[46]

The contribution of uncertainty shocks in driving aggregate fluctuations is presented in Table 1.3. The uncertainty shock accounts for around 85% of the variations in EFP and the bankruptcy, and more than 15% of the volatility in other financial variables for both short- and long horizons. Since fluctuations in financial variables first transmit into aggregate investment, investment turns out to be the real variable that is driven by the uncertainty shock most (18% for one period ahead). The remaining real variables are mostly driven by the first-moment shocks.[47]

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[45]They estimate time-fixed effects in a panel-AR(1) regression of firms' equity volatility to measure aggregate uncertainty. The uncertainty is defined as the innovation to idiosyncratic equity volatility that are common to all firms at t. This definition is conformable with the uncertainty defined in our model, time-variation in the cross-sectional dispersion of idiosyncratic productivity that affects all the entrepreneurs.

[46]Note also that the model implies a pro-cyclical debt which is at odds with the data. Note however that I do not consider policy reaction to volume of debt in the policy rules in the normative policy analysis. So, pro-cyclicality in debt should not pose a first-order problem for our normative results.

[47]Christiano, Motto and Rostagno (2010) finds a more pronounced contribution of uncertainty shock on the volatility of real and financial variables. They report that almost all the fluctuations in the EFP, and nearly half of the fluctuations in aggregate investment are driven by the risk shock. In their analysis, most of the contribution comes from the anticipated portion of the uncertainty

Moreover, while a substantial portion of fluctuations in EFP is driven by uncertainty, only 18% of the fluctuations in leverage is uncertainty-driven. This suggests that uncertainty governs most of the fluctuations in the sensitivity of EFP to the leverage, or as labeled before, *the strength of financial amplification.*

Table 1.3: Variance Decomposition (Decentralized Economy)

	Variable	TFP+G Shocks				Uncertainty Shocks			
		$t=1$	$t=4$	$t=8$	$t=\infty$	$t=1$	$t=4$	$t=8$	$t=\infty$
	Y	96.08	97.89	98.42	98.4	3.92	2.11	1.58	1.6
Real Variables	C	98.73	98.86	99.28	99.3	1.27	1.14	0.72	0.7
	I	81.67	88.19	90.85	93.16	18.33	11.81	9.15	6.84
	Q	81.67	88.12	90.61	92.47	18.33	11.88	9.39	7.53
	EFP	12.31	14.66	16.93	19.54	87.69	85.34	83.07	80.46
	Net Worth	81.66	85.47	87.37	89.51	18.34	14.53	12.63	10.49
Financial Variables	Debt	82.27	98.77	99.66	98.66	17.73	1.23	0.34	1.34
	Leverage	81.66	81.62	81.18	75.01	18.34	18.38	18.82	24.99
	Bankruptcy Rate	11.39	13.6	15.76	18.29	88.61	86.4	84.24	81.71
Monetary Variables	Policy Rate	61.78	71.01	79.53	94.13	38.22	28.99	20.47	5.87
	Inflation	61.78	67.49	70.86	81.14	38.22	32.51	29.14	18.86

Before presenting the normative results, note that when the economy is driven only by the first-moment shocks, the model cannot generate observed cyclical volatility of the external finance premium, the key variable in the amplification mechanism. Namely, for properly calibrated magnitudes of TFP and government spending shocks, the simulation-based cyclical volatility of the premium is almost one third than that observed in the data. If one is to match the volatility of premium by using first-moment shocks only, the standard deviation of innovations to TFP should be set at an implausibly high value, which, on the other hand, would yield an unrealistically high volatility in real GDP. Hence, the key role that uncertainty shocks, or financial shocks in general, play in a BGG-type financial amplification model is to match the observed volatility in the premium. This role is especially important for normative analysis, since credit frictions manifest itself through existence of an

shock.

EFP.

1.5   Welfare Evaluation

Aggregate welfare is given by

$$V_0 \equiv E_0 \sum_{t=0}^{t=\infty} \beta^t U(C_t, H_t) \tag{1.32}$$

Note that although the model exhibits heterogeneity of consumers (households and entrepreneurs), the fraction of entrepreneurial consumption in aggregate consumption can be reasonably assumed to be negligible, as emphasized in BGG, and Faia and Monacelli (2005, 2008).[48]

I conduct second-order approximation to the policy functions as well as to V_0 to have accurate normative results. Note that, under first-order approximation to the policy functions, the expected value of endogenous variables would be equal to their deterministic steady state values. Hence, welfare levels would be the same under alternative policy rules. Moreover, since the economy exhibits distortions even at the steady state, first-order approximation to the policy rules induces incorrect welfare rankings even under a second-order approximation to the welfare.[49] Accordingly, I

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[48]Note that since entrepreneurs are risk-neutral, they care only the mean level of entrepreneurial consumption. Also, alternative policy rules imply not only the same deterministic equilibrium for all the variables, but also the same stochastic mean for the entrepreneurial consumption. Hence, in comparing alternative policy rules, entrepreneurial consumption, however small it is, can be neglected. See also Faia and Monacelli (2005) and references therein.

[49]In particular, at the deterministic steady state, I do not assume any *ad-hoc* subsidy scheme to undo distortions due to monopolistic competition, nor I assume a zero long-run inflation that undoes price dispersion. Moreover, credit distortions are effective in the deterministic long-run as well. Such a subsidy scheme facilitates log-linearization around a zero-inflation steady state. Without that scheme, one need to rely on higher order approximation to the policy functions as well as to the welfare. For further discussion, see Schmitt-Grohe and Uribe (2006).

first define welfare in recursive form:

$$V_{0,t} \equiv U(C_t, H_t) + \beta E_t V_{0,t+1} \tag{1.33}$$

and conduct second-order approximation to $V_{0,t}$ (as well as to the policy functions).
SGU (2006) show that an equivalent representation is

$$V_{0,t} = \overline{V_0} + \frac{1}{2}\Delta(V_0) \tag{1.34}$$

where $\overline{V_0}$ is the welfare evaluated at the deterministic steady state, and Δ is the
constant correction term capturing the second-order derivative of the policy function
for $V_{0,t}$ with respect to the variance of shocks. Hence, equation (1.34) provides
an approximation to the aggregate welfare at $t = 0$ taking into account the lack
of certainty at the stochastic steady state. Aggregate welfares for decentralized
economies are conditional on the deterministic steady state of the Ramsey planner's
economy.[50] I will discuss Ramsey planner's problem in detail in the next section.

For each policy alternative, I perform standard consumption-based welfare
comparisons. In particular, let the aggregate welfare associated with a policy regime
a be given by

$$V_{0,t}^a \equiv E_0 \sum_{t=0}^{t=\infty} \beta^t U(C_t^a, H_t^a) \tag{1.35}$$

and the welfare attained by the Ramsey planner be given by

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[50]Decentralized economy starts from the Ramsey deterministic long-run equilibrium. As will be
evident below, this corresponds to setting deterministic long-run inflation rate equal to zero.

$$V_{0,t}^r \equiv E_0 \sum_{t=0}^{t=\infty} \beta^t U(C_t^r, H_t^r) \tag{1.36}$$

Let λ denote the percentage of consumption in Ramsey planner's economy r that the household is willing to give up to be as well of under regime a. λ then is implicitly given by

$$V_{0,t}^a = E_0 \sum_{t=0}^{t=\infty} \beta^t U((1-\lambda)C_t^r, H_t^r) \tag{1.37}$$

A positive λ, for instance, implies that Ramsey economy dominates the decentralized economy in welfare terms. To find optimal policy rules, I search over policy feedback coefficients that minimize λ.

1.6   Optimal Monetary Policy

1.6.1   Sources of Inefficiencies

The model economy has three features that lead to inefficient outcomes compared to a first-best flexible-price economy: the first two are monopolistic competition and price stickiness, standard distortions in New-Keynesian models. For a detailed textbook discussion on these distortions, interested readers may refer to Gali (2008). The third distortion is due to financial frictions.

Monopolistic Competition. Since the retailers are assumed to have imperfectly elastic demand for their differentiated products, they are endowed with some market power and set prices above marginal cost. Under flexible prices and no financial

frictions, $-\frac{\partial U(t)}{\partial H_t}/\frac{\partial U(t)}{\partial C_t} = W_t = MPL_t\frac{1}{X}$, where $X = \frac{\epsilon}{\epsilon-1} > 1$ is the desired gross

mark-up, and MPL is the marginal product of labor under no financial frictions.

Note that under the first-best economy, marginal rate of substitution should be

equal to marginal product of labor, MPL_t. Since, in equilibrium, marginal rate of

substitution is increasing in hours and marginal product of labor is decreasing in

hours, the presence of monopolistic competition, $X > 1$, leads to an inefficiently low

level of employment and output since $MPL_t\frac{1}{X} < MPL_t$.

Price Stickiness. To study this distortion in isolation, assume that distortions

due to monopolistic competition is undone by an optimal wage subsidy, $\tau = \frac{1}{\epsilon}$,

which is financed by lump-sum taxes.[51] Note that economy's average mark-up is

defined by P_t/P_t^W (up to a first-order). Then, existence of price stickiness together

with the optimal subsidy scheme implies $-\frac{\partial U(t)}{\partial H_t}/\frac{\partial U(t)}{\partial C_t} = W_t = MPL_t\frac{X}{X_t}$ which

violates the efficiency condition under the first-best economy that $-\frac{\partial U(t)}{\partial H_t}/\frac{\partial U(t)}{\partial C_t} =$

MPL_t, unless X_t is equal to X at all times. Moreover, due to constant (and equal)

elasticity of substitution across the intermediate goods, consumers would be willing

consume equal amount of each intermediate good. However, if there exists price

dispersion across the goods, then consumer would optimally choose different levels

of intermediate goods, which induces a welfare loss.

Compared to a second-best economy that features monopolistic competition

and financial frictions, the distortion due to price stickiness is due to $\theta \neq 0$ implying

that $\tilde{p}_t \neq 1$ and hence S_t is greater than one. $S_t > 1$ leads to an inefficient output

loss (see equation 1.24).

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[51] A wage subsidy of $\tau = \frac{1}{\epsilon}$ implies $-\frac{\partial U(t)}{\partial H_t}/\frac{\partial U(t)}{\partial C_t} = W_t = MPL_t\frac{1}{X(1-\tau)} = MPL_t$.

Financial Frictions. Note that in an economy with no inefficiencies (first-best economy), $\frac{\partial U(t)}{\partial C_t} = \beta E_t R^k_{t+1} \left[\frac{\partial U(t+1)}{\partial C_{t+1}} \right]$. Introducing financial frictions creates a wedge between expected return to capital and the risk-free rate, distorting households' intertemporal decision. Defining the wedge as $R_{t+1} = (1 - \tau^k_{t+1}) R^k_{t+1}$, I next show that the wedge depends on aggregate financial conditions.

As shown in Appendix A1, the intermediaries' zero-profit condition for the next period is,

$$[1 - F(\overline{\omega_{t+1}})] Z_{t+1}(\overline{\omega_{t+1}}; \sigma_{t+1}) B_{t+1} + (1-\mu) \int_0^{\overline{\omega_{t+1}}} \omega_{t+1} R^k_{t+1}(\overline{\omega_{t+1}}; \sigma_{t+1}) Q_t K_{t+1} dF(\omega_{t+1}) = R_{t+1} B_{t+1}$$

(1.38)

Substituting in $\overline{\omega_{t+1}} R^k_{t+1}(\overline{\omega_{t+1}}; \sigma_{t+1}) Q_t K_{t+1} = Z_{t+1}(\overline{\omega_{t+1}}; \sigma_{t+1}) B_{t+1}$, and dividing by $R^k_{t+1}(\overline{\omega_{t+1}}; \sigma_{t+1})(Q_{t+1} K_{t+1})$ yields

$$[1 - F(\overline{\omega_{t+1}})] + (1 - \mu) \int_0^{\overline{\omega_{t+1}}} \omega_{t+1} dF(\omega_{t+1}) = \frac{R_{t+1}}{R^k_{t+1}(\overline{\omega_{t+1}}; \sigma_{t+1})} \frac{B_{t+1}}{Q_t K_{t+1}}$$

(1.39)

The wedge is then given by

$$1 - \tau^k_{t+1} = \left(\frac{Q_t K_{t+1}}{B_{t+1}} \right) \left[[1 - F(\overline{\omega_{t+1}})] + (1 - \mu) \int_0^{\overline{\omega_{t+1}}} \omega_{t+1} dF(\omega_{t+1}) \right]$$

(1.40)

It is evident that fluctuations in the wedge are due to movements in aggregate

financial conditions. The (inverse) of the first term is an increasing function of the leverage ($\frac{Q_t K_{t+1}}{N_{t+1}}$), and the second term is the net contractual share going to the lenders.

1.6.2 Ramsey optimal policy problem

I assume that there is a benevolent planner at $t = 0$ that has been operating for an infinite number of periods. The planner is assumed commit to her decisions made at some indeterminate point in the past. In this sense, I consider an optimal policy problem from a timeless perspective (Woodford, 2003).

In Ramsey planner's economy, there is no exogenous monetary policy rule. The planner chooses the allocations, prices, and the policy rate to maximize aggregate welfare, respecting the competitive equilibrium conditions. The planner has only one policy tool, the short-run nominal interest rate.

Ramsey planner using a single policy tool to smooth the two wedges implies that the Ramsey problem is *incomplete* (in the sense of Chari and Kehoe, 1999). As evident from Section 1.6.1, a tax on return to capital would complete the system. Moreover, equation (1.40) suggests that the proposed tax should smooth fluctuations in the leverage and net contractual share going to the lenders. In this regard, interest-rate policy would be less effective if such a fiscal policy tool is introduced. Further analysis is left to future work.

Formally, the Ramsey planner chooses state-contingent processes $\{C_t, H_t, H_t^e, K_t, I_t,$
$N_t, R_t, AMC_t, R_t^k, \overline{\omega_t}; \sigma_t, x_t^1, x_t^2, W_t, W_t^e, R_t^k, X_t, \widetilde{p}_t, Q_t, \overline{\omega_t}, \Gamma(\overline{\omega_t}, \sigma_t), G(\overline{\omega_t}, \sigma_t), \Gamma'(\overline{\omega_t}, \sigma_t),$

$G'(\overline{\omega_t}, \sigma_t), \lambda(\overline{\omega_t}, \sigma_t), k(\overline{\omega_t}, \sigma_t), s(\overline{\omega_t}, \sigma_t), r_t^n, R_t, \pi_t\}_{t=0}^{t=\infty}$ to maximize (1.32), subject to

the competitive equilibrium conditions (as presented in Appendix B, excluding the

monetary policy rule), $R_t \geq 1$, for $t > -\infty$; given values of endogenous variables

(including the Lagrange multipliers associated with the competitive equilibrium con-

ditions) for $t < 0$, and exogenous stochastic processes $\{\varepsilon_t^A, \varepsilon_t^G, \text{ and } \mathcal{U}_t\}_{t=0}^{\infty}$.[52]

At the deterministic long-run equilibrium, the Ramsey planner can not achieve

first-best level of welfare. The planner has no policy tool (such as factor subsidies)

to undo distortions due to monopolistic competition. Moreover, since the policy rate

cannot affect the level of premium in the deterministic long-run, financial frictions

can not be eliminated as well.[53] In the stochastic steady state, however, the policy

tool can be used to balance the 'tension' between the three distortions. As will be

suggested by the impulse responses, the optimal inflation rate is not zero at all times

as would be in standard cashless New-Keynesian models with the aforementioned

factor subsidies.

1.6.2.1   Cyclical Volatilities

A standard result in Ramsey optimal policy literature is that the planner would

like to smooth wedges (which distorts intra- and/or inter-temporal decisions) to

maximize aggregate welfare.[54] Note from Section 1.6.1 that the wedges in the model

economy fluctuate due to movements in the EFP and aggregate gross mark-up

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[52]The endogenous objects, $\Gamma(\overline{\omega_t}, \sigma_t), G(\overline{\omega_t}, \sigma_t), \Gamma'(\overline{\omega_t}, \sigma_t), G'(\overline{\omega_t}, \sigma_t)$ are related to the debt-contract problem. See Appendix A2 for details.

[53]The premium, in the absence of aggregate shocks, is determined purely within the partial equilibrium debt-contract framework.

[54]Among many others, see Chari and Kehoe (1999), and Chugh and Arseneau (2010).

(respectively for each wedge). As shown in Table 1.4 below, the results suggest that the cyclical volatility of EFP is reduced by 17%, and that of inflation (which is intrinsically linked to mark-up) by 28% compared to the decentralized economy.

In addition, EFP being smoother while leverage being rather equally volatile in the planner's economy suggests that the planner smooths the sensitivity of premium to the leverage. I analyze this point more in detail in the next subsection.

Table 1.4: Cyclical Volatilities (%-standard deviations)

	Variable	Decentralized Economy	Planner's Economy
	Y	1.14	1.16
Real Variables	C	0.95	0.96
	I	2.90	2.86
	Q	0.73	0.72
	EFP	0.31	0.25
	Net Worth	1.48	1.44
Financial Variables	Debt	0.28	0.35
	Leverage	1.36	1.33
	Bankruptcy Rate	0.53	0.44
Monetary Variables	Policy Rate	0.16	0.91
	Inflation	0.30	0.22

1.6.2.2 Reducing the strength of financial amplification

In the dynamics, the Ramsey planner smoothes fluctuations in EFP, lowering its volatility by approximately 17% compared to the decentralized economy.[55] The way the planner reacts to EFP can be understood by decomposing it into two parts: sensitivity of EFP to the leverage, $h(\overline{\omega_{t+1}})$, and the leverage, $\left(1 - \frac{N_t}{Q_t K_{t+1}}\right)$.[56] Simulation-based $h(.)$ for the decentralized economy gets stronger as the leverage rises for the decentralized economy (see Figure 1.5). For the planner's economy,

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[55]A complete stabilization, however, is not optimal since that would imply higher level of fluctuations in inflation and hence higher distortions due to price dispersion.
[56]See equation (1.7).

on the other hand, sensitivity is rather smooth.[57] Accordingly, the spread reacts
smoother in the Ramsey economy as leverage changes. In other words, the planner
achieves a lower *strength of financial amplification.*

Figure 1.5: Strength of Financial Amplification (Planner's Economy)
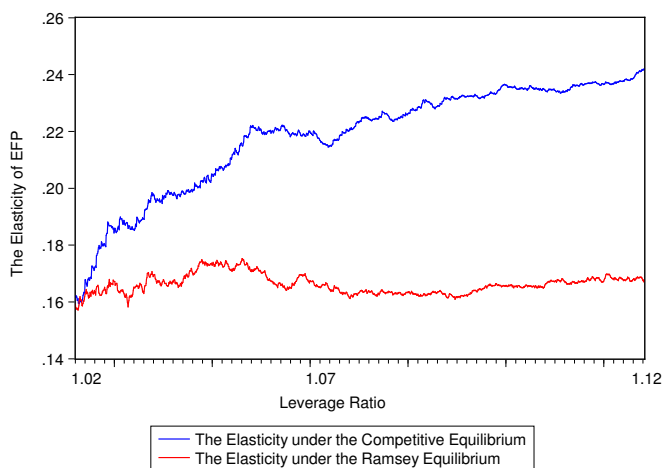
1.6.2.3 Reducing the contribution of uncertainty on business cycles

There are striking differences in the contribution of uncertainty shocks on the volatil-
ity of real and financial variables under the benchmark against the Ramsey planner's
economy (Table 1.5). The relative contribution of uncertainty on the volatility of
most real and financial variables is much lower under the Ramsey economy. On the
other hand, fluctuations in policy rate, mark-up, price dispersion and inflation are
driven substantially by uncertainty. In sum, the planner uses the policy rate almost

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[57]In particular, I first obtain simulated series for the EFP and the leverage for the two economies
(where each economy is simulated for 3000 periods, and the first 500 periods are omitted). Then I
sort the sample according to the leverage, and run an ordinary least squares log-log regression of
EFP on leverage for the first 1000 observations. Then I roll the sample by one observation -with
a fixed window size-, and obtain the estimate for the elasticity for this sample. Rolling the sample
further and obtaining the slope estimates give out the elasticity series in Figure 1.5.

solely due to uncertainty to lessen the contribution of uncertainty on business cycle fluctuations.

Table 1.5: Variance Decomposition (Decentralized Economy vs. Ramsey Planner's)

	Variable	Decentralized Economy		Planner's Economy	
		TFP+G Shocks	Uncertainty Shocks	TFP+G Shocks	Uncertainty Shocks
Real Variables	Y	96.08	3.92	97.7	2.3
	C	98.73	1.27	96.05	3.95
	I	81.67	18.33	96.54	3.46
Financial Variables	Q	81.67	18.33	96.52	3.48
	EFP	12.31	87.69	23.05	76.96
	Net Worth	81.66	18.34	99.12	0.88
	Debt	82.27	17.73	59.4	40.59
	Leverage	81.66	18.34	96.96	3.04
	Bankruptcy Rate	11.39	88.61	21.07	78.93
Monetary Variables	Policy Rate	61.78	38.22	3.34	96.66
	Inflation	61.78	38.22	8.8	91.21
Further Insights	Mark-up	48.41	51.59	5.19	94.8
	Price Dispersion	61.78	38.22	8.8	91.21

1.6.2.4 Impulse Responses

Figure 1.6 provides the impulse responses to a one-standard deviation increase in productivity for the Ramsey economy (dashed line) against the benchmark decentralized equilibrium (solid line). First, recall from Figure 1.2 that existence of financial amplification dampens the response of inflation to productivity shocks. Hence, there is no inherent trade-off for the planner in neutralizing the distortions due to financial frictions and price dispersion. The planner, endowed with a single tool, partially neutralizes price stickiness distortion, exerting negligible effect on the dynamics of financial variables.[58]

When the economy is driven by the uncertainty shock, however, there is a noticeable difference between the dynamics of decentralized economy and the planner's economy (Figure 1.7). The planner would like to smooth fluctuations in financial

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[58]See Faia and Monacelli (2005) for a similar result.

Figure 1.6: Ramsey Impulse Responses to a 1 sd. increase in total factor productivity
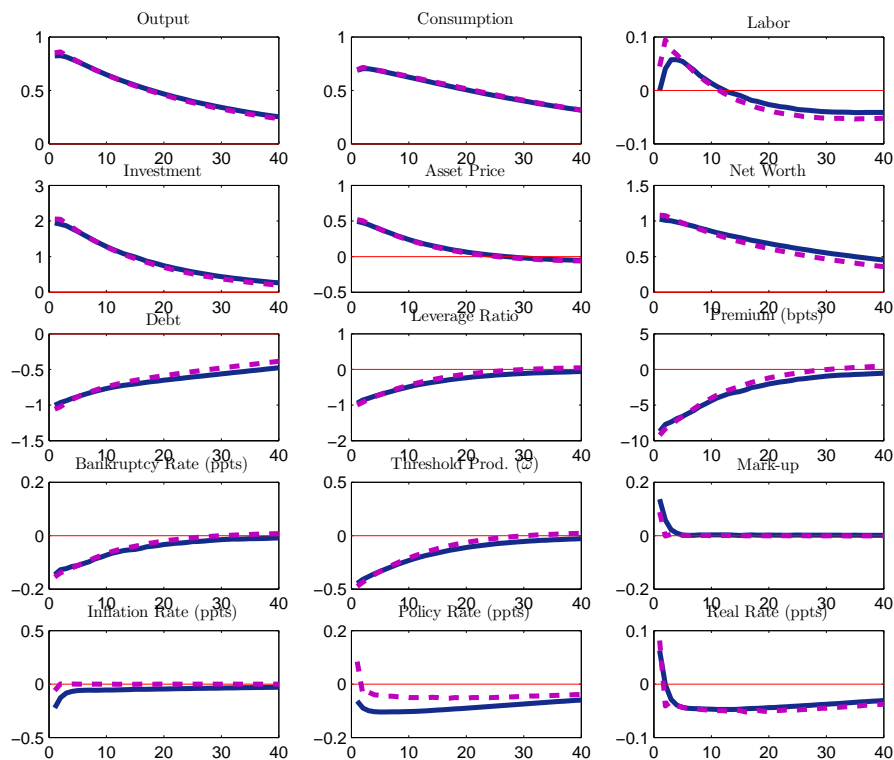
Notes. Solid line: Decentralized economy. Dashed line: Ramsey Planner's economy.

variables, yet at an expense of higher volatility in inflation. The intuition lies on the fact that the planner faces a trade-off in eliminating financial frictions and price dispersion. For instance, in response to an unfavorable uncertainty shock, the planner would like to reduce the real rate to contain movements in the premium. On the other hand, planner would like to increase the real rate to reduce fluctuations in inflation. In equilibrium, financial frictions, which are more pronounced under uncertainty shocks, overwhelms price dispersion, and the planner at the margin chooses to reduce the real rate.

Before studying optimal policy rules, note that it is the existence of price stick-

Figure 1.7: Ramsey Impulse Responses to a 1 sd. increase in uncertainty
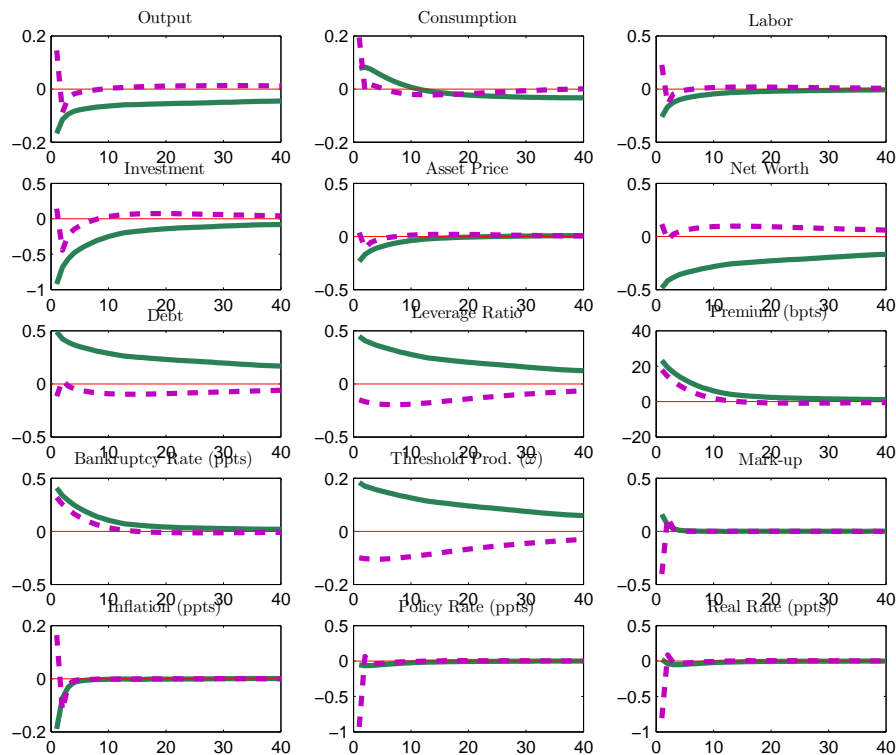
Notes. Solid line: Decentralized economy. Dashed line: Ramsey Planner's economy.

iness that enables the planner to reduce strength of financial amplification (or reduce the contribution of uncertainty on the business cycles). Without price stickiness, the policy tool, short-term nominal interest rate, cannot affect the real interest rate and hence real allocations in the economy. In turn, the policy would be ineffective in neutralizing the distortions.[59]

[59]To formally analyze this, I consider the model with only financial market imperfections (hence no monopolistic competition or price stickiness). The cyclical volatilities and cross-correlations are provided in Tables 1.9 and 1.10 in the Appendix. Without price stickiness and given symmetric retailers, there will be no price dispersion (hence no resulting inefficiencies). In this regard, the planner has no incentive to smooth fluctuations in inflation. Accordingly, inflation fluctuates substantially in the planner's economy (and leading to frequent violation of zero lower bound for the interest rate, which I ignore for the sake of this experiment). On the other hand, the planner would be willing to smooth fluctuations in the inter-temporal wedge to improve aggregate welfare, though, unable to do so since the policy rate cannot affect real allocations.

1.7 Optimal Simple and Implementable Policy Rules

The planner's problem yields equilibrium behavior of the policy rate as a function of the state of the economy. Implementing the planner's policy, hence, requires the policy maker to observe the equilibrium values of all endogenous state variables (including lagrange multipliers associated with the equilibrium conditions). Even if the policy maker could observe the state of the economy, the equilibrium may not render a unique competitive equilibrium. Hence, it is of particular interest whether a simple and implementable monetary policy rule that includes only a few observable macroeconomic variables and that ensures a (locally) unique equilibrium can achieve an aggregate welfare level virtually identical to that under the planner's economy.

The monetary policy rule is assumed to have the following form:

$$log\left(\frac{1+r^n_t}{1+\overline{r^n}}\right) = \rho_r log\left(\frac{1+r^n_{t-1}}{1+\overline{r^n}}\right) + (1-\rho_r)\left[\varphi_\pi log\left(\frac{1+\pi_t}{1+\overline{\pi}}\right) + \varphi_Y log\left(\frac{Y_t}{\overline{Y}}\right) + \varphi_F log\left(\frac{F_t}{\overline{F}}\right)\right]$$

(1.41)

where F stands for Financial, and denotes either asset price (Q) or external finance premium (EFP). In search for optimal values of ρ_r, φ_π, φ_Y, and φ_F, I restrict (long-run) inflation feedback coefficient to be within [1,3], persistence parameter to be within [0,1] and other policy rule coefficients to be within [-3,3]. The lower bound for φ_π is to ensure equilibrium determinacy. The upper bound for φ_π, and the range of [-3,3] for φ_Y and φ_F are set from a practical policy making view.[60]

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[60]To obtain policy rule coefficients, I search over 50000 alternative policy rules and calculate conditional welfare for each rule using equation (1.34). Then given the results suggested by the grid search, I use simulated annealing algorithm to pinpoint the policy rule that maximizes welfare.

As suggested by Schmitt-Grohe and Uribe (2006), a stronger policy reaction than what these bounds suggest might be difficult to implement in an actual economy. Moreover, I discuss potential implications of a binding upper bound for inflation feedback coefficient on the optimal magnitude of responses based on welfare loss results.

Responding to financial variables.

Confirming the conventional finding in the literature, if the economy is driven by traditional first-moment shocks, it is optimal not to respond to financial variables (column 5 in Table 1.6). Consider, for instance, a monetary authority reacting to asset prices in response to productivity shocks. In particular, ρ_r, φ_π, and φ_Y are set at their optimal values ($\varphi_r = 0.540, \varphi_\pi = 3, \varphi_Y = 0$), while φ_Q is set at 0.25 (a lean-against-the wind policy reaction).[61] Figure 1.8 suggests that such a reaction to asset prices leads to higher fluctuations in inflation, which in turn creates higher distortions due to relative price dispersion.

If the economy is driven by uncertainty shocks, optimal policy prescribes a reaction to financial variables. In particular, consider the impulse responses under two alternative policy rules (the optimal policy rule and a Taylor rule ($\varphi_r = 0.85, \varphi_\pi = 1.5, \varphi_Y = 0.5/4, \varphi_{EFP} = 0$)), versus the Ramsey economy.[62] Figure 1.9 shows that the optimal rules yield dynamics closer to the Ramsey economy.[63] Note

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[61]One can use a lean-on-the-wind policy reaction to asset prices ($\varphi_Q < 0$) as well. This would just exacerbate the difference between optimal and the non-optimal rule.

[62]I report the dynamics under the optimal rule with a reaction to premium ($\varphi_r = 0, \varphi_\pi = 2.94, \varphi_Y = 0$, and $\varphi_{EFP} = -0.681$). The optimal rule with a reaction to asset prices yields virtually the same dynamics.

[63]Similarly, one can show that such a response to financial variables would decrease the sensitivity of EFP to fluctuations in leverage.

Figure 1.8: Responding to Asset Prices -productivity shocks-
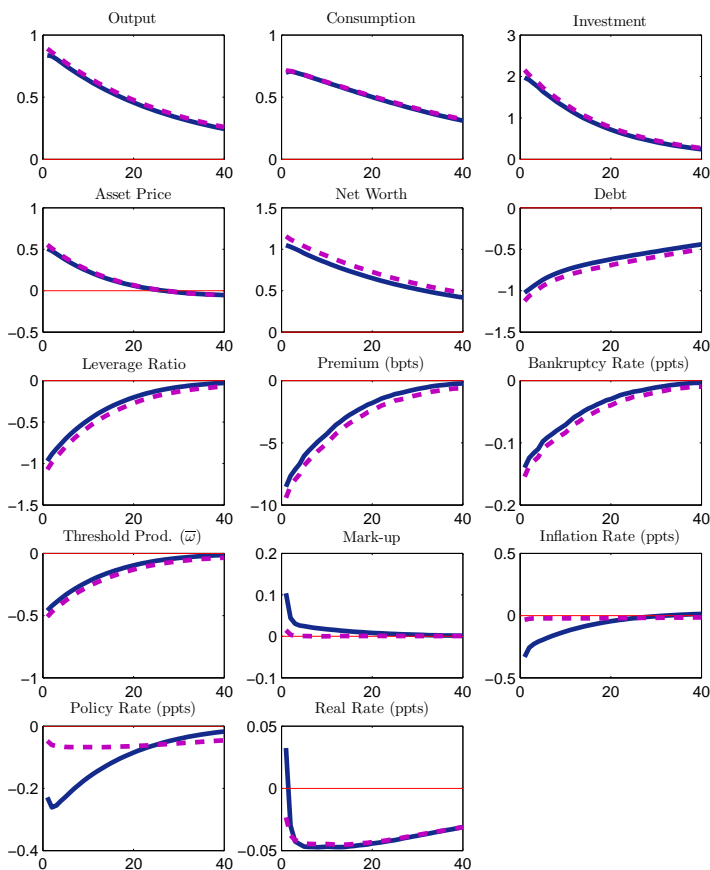
Notes. Solid line: Policy rule with $\varphi_Q = 0.25$ (other policy parameters are as in the optimal rule). Dashed Line: Optimal Rule.

that although mark-up fluctuates less under the optimal rule (compared to Ramsey dynamics), it yields a lower aggregate welfare. The reason lies on the fact that the premium fluctuates less under Ramsey economy, implying milder fluctuations in the intertemporal wedge. Such a difference seems to offset the welfare loss originated from higher price dispersion under the Ramsey economy.

If the economy is driven by first-moment as well as uncertainty shocks, then it is optimal to respond to credit spreads but not to asset prices (Table 1.6). This

Figure 1.9: Responding to Asset Prices -uncertainty shocks-
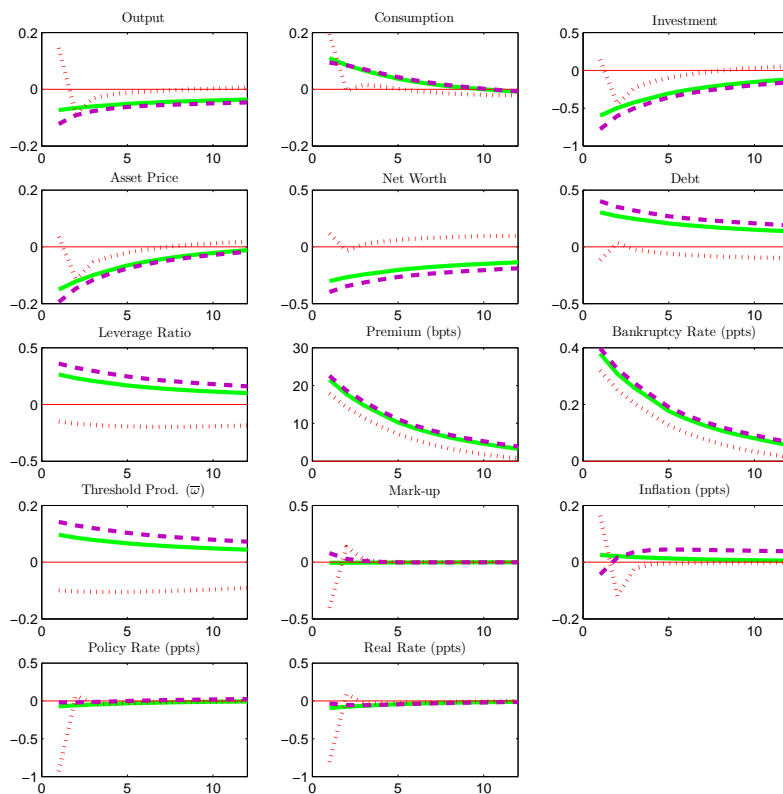
Notes. Solid line: Optimal rule. Dashed line: Taylor rule (ρ_r=0.85, φ_π=1.5, and $\varphi_Y = 0.5/4$). Dotted Line: Ramsey economy.

is mainly due to credit spreads being driven mostly by uncertainty shocks, whereas asset prices being driven mostly by productivity shocks (see Table 1.3). This is inline with planner's motive to mitigate fluctuations in uncertainty as discussed in the previous section. The optimal degree of response suggests that in response to a 1% increase in credit spreads, the policy rate should be reduced by 32 basis points. The optimized rule with a reaction to credit spreads achieves a welfare elvel slightly less than the strict inflation stabilization.

Note also that the upper bound for inflation is hit in this case (when all shocks

are present).[64] Since strict inflation stabilization dominates the optimized rule in welfare terms (though by a small margin), setting a higher upper bound for inflation would imply a higher optimal reaction to inflation and a decrease in the optimal magnitude of response to credit spreads. Eventually as one increases the upper bound, the optimal magnitude of response to credit spreads would be driven down to zero.

Figure 1.10: Welfare Surfaces (Benchmark Uncertainty versus High Uncertainty)
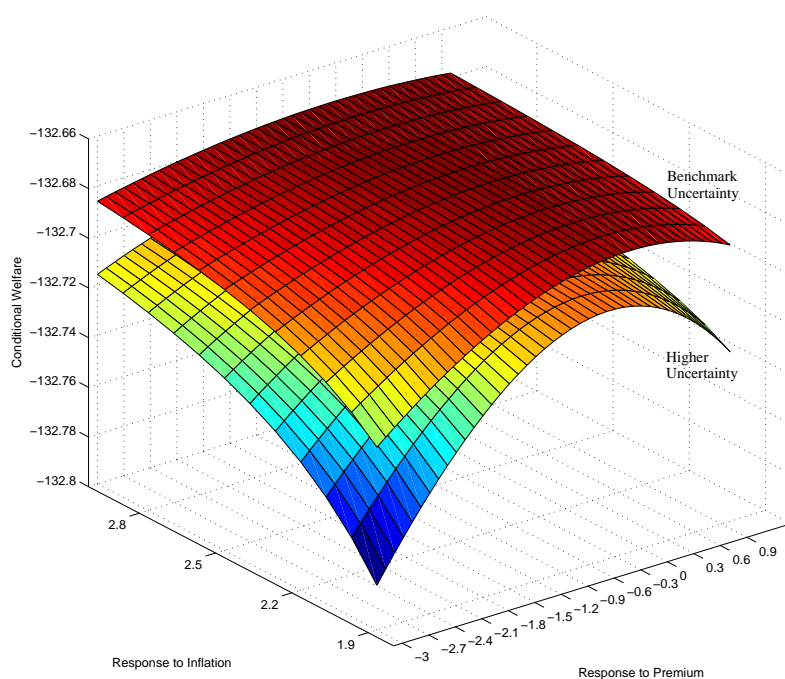
For sensitivity analysis, I consider an alternative calibration for uncertainty shocks (an increase in $\wp_{\mathcal{U}}$ to 0.25).[65] For brevity in the discussion that follows, I will

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[64]As argued above, the upper bound is set at 3 from a practical policy making view (Schmitt-Grohe and Uribe, 2006).

[65]In particular, I calibrate $\wp_{\mathcal{U}}$ to match the cyclical volatility of the spread between BAA-rated corporate bond yield and 10-year constant maturity treasury bill, the most volatile spread among the ones I consider. Joint calibration of $\wp_{\varepsilon^A}$, $\wp_{\varepsilon^G}$, and $\wp_{\mathcal{U}}$ now implies 0.00808, 0.00764, and 0.02506, respectively.

call this case as *higher uncertainty*. Under higher uncertainty, optimal policy pre-

scription suggests a stronger reaction to premium. In particular, the optimized rule

suggests $\varphi_r = 0, \varphi_\pi = 3, \varphi_Y = 0$ and $\varphi_{EFP} = -0.60$ (Figure 1.10). Moreover, the

welfare surface under higher uncertainty not only shifts down and induces a stronger

reaction to the premium, but also shows more concavity around the optimal rule.

A zero policy response to the premium under higher uncertainty would then imply

a much higher welfare loss compared to an economy under benchmark uncertainty.

Figure 1.11: Welfare Surfaces (Responding to Uncertainty)
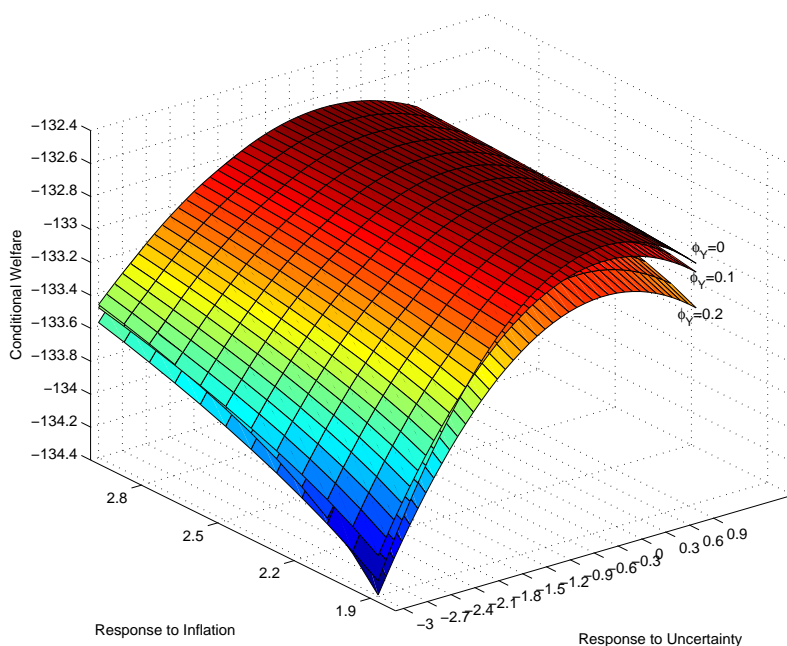
To provide a further understanding on whether time-variation in cross-sectional

dispersion is welfare detrimental, I next consider normative implications of react-

ing to the uncertainty itself in the policy rule.[66] This point is especially relevant,

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[66]Note that the deterministic steady state value of the uncertainty shock is equal to zero. Hence, the relevant part of the policy rule cannot be modified as log deviation of $\mathcal{U}$ from its deterministic value. I accordingly modify the relevant part as $...+\varphi_F(\mathcal{U})$.

since including asset prices or credit spreads in the policy rule counterfactually assumes that the central bank cannot observe uncertainty. In contrast, the central bank is able observe uncertainty, and importantly, would like to react directly to uncertainty, since the Ramsey optimal policy results suggest that the planner would like reduce the contribution of uncertainty on the business cycles. Welfare surfaces suggests that policy maker is willing to react to the uncertainty directly in a simple policy rule (Figure 1.11).[67]

Moreover, the welfare surface remains concave for higher degrees of inflationary reaction. Essentially, the optimal policy rule that includes uncertainty fares even better than the strict inflation stabilization (although slightly), and yields a welfare gain of 0.0026% in consumption terms.[68] In sum, I conclude that the time variation in cross-sectional dispersion induce inefficiencies in the economy. This is why it is the credit spreads, fluctuations in which are mostly driven by uncertainty shocks, call for a negative response, whereas asset prices, fluctuations in which are driven mostly by first-moment shocks, call for a zero response in the optimal policy rule.

Responding to inflation.

Under first-moment shocks, strict inflation stabilization that completely eliminates distortions due to relative price dispersion turns out to be the welfare-maximizing

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[67]With optimal policy rule coefficients $\varphi_r = 0, \varphi_\pi = 3, \varphi_Y = 0$ and $\varphi_{\mathcal{U}} = -0.20$.

[68]Interestingly, under this counterfactual scenario in which the policy maker could directly react to an exogenous state variable, the economy under the optimal policy rule welfare dominates the Ramsey economy slightly by 0.0022% in consumption terms. This is mainly due to approximating welfare at t=0 (taking into account lack of certainty at the stochastic steady state). Since the rule includes one of the exogenous state itself, the resulting correction term becomes closer to zero, increasing the welfare significantly, leading to this result. This result that the Ramsey planner might be dominated (even slightly) by an optimal rule is a result also noted in Schmitt-Grohe and Uribe (2006).

policy (Table 1.6). Comparing the impulse responses under strict inflation stabilization and that under Ramsey policy shows that the dynamics of real and financial variables are almost the same.[69] In a model with financial frictions, the reason why such an emphasis is given to price stickiness distortion manifests itself in the simulated volatility of external finance premium. In particular, in response to first-moment shocks, fluctuations in the premium is unrealistically low, suggesting an unrealistic low degree of financial amplification. Hence, less emphasis is given to mitigating financial amplification.

If the economy is driven by uncertainty shocks, the optimal policy allows for mild fluctuations in inflation, inline with Ramsey policy findings. Optimal rules achieve a welfare higher than the strict inflation stabilization.

If the economy is driven by all shocks, the price dispersion distortion becomes more relevant (mainly due to first-moment shocks), and the welfare attained under the optimal rule is slightly less than that under strict inflation stabilization (Table 1.6).

Responding to output gap.

If the economy is driven by first-moment shocks, a positive response to output gap exacerbates fluctuations in average mark-up in the economy, leading to much higher distortions due to price dispersion.[70] Consider, for instance, in Fig-

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[69]Shown in the Appendix Figure 1.1g in the Appendix. Curiously though, conditional on the initial state being the deterministic Ramsey steady state, strict inflation stabilization welfare dominates the Ramsey economy though by only a negligible amount. A consumer in the Ramsey economy would prefer a consumption subsidy of $3 * 10^{-7}\%$ to be as well off as under the strict inflation stabilization regime. See Schmitt-Grohe and Uribe (2006) for a similar result.

[70]For a detailed discussion, see Schmitt-Grohe and Uribe (2006).

ure 1.17 in the Appendix, the model dynamics under the benchmark policy rule ($\varphi_r = 0.85, \varphi_\pi = 2.309, \varphi_Y = 0$) and those under the calibrated rule ($\varphi_r = 0.85, \varphi_\pi = 2.309, \varphi_Y = 0.593/4$). It is evident that an output response reduces fluctuations in the premium, yet leads to much higher fluctuations in average mark-up in the economy. Welfare losses presented in Table 1.6 suggest that the distortion due to increase in relative price dispersion outweighs the potential welfare gain from having a smoother premium. Similarly, a comparison of Taylor rules (with no persistence) shows that an output reaction of $\varphi_Y = 0.5$ leads to a welfare loss equal to 0.4% in consumption terms.[71]

In response to uncertainty shocks, as evident from welfare surfaces (Figures 1.19 to 1.22 in the Appendix), responding to output gap becomes much less welfare reducing. For a mild policy reaction to inflation (such as φ_π=1.5), a positive policy response to output might even be welfare improving.

Gradualism in the policy.

The optimality of gradual policy reaction to (first-moment) disturbances has also been recognized in the literature.[72] Such a result implies that monetary policy should be backward looking. Nevertheless, welfare losses from acting proactively is negligible. Comparing the optimized rules shows that decreasing the persistence parameter ρ_r by approximately 0.1 induce a welfare loss less than one-thousandth of a percentage in consumption terms. Moreover, for $\varphi_\pi = 1.5$ as in the Taylor

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[71]In 2005$s, this welfare loss amounts to 24 billions dollars. To get this number, I first calculate the average real consumption expenditures on non-durables and services for 1989Q1-2009Q1, which is approximately 6 trillion (in 2005$s). Calculating the fraction of 0.4% then yields the desired number.

[72]See for instance Schmitt-Grohe and Uribe (2006).

rule, an increase in the persistence to .85 from nil costs 0.003% of consumption. Under uncertainty shocks, policy making should be pro-active (no gradual policy reaction). Yet, welfare losses due to a milder persistence seems negligible. Consider for instance an increase in the persistence from $\rho_r = 0$ to $\rho_r = 0.85$ in standard Taylor rules reported in Table 1.6. The resulting welfare loss is around 0.003%. Under a stronger anti-inflationary stance, the loss would even be lower.

1.8 Further Discussion

The analysis so far shows that policy makers should contain business cycle fluctuations due to uncertainty, by either directly responding to uncertainty, or more practically, by responding to credit spreads (which, themselves, are a good proxy for uncertainty). In this section, with the caveat in mind that the model is rather simplistic, I provide further insights on this result from a historical perspective.

First, note that the key equation in the financial amplification mechanism - that relates the external finance premium (EFP) to the aggregate leverage ratio ($\frac{Q_t K_{t+1}}{N_{t+1}}$)- can be expressed as a 'collateral' constraint. In particular,

$$EFP_t \equiv \frac{R^k_{t+1}}{R_t} = \left(1 - \frac{N_{t+1}}{Q_t K_{t+1}}\right) \left[[1 - F(\overline{\omega_{t+1}})] + (1 - \mu) \int_0^{\overline{\omega_{t+1}}} \omega_{t+1} dF(\omega_{t+1})\right]^{-1}$$

which implies that

$$\overbrace{Q_t K_{t+1} - N_{t+1}}^{AmountBorrowed} = \left[\frac{1}{1 - EFP_t \left[[1 - F(\overline{\omega_{t+1}})] + (1 - \mu) \int_0^{\overline{\omega_{t+1}}} \omega_{t+1} dF(\omega_{t+1})\right]} - 1\right] \overbrace{N_{t+1}}^{NetWorth}$$

Hence, firms can borrow a certain fraction of their net worth, the fraction depending on aggregate financial conditions in the economy.

How strong does the planner value marginally relaxing this constraint over the actual business cycles? Technically, how does the Lagrange multiplier associated with this constraint evolve over time?

To address this question, I use the stochastic processes for innovations to TFP, government spending, and cross-sectional dispersion derived from actual US data for the sample period 1989Q1 to 2009Q1. For uncertainty, I use three different measures, a macro-level measure, the implied stock market volatility (the VXO), and two micro-level measures, cross-sectional dispersion of industrial TFP growth, and of firm-level stock returns' growth.[73] For deriving each series of innovations, I estimate an AR(1) process for cyclical TFP, government spending, and the dispersion series (or the VXO). Actual series as well as details on the estimation are provided in Appendix D.

Figure 1.12 suggests that planner's willingness to relax the financial constraint shows a rapid deterioration starting in mid-2002 and eventually hits record low levels by the end of 2006. When industry-level dispersion is used as a measure of uncertainty, such rapid deterioration starts in 2001 and ceases by 2005. These all indicate that the planner -who respects the competitive equilibrium conditions- values relaxing the financial constraint at a historically low level in the run up to the recent crisis.

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[73]For the latter two, I use the data set provided by Bloom *et al.* (2010). You may refer to `http://www.stanford.edu/~nbloom/RUBC_data.zip`

Figure 1.12: Shadow Value of Relaxing the Financial Constraint
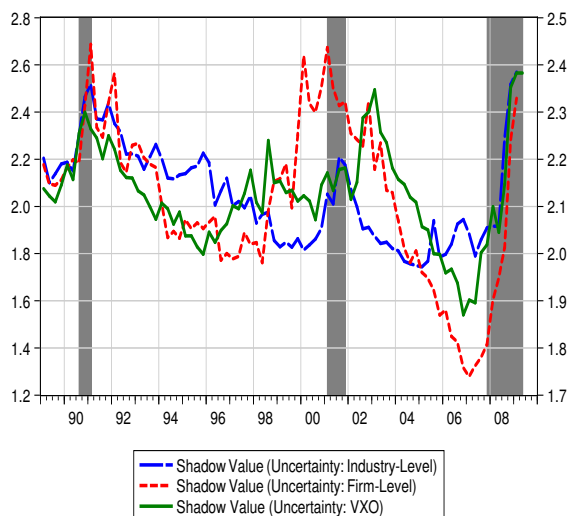
Moreover, marginal benefit of relaxing the financial constraint follows the dispersion (or the VXO) at a great extent.[74] In this regard, uncertainty captures well how strong the planner values relaxing the constraint. The reason lies on the fact that uncertainty drives most of the fluctuations in credit spread, the ease at which borrowers are able to fund their projects.

1.9   Conclusion

This paper studies normative implications of uncertainty, or as also called in the literature risk or dispersion shocks, on monetary policy. Uncertainty shocks, having a direct effect on aggregate financial conditions, prescribes that financial variables *per se* should matter for monetary policy making.

The results suggests that optimal policy is to contain business cycle fluctua-

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[74]See Figure 1.25 in the Appendix for the dispersion or the VXO series.

tions due to uncertainty. Moreover, a higher uncertainty makes the planner more willing to relax the financial constraints. From a practical point of view, however, the availability and the quality of information on the dispersion may not be available in real time. Yet, since credit spreads can serve as a good proxy for uncertainty, responding to credit spreads can be used as a general policy to have better aggregate outcomes. The optimal degree of response is generally less than one-to-one under various scenarios. A strict inflation stabilization, compared to the optimal rule, yields negligible welfare gains. Under 'higher uncertainty', the precise degree to which the policy maker should respond to the spread rises.

Note however that there are many credit spreads in an actual economy, business cycle properties of which, although mostly follow a common trend, might differ during abnormal times. Moreover, potential interaction between first-moment shocks and uncertainty can also be explored. To the extent first-moment shocks (e.g. productivity) lead to fluctuations in cross-sectional dispersion, and accordingly, induce more pronounced distortions in capital supply decisions, optimal policy would still prescribe a response to credit spreads. The optimal magnitude of response, though, requires a quantitative exercise. Besides, facing not a single but many measures of financial stability, monetary authorities, in a real economy, is to conjecture an optimal response to various types of disturbances (of real and financial types) depending on the quantity and the quality of the information available. These points are left to future work.

Table 1.6: Simple Rules versus Optimal Policy (Baseline Calibration)

First-Moment Shocks	ρ_r	φ_π	φ_Y	φ_F	σ_r	σ_π	σ_Y	σ_{EFP}	$CEV(\%)$
	0	1.5	0	0	0.190	0.126	1.180	0.131	0.0092
Taylor Rules	0	1.5	0.5/4	0	1.197	1.167	1.135	0.123	0.4015
	0.85	1.5	0	0	0.169	0.375	1.088	0.101	0.0121
	0.85	1.5	0.5/4	0	0.748	1.815	0.794	0.023	0.3050
Benchmark Rule	0.84	1.770	0	-	0.132	0.235	1.124	0.113	0.0022
	0.84	1.770	0.640/4	-	0.710	1.482	0.863	0.027	0.2325
Strict Inflation Stabilization	-	-	-	-	0.067	0	1.177	0.131	0.000
Ramsey Policy	-	-	-	-	0.166	0.064	1.149	0.120	0
Optimized Rules									
with Asset Price	0.540	3	0	0	0.092	0.043	1.174	0.129	0.0006
with Premium	0.445	3	0	0	0.093	0.039	1.175	0.130	0.0006

Uncertainty Shocks	ρ_r	φ_π	φ_Y	φ_F	σ_r	σ_π	σ_Y	σ_{EFP}	$CEV(\%)$
	0	1.5	0	0	0.252	0.166	0.119	0.270	0.0063
Taylor Rules	0	1.5	0.5/4	0	0.170	0.078	0.111	0.268	0.0052
	0.85	1.5	0	0	0.092	0.229	0.192	0.289	0.0100
	0.85	1.5	0.5/4	0	0.042	0.078	0.132	0.275	0.0069
Benchmark Rule	0.84	1.770	0	-	0.094	0.189	0.175	0.285	0.0086
	0.84	1.770	0.640/4	-	0.048	0.071	0.129	0.274	0.0062
Strict Inflation Stabilization	-	-	-	-	0.116	0	0.094	0.265	0.0033
Ramsey Policy	-	-	-	-	0.891	0.206	0.176	0.219	0
Optimized Rules									
with Asset Price	0	2.947	0	0.281	0.082	0.042	0.087	0.264	0.0032
with Premium	0	2.921	0	-0.684	0.090	0.031	0.090	0.264	0.0032

First-Moment & Uncertainty Shocks	ρ_r	φ_π	φ_Y	φ_F	σ_r	σ_π	σ_Y	σ_{EFP}	$CEV(\%)$
	0	1.5	0	0	0.316	0.208	1.186	0.300	0.0126
Taylor Rules	0	1.5	0.5/4	0	1.209	1.169	1.141	0.295	0.4037
	0.85	1.5	0	0	0.192	0.440	1.105	0.306	0.0191
	0.85	1.5	0.5/4	0	0.749	1.187	0.805	0.276	0.3090
Benchmark Rule	0.84	1.770	0	-	0.162	0.301	1.138	0.307	0.0107
	0.84	1.770	0.640/4	-	0.712	1.484	0.873	0.275	0.2385
Strict Inflation Stabilization	-	-	-	-	0.133	0	1.181	0.296	0.0004
Ramsey Policy	-	-	-	-	0.907	0.216	1.162	0.250	0
Optimized Rules									
with Asset Price	0	3	0	0	0.186	0.062	1.183	0.297	0.0016
with Premium	0	3	0	-0.325	0.169	0.050	1.181	0.296	0.0014

1.10   Appendix - Tables

1.11   Appendix - Figures

Figure 1.13: Long-run equilibria as a function of monopolistic competition

Notes. Dashed line: No financial frictions ($\overline{\sigma} \simeq 0$), Solid line: Financial frictions ($\overline{\sigma} = 0.263$).

Figure 1.14: Long-run equilibria as a function of long-run inflation

Notes. Dashed line: No financial frictions ($\overline{\sigma} \simeq 0$), Solid line: Financial frictions ($\overline{\sigma} = 0.263$).

Table 1.7: Business Cycle Statistics -Decentralized Economy-

		Real Variables			Financial Variables						Monetary Variables	
		Y	C	I	Q	EFP	Net Worth	Debt	Leverage	Bankruptcy Rate	Policy Rate	Inflation
Std. Dev (%)		1.14	0.95	2.90	0.73	0.31	1.48	0.28	1.36	0.53	0.16	0.30
Auto. corr.		0.73	0.75	0.72	0.72	0.66	0.72	0.93	0.70	0.66	0.85	0.32
Real Variables	Y	1	0.93	0.97	0.96	-0.50	0.96	0.53	-0.94	-0.48	-0.58	-0.44
	C		1	0.86	0.85	-0.23	0.85	0.60	-0.81	-0.21	-0.81	-0.62
	I			1	1.00	-0.68	0.99	0.47	-0.99	-0.67	-0.44	-0.34
Financial Variables	Q				1	-0.68	0.98	0.40	-0.99	-0.67	-0.42	-0.35
	Premium					1	-0.69	-0.19	0.71	1.00	-0.28	-0.23
	Net Worth						1	0.52	-0.98	-0.68	-0.42	-0.34
	Debt							1	-0.36	-0.19	-0.62	-0.02
	Leverage								1	0.70	0.33	0.37
	Bankruptcy Rate									1	-0.29	-0.24
Monetary Variables	Policy Rate										1	0.54
	Inflation											1

Table 1.8: Business Cycle Statistics -Planner's Economy-

		Real Variables			Financial Variables						Monetary Variables	
		Y	C	I	Q	EFP	Net Worth	Debt	Leverage	Bankruptcy Rate	Policy Rate	Inflation
Std. Dev (%)		1.16	0.96	2.86	0.72	0.25	1.44	0.35	1.33	0.44	0.91	0.22
Auto. corr.		0.71	0.71	0.71	0.71	0.66	0.72	0.83	0.71	0.66	-0.15	-0.37
Real Variables	Y	1	0.97	0.98	0.97	-0.44	0.98	0.46	-0.95	-0.42	-0.13	0.05
	C		1	0.96	0.95	-0.34	0.98	0.47	-0.95	-0.32	-0.21	0.07
	I			1	1.00	-0.54	0.99	0.46	-0.95	-0.52	-0.08	0.05
Financial Variables	Q				1	-0.55	0.98	0.40	-0.95	-0.53	-0.07	0.04
	Premium					1	-0.46	-0.51	0.36	1.00	-0.52	0.20
	Net Worth						1	0.44	-0.97	-0.44	-0.07	-0.01
	Debt							1	-0.21	-0.51	-0.15	0.36
	Leverage								1	0.34	0.04	0.11
	Bankruptcy Rate									1	-0.53	0.20
Monetary Variables	Policy Rate										1	-0.85
	Inflation											1

Table 1.9: Business Cycle Statistics (only financial frictions) -Decentralized Economy-

		Real Variables			Financial Variables						Monetary Variables	
		Y	C	I	Q	EFP	Net Worth	Debt	Leverage	Bankruptcy Rate	Policy Rate	Inflation
Std. Dev (%)		1.20	0.92	3.00	0.76	0.30	1.57	0.25	1.46	0.51	0.17	0.44
Auto. corr.		0.72	0.72	0.71	0.71	0.66	0.71	0.93	0.71	0.66	0.69	-0.05
Real Variables	Y	1	0.95	0.98	0.97	-0.51	0.98	0.46	-0.98	-0.49	-0.55	-0.33
	C		1	0.90	0.89	-0.28	0.92	0.50	-0.90	-0.26	-0.78	-0.45
	I			1	1.00	-0.65	0.99	0.42	-1.00	-0.63	-0.46	-0.29
Financial Variables	Q				1	-0.65	0.98	0.34	-1.00	-0.63	-0.44	-0.29
	Premium					1	-0.63	-0.29	0.63	1.00	-0.34	-0.20
	Net Worth						1	0.50	-0.99	-0.62	-0.48	-0.29
	Debt							1	-0.37	-0.29	-0.33	0.02
	Leverage								1	0.61	0.46	0.31
	Bankruptcy Rate									1	-0.35	-0.21
Monetary Variables	Policy Rate										1	0.57
	Inflation											1

Table 1.10: Business Cycle Statistics (only financial frictions) -Planner's Economy-

		Real Variables			Financial Variables						Monetary Variables	
		Y	C	I	Q	EFP	Net Worth	Debt	Leverage	Bankruptcy Rate	Policy Rate	Inflation
Std. Dev (%)		1.20	0.92	3.01	0.76	0.30	1.57	0.25	1.47	0.51	3682330310.15	3646188341.77
Auto. corr.		0.72	0.72	0.71	0.71	0.66	0.71	0.93	0.71	0.66	0.43	0.43
	Y	1	0.95	0.98	0.97	-0.51	0.98	0.45	-0.98	-0.49	0.15	0.10
Real Variables	C		1	0.90	0.89	-0.28	0.92	0.50	-0.90	-0.27	0.43	0.29
	I			1	1.00	-0.65	0.99	0.42	-1.00	-0.63	0.05	0.02
	Q				1	-0.65	0.98	0.34	-1.00	-0.63	0.04	0.01
	Premium					1	-0.63	-0.29	0.63	1.00	0.66	0.45
Financial Variables	Net Worth						1	0.50	-0.99	-0.62	0.07	0.03
	Debt							1	-0.37	-0.29	0.05	0.10
	Leverage								1	0.62	-0.06	-0.02
	Bankruptcy Rate									1	0.67	0.46
Monetary Variables	Policy Rate										1	0.43
	Inflation											1

Figure 1.15: Impulse Responses to a 1 sd. increase in government spending


Notes. Solid line: Financial amplification, Dashed line: No financial amplification (EFP is fixed). Unless otherwise noted, the responses are in terms of percentage deviation from the respective deterministic steady states.

Figure 1.16: Strict Inflation Stabilization versus Ramsey Policy -productivity shocks-
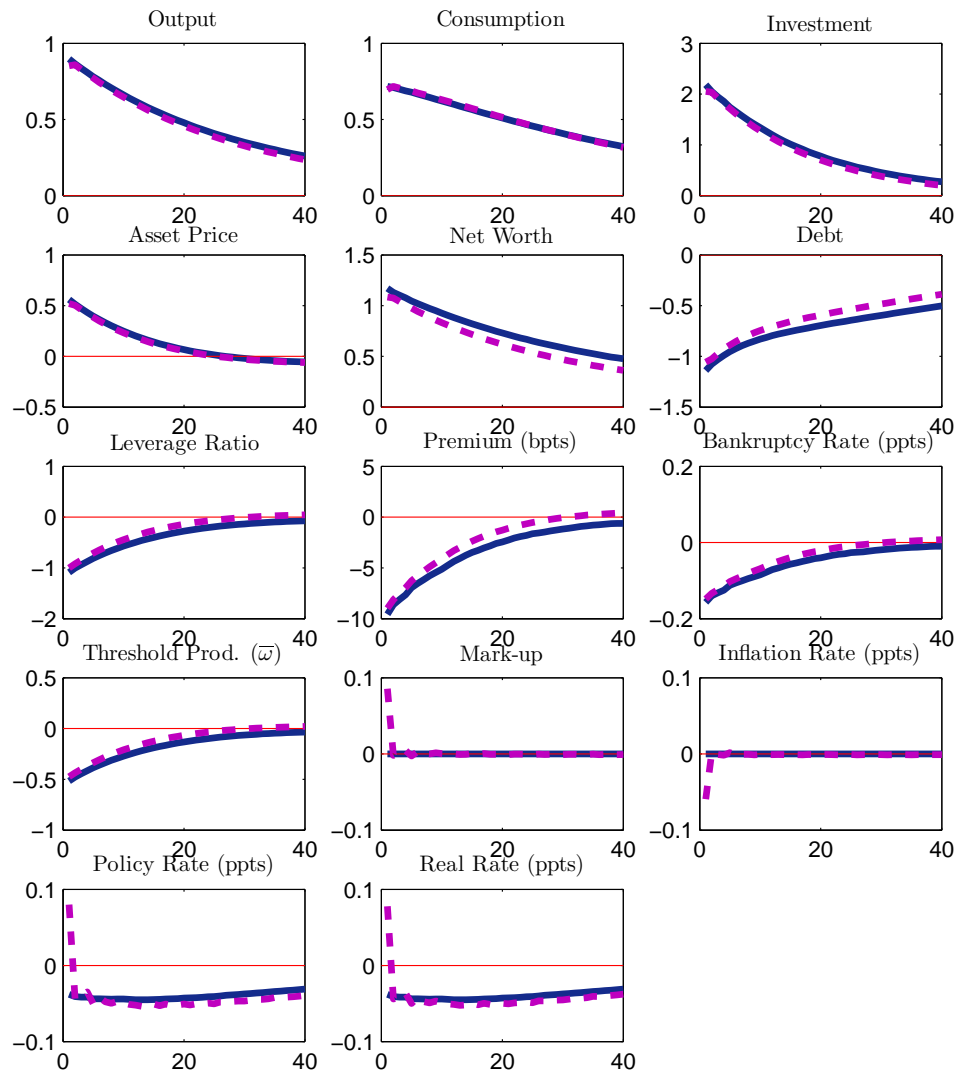
Notes. Solid line: Strict inflation stabilization. Dashed Line: Ramsey economy.

Figure 1.17: Responding to Output Gap -productivity shocks-
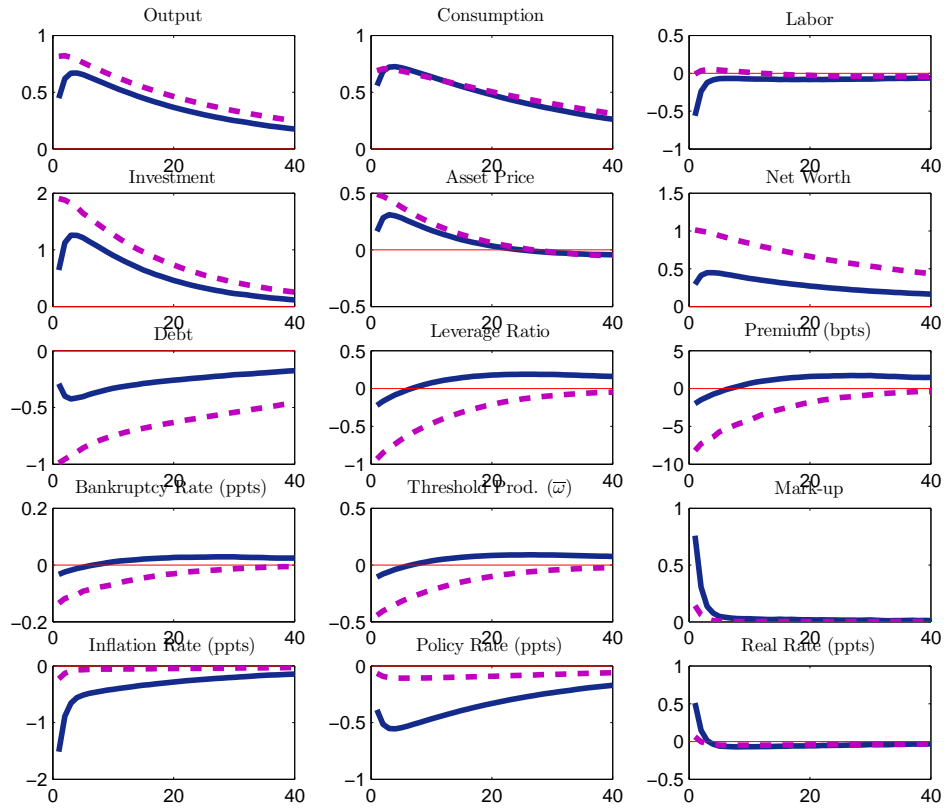
Notes. Solid line: Benchmark policy rule with a response to output gap (ρ_r=0.84, φ_π=1.770, $\varphi_Y = 0.640/4$). Dashed Line: Benchmark policy rule (ρ_r=0.84, φ_π=1.770).

Figure 1.18: Responding to Output Gap -uncertainty shocks-
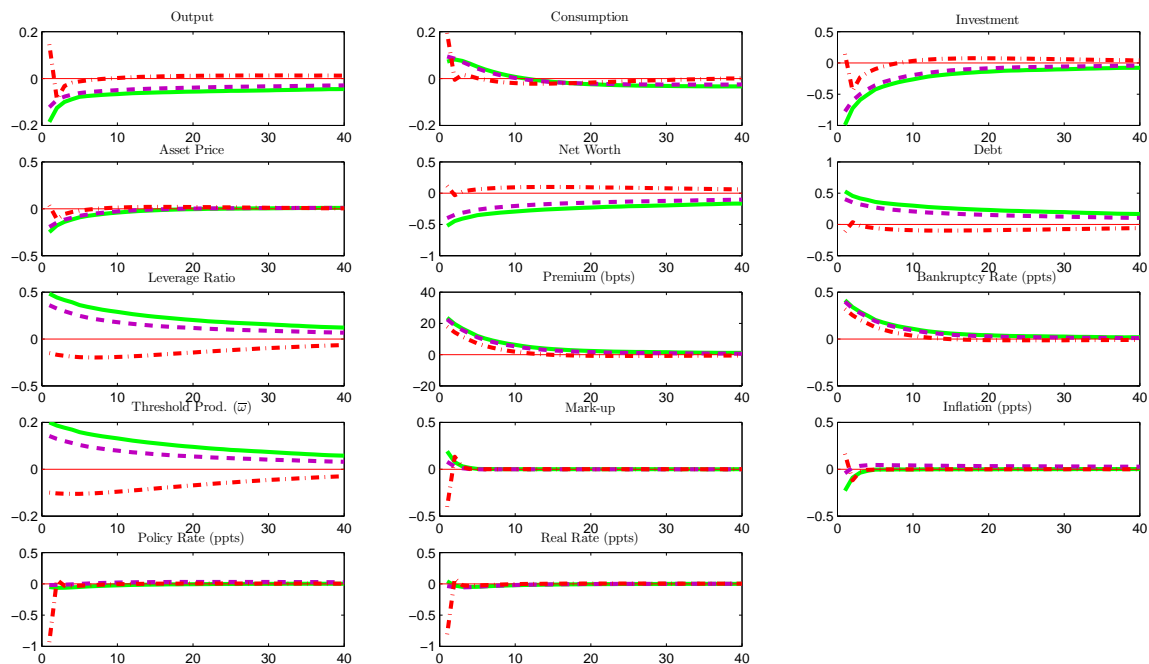
Notes. Solid line: Taylor rule with policy intertia (ρ_r=0.85, φ_π=1.5, and $\varphi_Y = 0$). Dashed Line: Taylor rule with policy inertia and response to output gap (ρ_r=0.85, φ_π=1.5, and $\varphi_Y = 0.5/4$). Dotted Line: Ramsey economy.

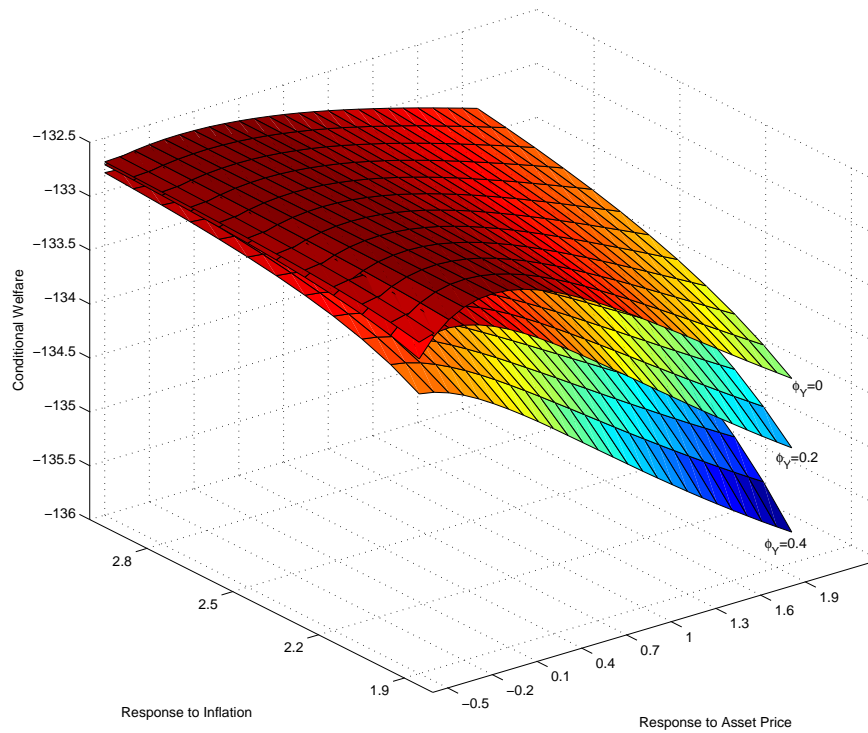## Figure 1.19: Welfare Surface -TFP and G Shocks-
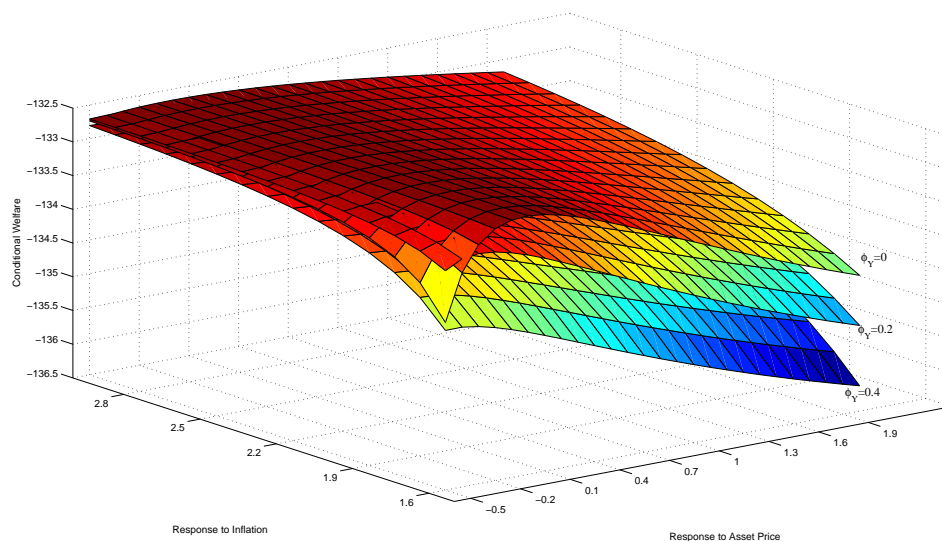
Notes. ρ_r is set at its optimal value.

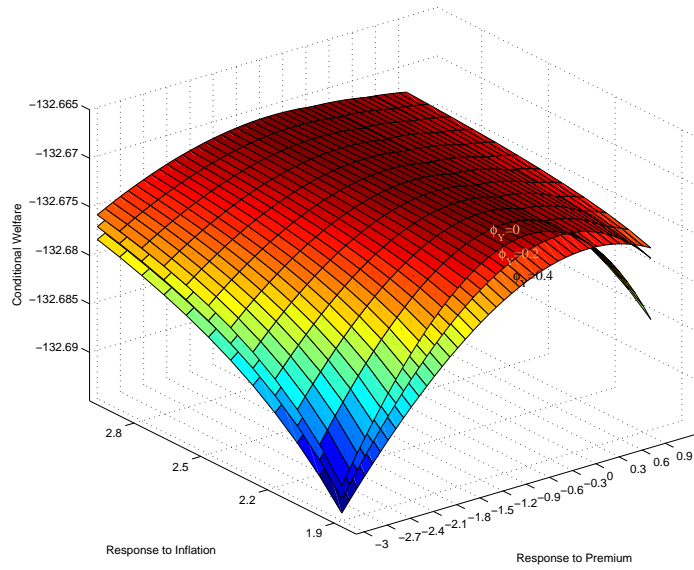Figure 1.20: Welfare Surface -Uncertainty Shock-
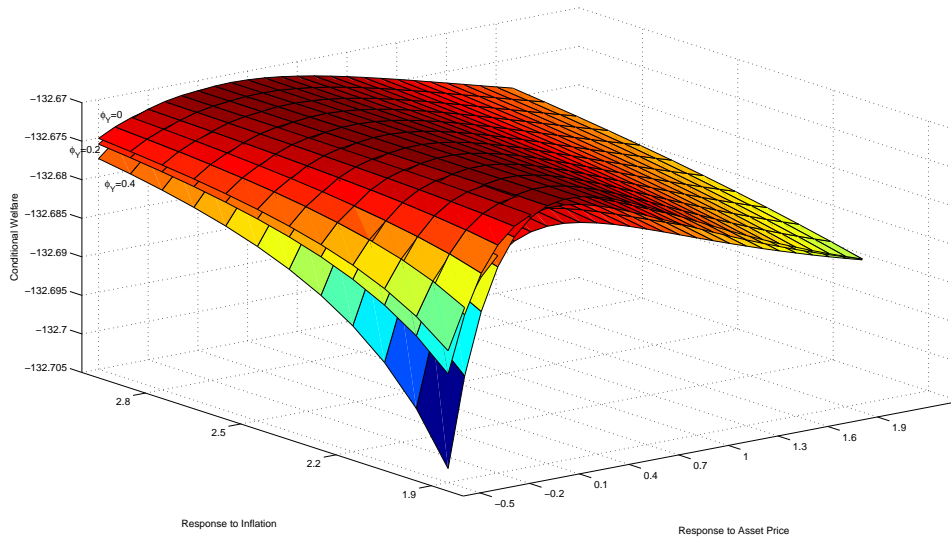
Notes. ρ_r is set at its optimal value.
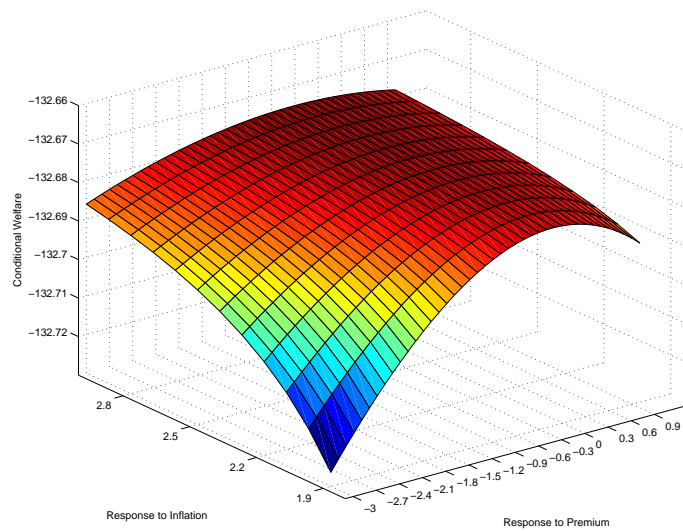
Figure 1.21: Welfare Surface -All Shocks-

Notes. ρ_r is set at its optimal value.

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Figure 1.22: Welfare Surface -Uncertainty Shock-

Notes. ρ_r is set at its optimal value.

Figure 1.23: Welfare Surface -All Shocks-

Notes. ρ_r and φ_Y are set at their optimal values. The welfare surfaces under $\varphi_Y = 0.2$ or $\varphi_Y = 0.4$ are not presented for presentation purposes. They are much lower than the one presented.

1.12 Appendix - Competitive Equilibrium, Calibration and Further Discussions

Appendix A1. Derivation of ex-post marginal real return to capital

The ex-post real marginal return to holding capital from $t-1$ to t for an entrepreneur i is given by

$$R_t^{i,k} = \frac{\alpha \frac{1}{X_t} Y_{it} + \omega_{it} Q_t (1-\delta) K_{it}}{Q_{t-1} K_{it}} \tag{1.42}$$

$$= \omega_{it} \frac{\frac{1}{X_t} \frac{\alpha \overline{Y_t}}{K_{it}} + Q_t (1-\delta)}{Q_{t-1}} \tag{1.43}$$

where $\overline{Y_t}$ is the average wholesale production across the entrepreneurs ($Y_{it} = \omega_{it} \overline{Y_t}$). Hence, the expected average return to capital across the entrepreneurs, $E_{t-1} R_t^{i,k}$, is

$$E_{t-1}\left(R_t^{i,k}\right) = E_{t-1} \frac{\frac{1}{X_t} \frac{\alpha \overline{Y_t}}{K_{it}} + Q_t (1-\delta)}{Q_{t-1}} \tag{1.44}$$

under the assumption that $E_{t-1} \omega_{it} = 1$ and CRTS production technology. The ex-post return to capital, $R_t^k(\overline{\omega_t}; \sigma_t)$, therefore, is the right hand side of the above equation without the expectation operator.

Appendix A2 - Debt Contract Problem

The intermediaries are assumed to operate in perfectly competitive markets, earning zero profits in equilibrium and perfectly diversifying any idiosyncratic risk. Hence, the opportunity cost of funds that the intermediaries face is the economy-wide real return of holding riskless government bonds from $t - 1$ to t, R_t. The debt contract problem should then satisfy that the intermediary earns his opportunity costs in expected terms, i.e.

$$E_{t-1}\left[[1 - F(\overline{\omega_{it}})]Z_t^i(\overline{\omega_t}; \sigma_t)B_t^i + (1 - \mu)\int_0^{\overline{\omega_{it}}} \omega_{it}R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}dF(\omega_{it})\right] = R_t B_t^i$$

(1.45)

The first term inside the square brackets amounts to the total receipts that the intermediary earns from the non-defaulting entrepreneurs. The second term is the receipts from the defaulting entrepreneurs which amounts to the net wholesale revenue (after proportional monitoring costs are incurred).

On the flip side, the expected return to holding capital for the entrepreneur is given by

$$E_{t-1}\left[\int_{\overline{\omega_{it}}}^{\infty} \omega_{it}R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}dF(\omega_{it}) - [1 - F(\overline{\omega_{it}})]\overline{\omega_{it}}R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}\right]$$

(1.46)

The first term inside the square brackets is the expected total return to capital (taking into account the probability that the entrepreneur i's idiosyncratic produc-

tivity ω_{it} is above the threshold level $\overline{\omega_{it}}$). The second term is the amount that the non-defaulting entrepreneur pays to the intermediary. Note that in the case of no-default, the entrepreneur keeps the equity $(\omega_{it} - \overline{\omega_{it}})R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}$.

Hence, the entrepreneur's maximization problem is

$$\max_{K_{it}, \overline{\omega_{it}}} E_{t-1}\left[\int_{\overline{\omega_{it}}}^{\infty} \omega_{it}R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}dF(\omega_{it}) - [1 - F(\overline{\omega_{it}})]\overline{\omega_{it}}R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}\right]$$

(1.47)

subject to

$$E_{t-1}\left[[1 - F(\overline{\omega_{it}})]Z_t^i(\overline{\omega_t}; \sigma_t)B_t^i + (1 - \mu)\int_0^{\overline{\omega_{it}}} \omega_{it}R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}dF(\omega_{it})\right] = R_tB_t^i$$

(1.48)

The entrepreneur takes net worth and asset prices as given in the maximization problem. Before deriving the first-order necessary conditions, I will manipulate the objective function and the constraint to make the problem more tractable.

After algebraic manipulation, the entrepreneur's expected return to holding capital can be expressed as

$$E_{t-1}\left[\left(1 - \left(\overline{\omega_{it}}\int_{\overline{\omega_{it}}}^{\infty} dF(\overline{\omega_{it}}) + \int_0^{\overline{\omega_{it}}} \omega_{it}dF(\overline{\omega_{it}})\right)\right)R_t^k(\overline{\omega_t}; \sigma_t)Q_{t-1}K_{it}\right]$$ (1.49)

and the zero-profit condition as

$$E_{t-1}\left[\left(\left(\overline{\omega_{it}}\int_{\overline{\omega_{it}}}^{\infty}dF(\overline{\omega_{it}})+\int_{0}^{\overline{\omega_{it}}}\omega_{it}dF(\overline{\omega_{it}})\right)-\mu\int_{0}^{\overline{\omega_{it}}}\omega_{it}dF(\overline{\omega_{it}})\right)R_t^k(\overline{\omega_t};\sigma_t)Q_{t-1}K_{it}\right]=R_tB_t^i$$

(1.50)

Now let

$$\Gamma(\overline{\omega_{it}})=\overline{\omega_{it}}\int_{\overline{\omega_{it}}}^{\infty}dF(\overline{\omega_{it}})+\int_{0}^{\overline{\omega_{it}}}\omega_{it}dF(\overline{\omega_{it}}$$

(1.51)

and

$$G(\overline{\omega_{it}})=\int_{0}^{\overline{\omega_{it}}}\omega_{it}dF(\overline{\omega_{it}})$$

(1.52)

Then, the maximization problem can be expressed shortly as

$$\max_{K_t,\overline{\omega_{it}}}E_{t-1}\left[1-(\Gamma(\overline{\omega_{it}}))R_t^k(\overline{\omega_t};\sigma_t)Q_{t-1}K_{it}\right]$$

(1.53)

subject to

$$E_{t-1}\left[(\Gamma(\overline{\omega_{it}})-\mu G(\overline{\omega_{it}}))R_t^k(\overline{\omega_t};\sigma_t)Q_{t-1}K_{it}\right]=R_t\left(Q_{t-1}K_t^i-N_{it}\right)$$

(1.54)

where $1-\Gamma(\overline{\omega_{it}})$ denotes the net share of contractual return going to the entrepreneur, and $\Gamma(\overline{\omega_{it}})-\mu G(\overline{\omega_{it}})$ is the net contractual share of the lender. As optimality conditions are presented in Appendix A3 of BGG (p.1385), then one can show that ex-ante external finance premium is an increasing function of leverage.

Moreover, in simulating the model, unexpected changes in return to capital due to aggregate shocks can be accommodated using partial-equilibrium debt contract problem optimality conditions together with ex-post marginal real return to capital (as defined in Appendix A1).[75]

I now present the equilibrium debt contract optimality conditions where R_{t+1}^k is assumed to known in advance and ω_i is assumed to be log-normal. Let $\Gamma(\overline{\omega}) = \int_0^{\overline{\omega}} \omega f(\omega) d\omega + \overline{\omega} \int_{\overline{\omega}}^\infty f(\omega) d\omega$ denote the expected payoff share of the lender. Note that $1 - \Gamma'(\overline{\omega}) = F(\overline{\omega})$ denotes the bankruptcy rate of entrepreneurs. Let $\mu G(\overline{\omega}) \equiv \mu \int_0^{\overline{\omega}} \omega f(\omega) d\omega$ denote the expected monitoring costs. Hence, the expected net payoff share to the lender is $\Gamma(\overline{\omega}) - \mu G(\overline{\omega})$, and the normalized payoff to the entrepreneur is $1 - \Gamma(\overline{\omega})$. Accordingly, the optimal contract problem is

$$\max_{K_{t+1}, (\overline{\omega})} (1 - \Gamma(\overline{\omega})) R_{t+1}^k Q_t K_{t+1}$$

subject to

$$(\Gamma(\overline{\omega}) - \mu G(\overline{\omega})) R_{t+1}^k Q_t K_{t+1} = R_t(Q_t K_{t+1} - N_{t+1})$$

The problem is easier to solve using $k = \frac{Q_t K_{t+1}}{N_{t+1}}$ the capital-to-wealth ratio (which is equal to one plus the leverage ratio -the ratio of external debt to the net worth-) as the choice variable. Let $s = \frac{R_{t+1}^k}{R_t}$ denote the external finance premium

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[75]Indeed, simulation results show that the ex-ante premium is an increasing function of leverage (regardless of aggregate shocks), whereas the ex-post premium may or may not be an increasing function of leverage, depending on various factors, one of which is the policy rule. A very aggressive policy response to output gap, for instance, might induce a pro-cyclical ex-post premium.

over the riskless rate. Then, the problem becomes

$$\max_{k,(\overline{\omega})}(1 - \Gamma(\overline{\omega}))sk$$

subject to

$$\left(\Gamma(\overline{\omega}) - \mu G(\overline{\omega})\right)sk = k - 1$$

Assuming an interior solution, the first-order optimality conditions imply

$$\Gamma'(\overline{\omega}) - \lambda(\overline{\omega})(\Gamma(\overline{\omega}) - \mu G'(\overline{\omega})) = 0$$

$$\Upsilon(\overline{\omega})s - \lambda(\overline{\omega}) = 0$$

$$(\Gamma(\overline{\omega}) - \mu G(\overline{\omega}))sk - (k - 1) = 0$$

where $\Upsilon \equiv 1 - \Gamma(\overline{\omega}) + \lambda(\overline{\omega})(\Gamma(\overline{\omega}) - \mu G(\overline{\omega}))$.[76] Rearranging gives

$$s(\overline{\omega}) = \frac{\lambda(\overline{\omega})}{\Upsilon(\overline{\omega})}$$

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[76] A sufficient condition for an interior solution is

$$s < \frac{1}{\Gamma(\overline{\omega}^*) - \mu G(\overline{\omega}^*)} \equiv s^*$$

$$k(\varpi) = \frac{\Upsilon(\varpi)}{1 - \Gamma(\varpi)}$$

and

$$\lambda(\varpi) = \frac{\Gamma'(\varpi)}{\Gamma'(\varpi) - \mu G'(\varpi)}.$$

BGG shows that $s'(\varpi) > 0$ for $s > 1$ sufficiently low. Then,

$$k(\varpi) = \psi(s(\varpi))$$

where $\psi' > 0$. Using the expressions for the return to capital, the evolution of net worth, and the parameters, one can deduce ϖ. The equation above implies that the external finance premium depends inversely on the capital-to-net-worth ratio.

The algebraic expressions for $\Gamma(\varpi)$ and $\Gamma(\varpi) - \mu G(\varpi)$ can be derived by assuming that ω is log-normally distributed. In particular, let $ln(\omega) \sim N(-\frac{1}{2}\sigma_\omega^2, \sigma_\omega^2)$. Then using the central limit theorem, $z \equiv (ln(\varpi) + 0.5\sigma^2)/\sigma$ is distributed standard normal. Hence, the set of equations characterizing the debt contract problem is

$$z = (log(\varpi) + 0.5\sigma_t^2)/\sigma_t$$

$$\Gamma(\varpi) = \Phi(z - \sigma_t) + \varpi(1 - \Phi(z))$$

$$\Gamma(\overline{\omega}) - \mu G(\overline{\omega}) = (1 - \mu)\Phi(z - \sigma_t) + \overline{\omega}(1 - \Phi(z))$$

$$\Gamma'(\overline{\omega}) = \phi(z - \sigma_t) + (1 - (\phi(z))) - \frac{\phi(z)}{\sigma_t}$$

$$\Gamma'(\overline{\omega}) - \mu G'(\overline{\omega}) = \Gamma'(\overline{\omega}) - \mu \frac{\phi(z - \sigma_t)}{\overline{\omega}\sigma_t}$$

$$\lambda(\overline{\omega}) = \frac{\Gamma'(\overline{\omega})}{\Gamma'(\overline{\omega}) - \mu G'(\overline{\omega})}$$

$$k(\overline{\omega}) = 1 + (\lambda(\overline{\omega}) * (\Gamma(\overline{\omega}) - \mu G(\overline{\omega}))) / (1 - \Gamma(\overline{\omega}))$$

$$s(\overline{\omega}) = \lambda(\overline{\omega}) / ((1 - \Gamma(\overline{\omega})) * k(\overline{\omega}))$$

where $k(\overline{\omega})$ is the equilibrium capital to wealth ratio ($\frac{Q_t K_{t+1}}{N_{t+1}}$), and $s(\overline{\omega})$ is the external finance premium over the riskless rate.

Appendix A3. Retailers' Problem

Let $y_t(j)$ be the output of retailer j, and Y_t^f the final good. We assume that the final goods are produced via the following Dixit-Stiglitz aggregator with elasticity of substitution ϵ:

$$Y_t^f = \left[\int_0^1 y_t(j)^{1-\frac{1}{\epsilon}} \right]^{\frac{1}{1-\frac{1}{\epsilon}}} \tag{1.55}$$

and sold at a price of P_t which satisfies

$$P_t = \left[\int_0^1 P_t(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}} \tag{1.56}$$

where $P_t(j)$ is the price of the retail good j. The demand for each retail good satisfies the following iso-elastic demand curve:

$$y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon} Y_t^f \tag{1.57}$$

The retailers, those who are allowed to change their prices, maximize their profits given this demand curve and given the price of wholesale goods. In particular, let P_t^* denote the price set by retailers who are allowed to change their price at t, $y^*(j)$ be the demand given this price, and P_t the aggregate price level for the final goods. Then, the retailers' maximization problem is

$$\max_{P_t^*} E_t \sum_{s=t}^{\infty} \Xi_{t,s} \theta^{s-t} \frac{P_t^* - P_s^W}{P_s} y_s^*(j) \tag{1.58}$$

subject to

$$y_s^*(j) = \left(\frac{P_t^*}{P_s}\right)^{-\epsilon} Y_s^f \quad \forall s \geq t \tag{1.59}$$

where $\Xi_{t,s}$ is the shareholders' (households') intertemporal elasticity of substitution which is taken as given by the retailers.

Appendix A4. Deriving the New-Keynesian Phillips Curve in recursive format

Let

$$x_t^1 = E_t \sum_{s=t}^{\infty} \Xi_{t,s} \theta^{s-t} \left(\frac{P_t^*}{P_s}\right)^{-\epsilon} Y_s^f \left(\frac{P_t^*}{P_s}\right) \tag{1.60}$$

$$= \left(\frac{P_t^*}{P_t}\right)^{1-\epsilon} Y_t^f + E_t \sum_{s=t+1}^{\infty} \Xi_{t,s} \theta^{s-t} \left(\frac{P_t^*}{P_s}\right)^{1-\epsilon} Y_s^f$$

$$= \left(\frac{P_t^*}{P_t}\right)^{1-\epsilon} Y_t^f + E_t \Xi_{t,t+1} \theta \left(\frac{P_t^*}{P_{t+1}^*}\right)^{1-\epsilon} E_{t+1} \sum_{s=t+1}^{\infty} \Xi_{t+1,s} \theta^{s-t-1} \left(\frac{P_{t+1}^*}{P_s}\right)^{1-\epsilon} Y_s^f$$

$$= \left(\frac{P_t^*}{P_t}\right)^{1-\epsilon} Y_t^f + E_t \Xi_{t,t+1} \theta \left(\frac{P_t^*}{P_{t+1}^*}\right)^{1-\epsilon} x_{t+1}^1$$

Defining $\widetilde{p}_t = \frac{P_t^*}{P_t}$, we have

$$= \widetilde{p}_t^{1-\epsilon} Y_t^f + E_t \Xi_{t,t+1} \theta (1 + \pi_{t+1})^{\epsilon-1} \left(\frac{\widetilde{p}_t}{\widetilde{p_{t+1}}} \right)^{1-\epsilon} x_{t+1}^1$$

Similarly,

$$x_t^2 = E_t \sum_{s=t}^{\infty} \Xi_{t,s} \theta^{s-t} \left(\frac{P_t^*}{P_s} \right)^{-\epsilon} Y_s^f \left(\frac{P_s^w}{P_s} \right) \qquad (1.61)$$

$$= \left(\frac{P_t^*}{P_t} \right)^{-\epsilon} Y_t^f \left(\frac{P_t^w}{P_t} \right) + E_t \sum_{s=t+1}^{\infty} \Xi_{t,s} \theta^{s-t} \left(\frac{P_t^*}{P_s} \right)^{-\epsilon} Y_s^f \left(\frac{P_s^w}{P_s} \right)$$

$$= \left(\frac{P_t^*}{P_t} \right)^{-\epsilon} Y_t^f \left(\frac{P_t^w}{P_t} \right) + E_t \Xi_{t,t+1} \theta \left(\frac{P_t^*}{P_{t+1}^*} \right)^{-\epsilon} E_{t+1} \sum_{s=t+1}^{\infty} \Xi_{t+1,s} \theta^{s-t-1} \left(\frac{P_{t+1}^*}{P_s} \right)^{-\epsilon} Y_s^f \left(\frac{P_s^w}{P_s} \right)$$

$$= \left(\frac{P_t^*}{P_t} \right)^{-\epsilon} Y_t^f \left(\frac{P_t^w}{P_t} \right) + E_t \Xi_{t,t+1} \theta \left(\frac{P_t^*}{P_{t+1}^*} \right)^{-\epsilon} x_{t+1}^2$$

$$= \widetilde{p}_t^{-\epsilon} Y_t^f \frac{1}{X_t} + E_t \Xi_{t,t+1} \theta (1 + \pi_{t+1})^{\epsilon} \left(\frac{\widetilde{p}_t}{\widetilde{p_{t+1}}} \right)^{-\epsilon} x_{t+1}^2$$

Appendix A5. Deriving the Demand for the Final Goods

For any given level of demand for the composite consumption good C_t, the demand for each c_{it} solves the problem of minimizing total expenditures, $\int_0^1 P_{it}c_{it}di$ subject to the aggregation constraint $C_t = \left[\int_0^1 c_{it}^{1-\frac{1}{\epsilon}}di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}$, where P_{it} is the nominal price of variety c_{it}. The solution to this problem yields the optimal demand for c_{it} which satisfies

$$c_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\epsilon} C_t \tag{1.62}$$

where the aggregate price P_t is

$$P_t = \left[\int_0^1 P_{it}^{1-\epsilon}di\right]^{\frac{1}{1-\epsilon}} \tag{1.63}$$

Similarly, the investment good I_t is assumed to be a composite good made with varieties i_{it}, satisfying $I_t = \left[\int_0^1 i_{it}^{1-\frac{1}{\epsilon}}di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}$. Then, capital producers minimize the total expenditure of buying investment goods, $\int_0^1 P_{it}i_{it}di$, which implies a demand for i_{it} satisfying $i_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\epsilon} I_t$.

For a given level of G_t, the government minimizes the total cost of absorbing G_t. Hence, the public demand for each retail good j is given by $g_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\epsilon} G_t$.

Appendix A6. Deriving S_t in recursive format

Let $1-\theta$ measure of retailers choose a price level P_t^* at the (symmetric) equilibrium, and the remaining measure of retailers does not change their prices. Those who have

not changed their prices in the current period, however, might have been allowed to change their prices (with probability $1 - \theta$) and choose P_{t-1}^* in the previous period.

Similarly going backwards, one can get a recursive representation for S_t. Namely,

$$S_t \equiv \int_0^1 \left(\frac{P_{it}}{P_t} \right)^{-\epsilon} di$$

$$= (1 - \theta) \left(\frac{P_t^*}{P_t} \right)^{-\epsilon} + \theta \left[(1 - \theta) \left(\frac{P_{t-1}^*}{P_t} \right)^{-\epsilon} + (1 - \theta)\theta \left(\frac{P_{t-2}^*}{P_t} \right)^{-\epsilon} + ... \right]$$

$$= (1 - \theta) \left(\frac{P_t^*}{P_t} \right)^{-\epsilon} + \theta \left(\frac{P_{t-1}}{P_t} \right)^{-\epsilon} \left[(1 - \theta) \left(\frac{P_{t-1}^*}{P_{t-1}} \right)^{-\epsilon} + (1 - \theta)\theta \left(\frac{P_{t-2}^*}{P_{t-1}} \right)^{-\epsilon} + ... \right]$$

$$= (1 - \theta) \left(\frac{P_t^*}{P_t} \right)^{-\epsilon} + \theta \left(\frac{P_{t-1}}{P_t} \right)^{-\epsilon} S_{t-1}$$

$$= (1 - \theta)\widetilde{p}_t^{-\epsilon} + \theta \pi^\epsilon S_{t-1} \tag{1.64}$$

Appendix B - Competitive Equilibrium

The competitive equilibrium for this economy is a set of endogenous objects $\{C_t, H_t, H_t^e, K_t, I_t,$
$N_t, R_t, AMC_t, R_t^k, \overline{\omega_t}; \sigma_t, x_t^1, x_t^2, W_t, W_t^e, R_t^k, X_t, \widetilde{p}_t, Q_t, \overline{\omega_t}, \Gamma(\overline{\omega_t}), G(\overline{\omega_t}), \Gamma'(\overline{\omega_t}), G'(\overline{\omega_t}), \lambda(\overline{\omega_t}),$
$k(\overline{\omega_t}), s(\overline{\omega_t})\}_{t=0}^{t=\infty}$, given exogenous stochastic processes A_t, G_t, σ_t, the long-run infla-

tion $\overline{\pi}$, the parameters and the functional forms, such that the following block of equations are satisfied:

- The Households:

$$\frac{\partial U(t)}{\partial C_t} = \beta R_t E_t \left[\frac{\partial U(t+1)}{\partial C_{t+1}} \right]$$

$$W_t = -\frac{\frac{\partial U(t)}{\partial H_t}}{\frac{\partial U(t)}{\partial C_t}}$$

- The Evolution of Relative Price and the New-Keynesian Phillips Curve:

$$1 = \theta(1+\pi)^{-1+\epsilon} + (1-\theta)\widetilde{p}_t^{1-\epsilon}$$

$$x_t^1 = \widetilde{p}_t^{1-\epsilon}Y_t^f + E_t\Xi_{t,t+1}\theta(1+\pi_{t+1})^{\epsilon-1}\left(\frac{\widetilde{p}_t}{\widetilde{p}_{t+1}}\right)^{1-\epsilon}x_{t+1}^1$$

$$x_t^2 = \widetilde{p}_t^{-\epsilon}Y_t^f\frac{1}{X_t} + E_t\Xi_{t,t+1}\theta(1+\pi_{t+1})^{\epsilon}\left(\frac{\widetilde{p}_t}{\widetilde{p}_{t+1}}\right)^{-\epsilon}x_{t+1}^2$$

$$x_t^1 = \frac{\epsilon}{\epsilon-1}x_t^2$$

- Aggregate Resource Constraint

$$Y_t = C_t + C_t^e + I_t + G_t + AMC_t$$

$$Y_t - C_t^e - AMC_t = \frac{1}{\overline{\omega_t}; \sigma_t}(F(K_t, H_t, H_t^e) - C_t^e - AMC_t)$$

$$\overline{\omega_t}; \sigma_t = (1 - \theta)\widetilde{p}_t^{-\epsilon} + \theta\pi_t^\epsilon S_{t-1}$$

where

$$AMC_t = \mu * \int_0^{\overline{\omega}} \omega F(\omega) R_t^k Q_{t-1} K_t$$

- The Optimal Contract Problem

$$z = (log(\overline{\omega}) + 0.5\sigma_t^2)/\sigma_t$$

$$\Gamma(\overline{\omega}) = \Phi(z - \sigma_t) + \overline{\omega}(1 - \Phi(z))$$

$$\Gamma(\overline{\omega}) - \mu G(\overline{\omega}) = (1 - \mu)\Phi(z - \sigma_t) + \overline{\omega}(1 - \Phi(z))$$

$$\Gamma'(\overline{\omega}) = \phi(z - \sigma_t) + (1 - (\phi(z))) - \frac{\phi(z)}{\sigma_t}$$

$$\Gamma'(\overline{\omega}) - \mu G'(\overline{\omega}) = \Gamma'(\overline{\omega}) - \mu \frac{\phi(z - \sigma_t)}{\overline{\omega}\sigma_t}$$

$$\lambda(\overline{\omega}) = \frac{\Gamma'(\overline{\omega})}{\Gamma'(\overline{\omega}) - \mu G'(\overline{\omega})}$$

$$k(\overline{\omega}) = 1 + (\lambda(\overline{\omega}) * (\Gamma(\overline{\omega}) - \mu G(\overline{\omega}))/(1 - \Gamma(\overline{\omega}))$$

$$s(\overline{\omega}) = \lambda(\overline{\omega})/((1 - \Gamma(\overline{\omega})) * k(\overline{\omega}))$$

where $k(\overline{\omega})$ is the equilibrium capital to wealth ratio $(\frac{Q_t K_{t+1}}{N_{t+1}})$, and $s(\overline{\omega})$ is the external finance premium over the riskless rate.

- Capital Accumulation and Investment Demand

$$E_t R_{t+1}^k = E_t \left[\frac{\frac{1}{X_{t+1}} \frac{\alpha Y_{t+1}}{K_{t+1}} + (1 - \delta)Q_{t+1}}{Q_t} \right]$$

$$E_t R_{t+1}^k = R_t s(\overline{\omega})$$

$$Q_t = \left[\Psi\left(\frac{I_t}{K_t}\right)' \right]^{-1}$$

$$K_{t+1} = (1 - \delta)K_t + K_t \Psi\left(\frac{I_t}{K_t}\right)$$

where $\Psi\left(\frac{I_t}{K_t}\right) = \frac{I_t}{K_t} - \frac{\Psi_k}{2}\left[\frac{I_t}{K_t} - \delta\right]^2$

- Labor Demands

$$W_t = (1 - \alpha)\Omega \frac{Y_t}{H_t} \frac{1}{X_t}$$

$$W_t^e = (1 - \alpha)(1 - \Omega) \frac{Y_t}{H_t^e} \frac{1}{X_t}$$

$$H_t^e = 1$$

- Evolution of Net Worth and Entrepreneurial Consumption

$$N_{t+1} = \gamma_t \left[R_t^k Q_{t-1} K_t - \left(R_t + \frac{AMC_t}{Q_{t-1}K_t - N_t} \right) * (Q_{t-1}K_t - N_t) \right] + W_t^e$$

$$\Pi_t^e = (1 - \gamma_t) \left[R_t^k Q_{t-1} K_t - E_{t-1} R_t^k B_t \right]$$

- Exogenous Processes

$$log(A_t) = \rho_A * log(A_{t-1}) + \varepsilon_t^A$$

$$log(G_t) = (1 - \rho_G)log(\overline{G}) + \rho_G log(G_{t-1}) + \varepsilon_t^G$$

$$log(\sigma_t) = (1 - \rho_\sigma)log(\overline{\sigma}) + \rho_\sigma log(\sigma_{t-1}) + \mathcal{U}_t$$

- Monetary Policy Rule and the Fiscal Policy

$$log\left(\frac{1 + r_t^n}{1 + \overline{r^n}} \right) = \rho_r log\left(\frac{1 + r_{t-1}^n}{1 + \overline{r^n}} \right) + (1 - \rho_r) \left[\varphi_\pi log\left(\frac{1 + \pi_t}{1 + \overline{\pi}} \right) + \varphi_Y log\left(\frac{Y_t}{\overline{Y}} \right) + \varphi_F log\left(\frac{F_t}{\overline{F}} \right) \right]$$

where $r_t^n \geq 0$, $R_t = \frac{1+r_t^n}{1+\pi_{t+1}}$, $1 + \overline{\pi} = \beta(1 + \overline{r^n})$, $\overline{\pi} = 0$ or $= 1.0266^{1/4}$.

$$G_t = T_t$$

Appendix C- Data Definitions

The data is over the period 1989:Q1-2009:Q1, and is taken from Federal Reserve St.Louis FRED. All the statistics are based on cyclical components of the variables (based on HP filter with a smoothing parameter 1600). The cyclical volatility is defined as the log-deviation of a variable from its HP-trend.

Consumption (C) defined as the sum of real personal consumption expenditures of non-durable goods and services.

Investment (I) is the sum of real personal consumption expenditures on durables and real gross domestic private investment.

Government Expenditures (G)- is defined as the real government consumption expenditures and gross investment.

*Real GDP (Y)* is the sum of C, I, and G as defined above.

Labor hours (H)- is the the average private labor hours times the total number of workers.

External Finance Premium (EFP)- is the average of the (annualized) yield spreads between (i) prime-lending rate and 6-month constant maturity treasury bill, (ii) prime-lending rate and 3-month constant maturity treasury bill, (iii) Moody's BAA-rated and AAA-rated corporate bonds, (iv) Moody's BAA-rated corporate bond and 10-year constant maturity treasury bill.

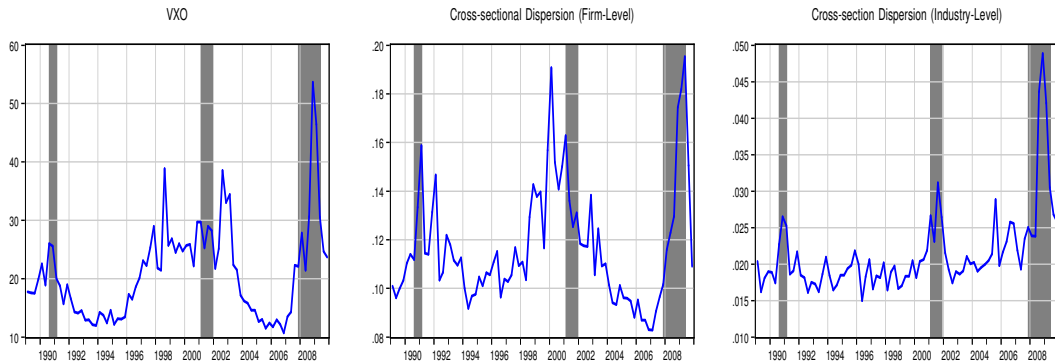# Appendix D - Further Discussion

The actual processes for TFP, government spending, and uncertainty (measured either at a macro- or micro-level) are given in Figures 1.24 and 1.25.

Figure 1.24: TFP and Real Government Spending (G)
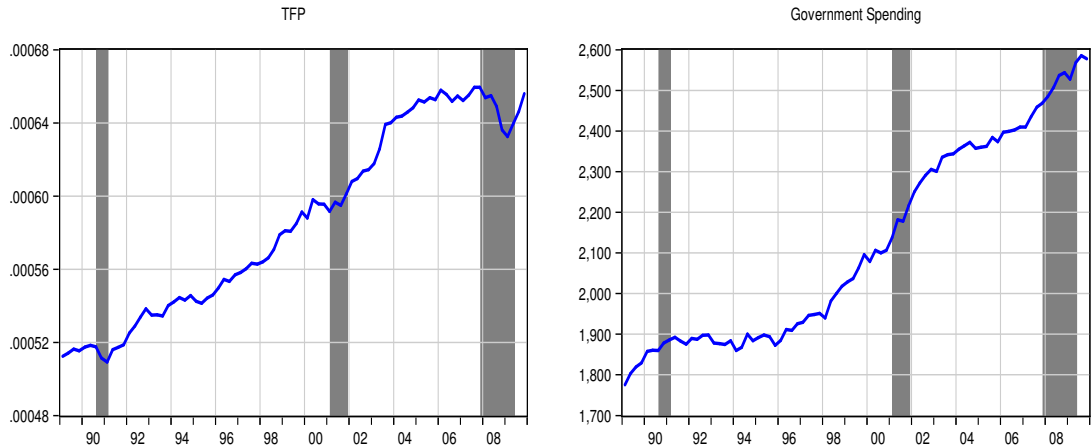
Notes. G is defined as the real government consumption expenditures and gross investment.

Figure 1.25: VXO or Cross-Sectional Dispersion

Source: Bloom *et al.* (2010) and own calculations. At the firm-level, cross-sectional dispersion in firms' sales growth is reported. At the industry-level, cross-sectional dispersion of industrial TFP growth is reported. The implied volatility is the Chicago Board of Options Exchange VXO index of percentage implied volatility. I use the VXO, rather than the VIX, since the VIX starts only after 1990. The correlation between the two series is above 0.99.

I use the log-linearly de-trended series in estimating the following AR(1) pro-

cesses for the period 1989Q1-2009Q1.

$$log(A_t) = \rho_A * log(A_{t-1}) + \varepsilon_t^A \qquad (1.65)$$

$$log(G_t) = (1 - \rho_G)log(\overline{G}) + \rho_G log(G_{t-1}) + \varepsilon_t^G \qquad (1.66)$$

$$log(\sigma_t) = (1 - \rho_\sigma)log(\overline{\sigma}) + \rho_\sigma log(\sigma_{t-1}) + \mathcal{U}_t \qquad (1.67)$$

where ρ_A, ρ_G, ρ_σ are the respective persistence parameters, $\overline{G}$ is the long-run level of real government expenditures, $\overline{\sigma}$ is the long-run cross-sectional dispersion, and ε_t^A, ε_t^G, and $\mathcal{U}_t$ are the respective i.i.d Gaussian innovations. The estimated parameters are given in Table 1.11.

Table 1.11: Estimated AR(1) Processes

Dependent Variable	ρ (Persistence)	$\wp_\varepsilon$ (Std. of innovations)	R^2
TFP	0.976	0.0066	0.848
G	0.955	0.0074	0.928
σ^f	0.815	0.1145	0.615
σ^i	0.823	0.1451	0.582
VXO	0.879	0.1859	0.728

Notes. A superscript f denotes cross-sectional dispersion of firm-level sales growth, i denotes cross-sectional dispersion of industry-level TFP growth. See Bloom *et al.* (2010) for details on the data set.

The estimated shock processes are given in Figure 1.26.

Figure 1.26: TFP, Government Spending, and Uncertainty Shocks
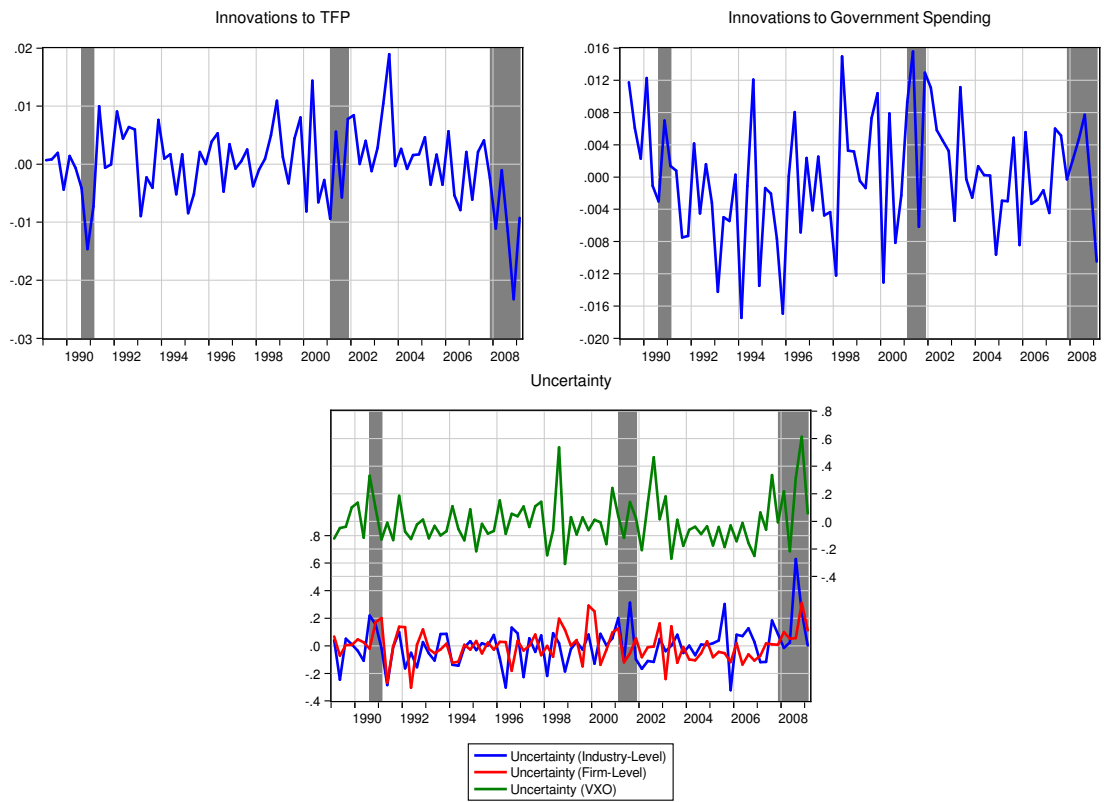
Chapter 2

Global and Regional Factors in Driving Emerging Markets'

Sovereign Risk Premium

2.1 Introduction

Sovereign credit risk is an important driver of emerging markets' business cycles, as studied by many papers including Blanchard (2004), Favero and Giavazzi (2004), Neumeyer and Perri (2005), and Izquierdo *et al.* (2007). Large fluctuations in credit risk are often associated with swings in capital flows, creating challenges for policy makers such as ensuring a stable exchange rate, maintaining inflation or financial stability.[1] Given its relevance for business cycles as well as the challenges it poses, understanding the nature of sovereign credit risk is of crucial importance for policy makers in emerging markets.

In this paper, I study the nature of sovereign risk premia in emerging markets by decomposing the premia into global, regional, and idiosyncratic factors using dynamic factor modeling (DFM). Moreover, I assess how global financial market indicators often used in the literature to gauge global risk fare in explaining the extracted latent global factor, accounting for potential regime changes. I also assess estimated evolution of idiosyncratic factors by using easily identifiable idiosyncratic

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[1]See Blanchard (2004), Reinhart and Reinhart (2008), and Cardarelli *et al.* (2010) for policy challenges for emerging markets due to fluctuations in capital flows.

events, such as major political events or rating downgrades. Last, the contribution of each factor to sovereign risk premium and potential policy implications are noted.

To measure sovereign credit risk, I use credit default swap (CDS) premia on the external sovereign debt. A CDS is simply an asset that facilitates transfer of default risk of one or more entities from one party to another. The premium reflects market expectation of a sovereign credit event, e.g. failure to pay, restructuring or repudiation of the external debt, or even a drop in the borrower's credit rating. I use the CDS premia rather than another popular measure, the bond yield spreads, since CDS markets are typically more liquid, and CDS premia provide a more direct market-based measure of likelihood of a credit event, as argued by Pan and Singleton (2008), Stultz (2010), and Ang and Longstaff (2011).

The data set includes a large set of emerging market economies with different geopolitical properties and credit risk, providing a good base to study common and idiosyncratic risk factors. In selecting the countries, I require that countries have sufficiently developed external debt markets, hence the information content is not driven by idiosyncratic pricing of sovereign risk. For convenience, I choose those included in the J.P. Morgan's Emerging Market Bond Index (EMBI+ or EMBI Global) for at least a year during the last decade.[2] The selection criteria is satisfied for 25 economies.[3] The sample includes 8 Latin American, 10 European, and 7

[2]Instruments in the EMBI are required to have a minimum face value of $500 million and meet certain liquidity criteria. EMBI+ has a more strict liquidity criteria than the EMBI Global.

[3]The economies included are Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Greece, Hungary, Indonesia, Korea, Lithuania, Malaysia, Mexico, Panama, Peru, Philippines, Poland, Romania, Russia, Thailand, Turkey, Ukraine, Venezuela, and Vietnam. I exclude African economies, Egypt, Nigeria and South Africa, since having only 3 countries (especially for a region that exhibits weaker financial and trade linkages compared to other regions) would not be reasonable to use to extract the regional factor.

Asian countries. The list includes economies with a recent default/restructuring (e.g. Argentina), restructuring (e.g. Greece), high inflation (e.g. Venezuela), high volume of commodity exports (e.g. Chile, Venezuela), high political instability (e.g. Philippines), to name a few. The list in other words reflects a wide range of geopolitical features and risk patterns, hence suitable for studying common external and idiosyncratic factors.

I use dynamic factor modeling (DFM) as it is well suited to study comovement of macroeconomic series.[4] DFM is widely used in the literature on a variety of topics, including constructing coincident macroeconomic indicators (Stock and Watson, 1989), forecasting (Stock and Watson, 2002a, 2002b; Forni *et al.*, 2005), monetary policy analysis (Bernanke, Boivin and Eliasz, 2005; Stock and Watson, 2005; Forni and Gambetti, 2010), and international business cycles (Kose *et al.*, 2003, 2008; Del Negro and Otrok, 2008; Aruoba *et al.*, 2011; Crucini *et al.*, 2011). This paper mainly follows the last strand. DFM can capture potential dynamics of common driver(s), handles missing observations (through Kalman filtering), and is immune to measurement errors. Last but not the least, and importantly for the focus of this paper, it does not rely on restrictive assumptions about the choice of variables that potentially reflect global, regional or idiosyncratic factors.

The results suggest the following: First, emerging markets' sovereign risk pre-

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[4]A pure bivariate correlation analysis, while providing *a priori* evidence, does not disentangle the common versus the idiosyncratic factors, and misses potential persistence in common fluctuations. A simple principal component analysis (PCA) can extract the common factors, but cannot handle missing observations. For instance, using PCA for our data set would imply using only one third of the data set. Nor does it capture the persistence of common factors. Interested readers may refer to Diebold and Rudebusch (1996), Breitung and Meier (2005), Bai and Ng (2008), and Stock and Watson (2010) for literature surveys on DFM.

mium is mostly due to common external factors. On average, about 63% of the movements in the sovereign risk premium is due to the global factor, and about 21% due to regional factors. There is, however, substantial heterogeneity among the emerging markets. The contribution of external factors are substantially low for economies that have experienced major idiosyncratic events, e.g. Greece, Philippines. Moreover, there are a few economies that seem to decouple from regional risk factors, e.g. Chile, Venezuela and Turkey, as the contribution of regional factor is rather low for these economies. In addition, sovereign risk of largest economies in the regions (e.g. Brazil and China) appears to move strongly with the regional factor, potentially suggesting that these economies are by-and-large the driver of regional comovement of sovereign risk premium.

Second, the extracted latent global risk factor can be explained fairly well by global financial variables considered. It appears that the global risk factor is best reflected by the CBOE's VIX, a reflection of investors' risk sentiment, regardless of the regimes. VIX explains around 87% of the global factor during 'high stress' times, and around 55% on average. As a reflection of credit and liquidity risks in global financial markets, the TED spread (spread between London Interbank Offer Rate (LIBOR) and 3-month US Treasury Bill) captures the global factor at a lesser extent (20% on average). During high stress times, though, the TED spread explain nearly half of the movements in the global factor. The yield spread between long-term US Treasury notes has a lower power in explaining the global factor (of about 7% to 25%). Global financial variables becoming much more powerful in explaining the global risk factor during high-stress times indicates that volatility, credit and

liquidity risks are heightened substantially during the global crisis starting in late 2008. Furthermore, the results also suggest that in times of high stress, investors seek for safe US assets, which contributes to a rise in emerging markets' sovereign risk.

Third, idiosyncratic factor matters, e.g. political instability, major idiosyncratic economic events (isolated banking, currency, or debt crises, or rating downgrades) matter for sovereign risk premium. For instance, nearly 60% of the movements in Philippines' sovereign risk premium is due to idiosyncratic factor which can mostly be attributed to political instability. For Greece, political instability and fiscal solvency issues seem to contribute nearly 80% of the variations in her sovereign risk premium.

Moreover, increasing concerns about the future of the Eurozone appear to be a global risk factor in the recent era. In particular, I first estimate a DFM with a single factor and compare the estimated evolution of common factor with the regional European factor estimated from the baseline two-factor DFM. The common factor follows the European risk factor surprisingly well starting in June 2010. This result suggest that the European debt crisis has gone beyond its boundaries and become a global factor in driving sovereign risk premium.

The results so far are based on emerging markets. A natural question then is how "global" is the estimated global factor? To address this question, I use a set of 35 developed and emerging market economies. Given recent fiscal solvency problems in developed economies (e.g. Portugal, Spain, Italy, etc.), it may also be of interest of its own studying sovereign risk of debt-crippled developed economies. Moreover,

I use higher frequency (weekly) to see whether using monthly frequency misses relevant information. The results show that the evolution of common external factors are by and large robust to including developed economies and using higher frequency. This result suggests that emerging markets' sovereign risk premium during the last decade is not decoupled from how developed economies perform.

The contribution of this paper is two-fold: First, I study which financial market indicators best reflect the global factor, and whether there are statistically significant regime changes in the relation. The relevance of global factors in driving emerging markets' sovereign risk is recognized in the literature. Numerous studies show that global financial market variables affect emerging markets' sovereign risk significantly. For example, using global and local financial market variables, Longstaff *et al.* (2011) show that US financial market variables are more significant than the country-specific variables in explaining changes in sovereign CDS. Ebner (2009) studies 11 central and eastern European economies' bond spreads, using a large set of country-specific variables, and proxies for external common factors. Common external factor, as captured by market volatility, appears to affect the bond spreads significantly. Country-specific variables also matter, though less significantly, for sovereign risk. Yet, such analyses rely on restrictive assumptions about which variable captures the global risk. Here I instead extract the global risk factor using DFM, and report the contribution of global factor for each economy. Moreover, I assess how commonly used global financial market indicators fare in explaining the global risk factor.[5]

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[5]To test whether there are regime changes in the relation, I employ Hansen's (2000) threshold estimation.

Second, I explicitly study regional risk factor. The analysis sheds light on heterogeneity among the regions, and which economies (if any) are decoupled from regional factors. Moreover, incorporating the regional risk factor provides a better picture on the 'true' global risk factor. Recent experience has shown compelling evidence that there exists noticeable heterogeneity in the sovereign risk among the regions. For instance, European debt crisis unfolding in mid 2010 led to a surge in European economies' sovereign CDS, while having a less strong effect on Latin American economies. Moreover, economies with relatively sound fundamentals might be decoupled from regional risk factors. These points are relatively unexplored in the literature.[6]

Closely related to my work, Longstaff *et al.* (2011) have pointed out that there is a single common component explaining an average of 64% of the movements in sovereign CDS (for a set of 26 economies).[7] They document that about two thirds of the spread is due to default component, and on average, it is the default component that is strongly linked to global financial variables. Ciarlone *et al.* (2009) extracts a single common factor driving bond spreads of 14 emerging markets. Using principal factoring, they conclude that 85% of the variation in bond spreads is explained by a single common factor. They report that the VIX is strongly significant in explaining the common factor, and it performs better than other financial market indicators considered. They also note country-specific fundamentals having a non-

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[6]Longstaff *et al.* (2011) report second and third principal components of sovereign risk as potentially reflecting regional factors, though do not study in detail. Existing literature focusing on both the global and the regional factors are mostly related to business cycles, see for instance Kose *et al.* (2003, 2008), Aruoba *et al.* (2011).

[7]Of these, there are 23 emerging markets and 3 developed economies.

negligible effect on the spreads. This paper differs from these studies in several respects. First, DFM provides a better picture of the relative contribution of each factor on sovereign risk. The DFM is widely used in the literature ranging from coincident macroeconomic indicators to international business cycles, though, to my best knowledge, have not been employed using sovereign CDS spread data. Second, I address whether global financial market variables fare well in explaining the global risk, and whether that depends on regime changes. Third, I explicitly study the regional factor. Last, I use longer time span and more countries (and further include developed economies for robustness).

The chapter proceeds as follows. Section 2.2 presents the the data and the methodology. Section 2.3 presents the empirical results, Section 2.4 the relationship between the global factor and financial market indicators. Section 2.5 presents robustness analysis, and Section 2.6 concludes.

2.2 Data and the Methodology

Credit default swaps enable transfer of credit risk from one party to another. Credit event may be triggered due to failure to pay beyond any grace period allowed on the obligation indenture; restructuring of the debt, altering the principal amount, coupon, currency or maturity; repudiation/moratorium of the debt; or even a drop if borrower's credit rating.[8] A seller of a CDS contract (protection seller) receives annual payments, but incurs the cost of a credit event. The buyer (protection buyer),

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[8]Note that bankruptcy/default is not taken as a credit event (as there is no international court to force a sovereign to honor its premises), as typically around 40-50% of the debt is recovered (see Reinhart and Rogoff, 2008). For a detailed definition of credit event, see Barclays (2010).

pays the premium and receives a payment equivalent to the loss in case of the credit event. The CDS 'spread' is the annual amount that the protection buyer must pay the protection seller till the maturity of the contract, expressed in percentage of the notional amount. For instance, consider a protection buyer paying a spread of 500 basis points to insure $100 of debt. She would pay $5 per annum till the maturity of the CDS contract to insure herself against a credit event of the reference entity (the sovereign in our case).[9] Moreover, magnitude of the spread is intrinsically linked to the likelihood of the sovereign default. Assuming that the loss associated with the default is 60% and the maturity is five years, the risk-neutral likelihood of default is 12.5% for each year over the next 5 years.[10]

I choose the CDS pricing data rather than another popular measure, bond spreads, since the CDS markets are typically more liquid than the bond markets, and CDS spreads provide a more direct measure of sovereign risk. Bond spreads, for instance, are driven not only by sovereign risk, but also by fluctuations in interest rate and by illiquidity effects on sovereign debt prices.[11] Moreover, I choose the sovereign CDS with 5-year maturity since it is generally the most liquid one among other maturities.[12]

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[9]Most CDS contracts are cash settled where an auction determines the market price of the distressed bond and thus the recovery value. In physical settlements, the CDS issuer receives the bond in exchange for money. However, most contracts are cash settled, since physical delivery would make the protection seller worse off in case the corresponding bond market becomes illiquid. In certain cases, the protection buyer could sell the bond at its par value, though if the corresponding market had become illiquid, could sell any list of bonds or loans with equivalent seniority rights depending on the contractual terms.

[10]See Hull *et al.* (2005) for details on the derivation of default probability using CDS premium.

[11]See Ang and Longstaff (2011), and Longstaff *et al.* (2011) for a similar discussion on why CDS markets may be preferred over bonds market to measure sovereign credit risk.

[12]See Pan and Singleton (2008) and Longstaff *et al.* (2011) for bid-ask spreads on a selective number of emerging market sovereign CDSs.

The data set consists of a large set of emerging market economies with sufficiently developed external debt markets. For convenience, I choose those included in the J.P. Morgan's Emerging Market Bond Index (EMBI+ or EMBI Global) for at least a year during the last decade. The selection criteria pick 25 economies: Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Greece, Hungary, Indonesia, Korea, Lithuania, Malaysia, Mexico, Panama, Peru, Philippines, Poland, Romania, Russia, Thailand, Turkey, Ukraine, Venezuela, and Vietnam.[13] The sample includes 8 Latin American, 10 European, and 7 Asian economies. The frequency is monthly (monthly average), and the sample period covers October 2000 to February 2012. The starting period is due to data limitations, since the sovereign CDS markets have been developed after 2000.

Table 2.1 presents the descriptive statistics of the data. The values are reported in basis points. As evident from the starting dates of sovereign CDS trading, the data become available for most of the countries by 2003 (20 economies).[14] The data range widely across the countries. Average sovereign CDS ranges from 59 basis points (China) to 909 basis points (Argentina, which experienced an external default along with banking and currency crises during 2001-2005), with standard deviation ranging from 47 to 934 basis points. The CDS spread reaches as high as 4280 basis points for Ukraine (in late 2009), for which a default was imminent had external funding not extended, while it is a mere 230 basis points for China. To accompany Table 2.1, Figure 2.1 displays the evolution of sovereign CDSs during the

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[13]I exclude African economies, Egypt, Nigeria and South Africa.

[14]Note that two economies with the same start date might have different number of observations (e.g. Colombia and Peru) due to missing observations.

sample period. The figure by itself suggests some degree of comovement in sovereign risk: There is a noticeable jump in late 2008 and a re-surge in mid 2011 for most economies.

Next, I present the DFM to extract the global, regional and idiosyncratic components of sovereign risk. I assume that sovereign CDS pricing data, y_{it}, have the following factor structure:

$$y_{it} = \mu_i + \Lambda_i^G G_t + \Lambda_i^R R_t + \varepsilon_{it} \quad \text{for } i = 1, 2, ..., n \tag{2.1}$$

where G_t is the global factor affecting all the countries, and $R_t \equiv (R_t^1, R_t^2, ..., R_t^k)'$ are the k regional factors. Λ_i^G and $\Lambda_i^R \equiv (\Lambda_i^1, \Lambda_i^2, ..., \Lambda_i^k)$ are the factor loadings for global and regional factors for country i. To separately identify the two common factors, I assume that each regional factor affects only the countries in the corresponding region. For a European country i, for example, the above equation simplifies to

$$y_{it} = \mu_i + \Lambda_i^G G_t + \Lambda_i^{Europe} R_t^{Europe} + \varepsilon_{it} \tag{2.2}$$

ε_i captures all the variation in y_i that is not captured by the common factors, reflecting idiosyncratic factors, and potentially, measurement errors. μ_i is unconditional mean of sovereign CDS for country i.

I assume that the factors follow a stationary autoregressive process of order one, and are independent from each other:

$$G_t = \alpha_1^G G_{t-1} + u_t^G \quad u_t^G \sim i.i.d. N(0, 1) \tag{2.3}$$

$$R_t^j = \alpha_1^{R^j} R_{t-1}^j + u_t^{R^j} \quad u_t^{R^j} \sim i.i.d.N(0,1) \;\; j = 1,2,...k \tag{2.4}$$

$$\varepsilon_{it} = \alpha_1 \varepsilon_{it-1} + v_{it} \quad v_{it} \sim i.i.d.N(0,\sigma_i^2) \tag{2.5}$$

where $E[v_{it}v_{js}] = 0$ for $i \neq j$, and where G_0 and R_0 are uncorrelated with v_t and u_t for all t. The model above is a backbone DFM for a variety of DFMs used in the literature. It is a simple version of DFM studied in, for instance, Kose *et al.* (2003) (on international business cycles), Del Negro and Otrok (2008) (on the European business cycles), and Stock and Watson (2008) (on the US housing market).

Identification.

The identification assumptions are as follows. First, the relative scale of the model is indeterminate. Consider multiplying the common factor by κ, $\widetilde{F}_t = \kappa F_t$. Also divide the factor loading by κ, $\widetilde{\Lambda} = \Lambda/\kappa$. The scale of the model ΛF_t is observationally equivalent to $\widetilde{\Lambda}\widetilde{F}_t$. To normalize the scale, I set global and regional factor shock variances equal to one (Stock and Watson, 1993).[15]

Second, the sign of the factor loadings and factors cannot be separately identified. Consider setting κ above equal to -1. Similarly as above, ΛF_t is again observationally equivalent to $\widetilde{\Lambda}\widetilde{F}_t$. As a remedy, I initialize factor loadings (for all the factors) to be positive. Such a restriction identifies the sign of the factors. Note that scale and sign normalization has no effect on economic inferences such as the

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[15]Note that the scaling does not affect economic inferences such as the estimated evolution of factors or variance decomposition. There might be applications for which the exact identification of F_t is not sought, e.g. forecasting, yet, since I study the evolution of factors, such a scaling assumption is necessary.

estimated evolution of factors and their contribution to the observable variables.

Third, common factors (global and regional factors) cannot be identified separately. I make a natural assumption that, for a country i in region s, the factor loadings on other regions are zero. That is, Λ_i^j is set equal to zero if $i \notin R^j$ for all $j = 1, 2, \ldots, k$ and for all $i = 1, 2, \ldots, n$.

Number of Factors.

A modeling assumption made above is that the data generating process admits two common factors, global and regional. Potentially, however, there can be many common factors, e.g. one might include sub-regions as well. Although a conventional way to see how many (independent) factors are needed to capture covariation in the data sufficiently well is to obtain proportion of variance that is explained by each common factor (through principle component analysis), it is not comparable to the dynamic model above since there is only a single common factor, i.e. the global factor, and the regional factors are common only those within the region. Hence, I rather verify the relevance of global and regional factors by documenting whether they account for a large portion of movements in sovereign risk premium for each country.

Contribution of Factors.

The estimated fraction of volatility in y_i that is explained by global and regional factors can be calculated by simply applying the variance operator to each signal equation. Using the fact that the factors are orthogonal to each other, the fraction of movements in y_i that is explained by the global factor is given by

$$\frac{(\Lambda_i^G)^2 var(G)}{var(y_i)} \tag{2.6}$$

and, similarly, the fraction of movements in y_i that is explained by the regional factor is given by

$$\frac{(\Lambda_i^R)^2 var(R)}{var(y_i)} \tag{2.7}$$

2.3 Empirical Results

The CDS series are first standardized to have mean zero and standard deviation one to ensure that an individual economy does not have a direct impact on the evolution of factors. The model is then estimated by Gaussian maximum likelihood, where the likelihood function is evaluated using the Kalman filter. The estimated state variables are presented in the Appendix Figure 2.10.

The stationarity of the system is verified through analyzing the estimated model. The estimated autoregressive coefficients for all the factors are below 1 (ranging in between 0.08 to 0.99, with an average of 0.88). The estimates for smoothed state disturbances and one-period-ahead signal disturbances are stationary (with p-values 0.00) based on standard univariate or group unit root tests.

2.3.1 Evolution of Global and Regional Factors

Global Factor.

Figure 2.2 presents the evolution of global factor. The global factor captures

the common driver of sovereign CDS for *all the emerging markets* in the data set. In reporting the factors, hereforth, I use October 2001 onwards to have the results robust to initial state values and since the data become available for most of the countries by this time. The estimated evolution of the global factor seems to follow major economic events during the sample period. To shed light on the magnitude of the global factor, note that the estimated standard deviation is roughly equal to three.

The global factor hits unusually high levels during late 2002 and in late 2008, consistent with the currency and banking crisis in Latin America and Turkey in 2001 and 2002, and with the US financial turmoil started in late 2007. The sharp increase in the global factor in October 2008 suggests that the recent US recession have become a global risk factor after the Lehman Brothers' collapse. Compared to its pre-crisis levels, the factor rises by about four standard deviation. The figure also suggests that proactive policy responses in advanced economies, –e.g. TARP, CPFF, and in an international scale, extending swap lines among central banks, IMF's provision of short-term liquidity with looser terms for economies battered by the financial crises, e.g. Iceland, Ukraine, Hungary, Belarus, Romania, Mexico, to name a few,– seem to avoid further increases in the global risk factor.[16]

By late 2009, the global risk factor gets stabilized, though, around a level higher than its pre-crisis level (about one standard deviation higher). It is only

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[16]To name a few, Ukraine signed a stand-by agreement with the IMF on Oct. 2008 to conditionally receive $16.5 billion, Hungary on Nov. 2008 to receive $15 billion, Belarus on Jan. 2009 to receive $2.5 billion, and Romania on March 2009 to receive $27 billion (together with the EU, WB, and EBRD). Through Flexible Credit Line, Mexico on March 2009 have secured $47 billion line of (unconditional) credit from IMF.

after increased concerns about Italy and Spain rolling over its debt (hence concerns about the Eurozone's future) that the global factor starts to rise again (August 2011).[17] In the next section, I provide a further analysis on this recent episode.

Regional Factors.

Figure 2.3 presents the European, Latin American, and Asian regional risk factors. The regional factor captures the comovement of the sovereign risk *for the economies within the region*, and shows the pricing of sovereign risk independent from global or idiosyncratic factors.[18]

The estimated evolution of regional factors seems to follow major regional economic events during the sample period. To shed light on the magnitude of regional factors, note that the standard deviation is roughly 4 for the Latin American and the Asian, and 4.5 for the European factor.

The European risk factor starts at a relatively high level in late 2001, mostly due to Russian and Turkish financial crisis. Then, as subsequent years and more economies chime in the estimation, the regional factor becomes stable till the Lehman Brother's collapse in October 2008. Following October 2008, the European regional factor surges. This surge implies that, the European factor feeds further risk to the European economies (on top of the global factor). Moreover, European emerging markets (on average) are hit more during this time compared to emerging markets in other regions. This result might suggest that Europe has stronger financial and

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[17]Note that Italy holds around 25% and Spain around 15%, in percent of total euro area government debt (on average for the last three years).

[18]While this orthogonality assumption hinders potential spillover from other factors to the regional factor, studying the spillover mechanism requires restrictive identification assumptions, and is not the focus of this paper. Note also that the orthogonality assumption is standard in the DFM literature that studies global and regional factors (see, for instance, Kose *et al.* 2003; 2008).

trade linkages with the US (compared to other regions), though further investigation is needed.

For the European regional risk factor, there are two distinctive episodes after 2009. The regional factor rises from mid-2009 to 2010 corresponding to the first-phase of European debt crisis, which is mostly limited to Greece and Ireland. The second phase starts in mid-2011, exhibiting a surge in the regional risk. This period corresponds to increased concerns about the future of Eurozone, as fiscal solvency problems arouse for two large indebted economies in Euro area, Spain and Italy, and further concerns about Greece.

Note that the second phase also coincides with the increase in the global factor, potentially suggesting that the second phase in Europe goes beyond the boundaries, and affects the sovereign risk of all the emerging markets. To shed further light on this, I estimate a DFM with a single common factor (the single-factor DFM), and plot the estimated common factor with the regional European factor (Figure 2.4).[19] The evolution of two series coincide surprisingly well for the recent era, suggesting that concerns about the Eurozone become a global risk factor thereafter (after June 2010).

The Latin American factor, on the other hand, shows a different risk pattern than the European, noticeably for early 2000s and 2008 onwards. The factor is at historically high levels during mid 2002, due to political instability in Brazil at the time, contagious effects on the region of Argentina's debt, currency, and banking crises starting in 2001. The region enjoys a slowly decreasing risk, as the economies

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[19]For all the estimated factors in the single-factor DFM, see Appendix A2.

implement sound policies (and some follow IMF supported programs, e.g. Brazil in 2002, and Colombia in 2003 and 2005). At the time global factor hits record high levels in late 2008, the Latin American factor falls noticeably, suggesting that the markets were pricing the Latin American economies' sovereign risk lower than the rest of the emerging markets. By 2010, the regional factor returns back to its pre-crisis levels.

The Asian factor has an increasing pattern from 2003 till early 2008, potentially due to Asian economies experiencing stable CDSs despite the decrease in the global risk factor during this period. The nearly-discrete change in the regional factor in 2008 happens to be earlier for Asian economies, coinciding with the start of the US recession. The factor goes back to its pre-crisis levels by mid to late 2009, and then keeps rising for the last three years.

Note that the regional factors are constructed to be orthogonal to each other as well as to the global factor. However, estimation results suggest some degree of correlation (Table 2.2). Two results emerge: First, regional factors are only slightly correlated with the global factor, with the correlation ranging from -0.09 to 0.19, inline with how the DFM is constructed. On the other hand, regional factors appear to be correlated with each other, with the correlation ranging from -0.53 to 0.80. The second result suggests that there are within-month *spillovers* across the regions. This point is left to future work.

2.3.2   Contribution of Factors

Table 2.3 presents the contribution of global, regional and idiosyncratic factors to the emerging economies' sovereign CDSs.

A substantial portion of emerging markets' sovereign risk is driven by external factors (84%). On average, the global factor accounts for 63%, and the regional factor 21% of the variations in sovereign risk. The contribution of external factors differs widely across the economies. The global factor, for instance, accounts for as low as 1% for Greece, and as high as 93% for Chile.[20]

The wide range for the contribution of external factors can be due to different degrees of capital market openness across the economies. Moreover, one might expect a higher contribution of external factors for more open economies. In Figure 2.6, I plot the Chinn-Ito capital account openness index (averaging over 2001-2010) against the total contribution of external factors for all the countries.[21] For countries with more open capital accounts, the contribution of external factors is higher.

The regional factor, on average, accounts for 21% of the fluctuations in emerging markets' sovereign risk. The contribution of which is highest for Brazil (82%)

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[20]Comparison of contributions across the economies should be handled with care, though. Consider, for instance, two countries for which the contribution of global factor on her sovereign risk premium is close (e.g. Ukraine versus Chile), while the former having a higher level of fluctuations in sovereign risk. A surge in global risk might push the former into a near default stage while exerting comparatively negligible effect on the latter. In this sense, comparison should be made along with country-specific macroeconomic conditions.

[21]Chinn-Ito (2008) index is based on extracting the common factor for variables (i) indicating presence of multiple exchange rates, (ii) indicating restrictions on current and capital account transactions, and (iii) indicating the requirement of the surrender of export proceeds. The graph shows the Chinn-Ito index against the contribution of external factor for all the economies with the exceptions Greece and Argentina. I exclude Greece –which is a fairly open economy– whose CDS is driven substantially by the idiosyncratic factor. Moreover, Argentina has defaulted for nearly half of the sample period, and since the default was idiosyncratic, I set the contribution of idiosyncratic factor at 50%.

in Latin America, Croatia (52%) in Europe, and China (20%) in Asia. It is no co-incidence that Brazil's and Chinese sovereign risk, of the largest economies in their regions, move strongly with the regional factors. It is reasonable to think that these economies are the main driver of regional risk, leading to a strong comovement with the regional factor. For other economies with a high level of contribution of regional risk factors, e.g. Colombia (67%), Peru (57%), Croatia (52%), they might possibly be driven by (rather than drive) the regional factor. In these regards, the estimated contribution of regional factors seems economically plausible.

The idiosyncratic factor, on average, accounts for 8% of the variations in sovereign risk. The wide range applies to the idiosyncratic factor as well: it is as high as 78% for Greece, 57% for Philippines, and nearly nil for Colombia and Thailand.

To shed further light on the validity of evolution and contribution of factors, next I study decomposition of sovereign CDS for four economies with different credit risk patterns: Chile, Greece, Philippines and Turkey (see Figure 2.5).

2.3.3 Idiosyncratic factor and four examples.

I choose four economies with 'different' sovereign risk patterns: Chile, Greece, Philippines and Turkey, different in the sense that the contribution of each factor differs noticeably across these economies. The contribution of global factor is highest for Chile (93%), that of the idiosyncratic factor is highest for Philippines in Asia (57%), and for Greece in Europe (78%). The global and idiosyncratic factors

each share nearly half of the movements for Turkey. Moreover, Greece, Philippines and Turkey have experienced idiosyncratic events that can be conveniently identified (debt, inflation, banking or political crisis) during the last decade, hence the estimated evolution of idiosyncratic factors can be conveniently judged against.

It is also worth noting that the idiosyncratic factor should not be thought as a sole reflection of country-specific fundamentals commonly used in the related literature (such as international reserves to imports, total external debt to real GDP, imports to export ratios, to name a few). The idiosyncratic factor is orthogonal to global and regional factors, whereas country-specific variables (particularly those pertaining to external balances) are most likely to be affected by global or regional economic stance. Idiosyncratic factor, instead, can be interpreted as the idiosyncratic nature of a sovereign's credit risk, such as rule of law or institutional quality, transparency in economic policy decisions and objectives, central bank independence, strength of business environment, effectiveness/efficiency of the public sector (in raising taxes, cutting spending, selling assets), default history, or robustness/effectiveness of financial sector.[22]

Chile is one of the most stable and prosperous economies in the Latin American region. Moreover, as a commodity-exporter, Chile has one of most sound sovereign wealth fund in the world. The country enjoys one of the lowest public debt to GDP ratio and inflation rate in the region, e.g. of around 6% and 4-5% respectively as of 2011.[23] In line with these, the decomposition results suggest that Chilean sovereign

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[22]For variables which are potentially idiosyncratic, see for instance IMF (2010, p. 101).

[23]To give a sense of these numbers, the largest economy in the region, Brazil, has a public debt to GDP ratio of 60% and an inflation rate of 9%.

risk is driven only negligibly by the Latin American-specific risk factors. Moreover, due to its rather stable economy, the contribution of idiosyncratic factor is small (7%). It is therefore mostly the global factor that drives the sovereign risk (however comparatively small the movements are).

Greek credit risk, on the other hand, is driven only negligibly by the global factor. After a long stable period, the Greek CDS rises after the Lehman Brother's collapse (as for all the emerging markets). Markets at the time seem to be pricing the Greek sovereign risk lower than its global and regional counterparts, as reflected in the decline in the idiosyncratic factor. After 2009, there are three distinctive surges in the Greek CDS, where each one is reflected in the idiosyncratic factor. The first occurs in December 2009, coinciding with the announcement of debt to GDP (of nearly 13%, which is to be revised later), and the downgrade of Greek credit rating. It is only after the IMF and EU's bailout package (of about $145bn) that it slows down the increase in the sovereign risk. The second occurs in February 2011, in which the Greek authorities slammed EU and IMF officials' overseeing efforts to reform its debt-crippled economy. The third occurs in July 2011, in which Greek credit rating were downgraded by all the main three rating agencies to a level associated with a substantial risk of default. These Greek-specific events are captured by the evolution of its idiosyncratic factor.

Philippines' sovereign risk is driven mostly by the idiosyncratic factor (57%), where the idiosyncratic factor seems to capture phases of political instability in the economy, e.g. a surge in the CDS due to increasing political tension till March 2003, the Oakwood mutiny in July 2003, and a relatively long-lived decline in the

CDS during a relatively calm political environment after July 2005. In other words, political instability seems to contribute more than half of the Philippines' sovereign risk.

Turkish sovereign risk is driven mainly by global and idiosyncratic factors. Despite strong trade and financial linkages with Europe, the contribution of regional European factor to Turkish sovereign risk is weak (of about 7%). Before 2005, the idiosyncratic factor seems to capture political instability, e.g. resignation of eight cabinet members in July 2002, elections in November 2002, political upheaval in late 2003, all captured by a jump in the idiosyncratic factor. After a five-year stable period, the idiosyncratic factor declines in early 2008 till early 2009, suggesting that Turkish sovereign risk is perceived to be lower than European emerging markets. The idiosyncratic factor resumes back to its pre-crisis level by the end of 2010 (where it had been for nearly 5 years). 2011 is characterized by a noticeable surge in the idiosyncratic factor. Potential explanations might be increasing concerns about current account deficit to real GDP reaching record high levels through the year and a jump in exchange rate volatility towards the end of the year. The idiosyncratic factor starts to decline in 2012, suggesting that investors start to perceive Turkish idiosyncratic risk at a lower level.

2.4 Interpreting the Global Risk Factor

The analysis so far sheds light on the evolution of global factor by associating it with major financial events. This section takes a formal stand. It provides an

understanding on the nature of global factor by linking it to global financial market indicators, taking into account potential regime changes in the relation.

I consider three financial market indicators often quoted in the literature as a way to gauge the stance of global financial markets: the TED spread, the yield spread between long-term Treasury notes (10- and 20-year Treasury notes), and Chicago Board of Exchange's Implied Volatility Index (VIX).[24] As discussed briefly below, these variables capture the strength of credit or liquidity risks, as well as risk averseness in the US financial markets. The evolution of these indicators are provided in Figure 2.7.

The TED spread is the difference between the interest rate at which the US government is able to borrow on a 3-month period (3-month U.S. Treasury bill), and the rate at which banks are willing to lend to each other in a 3-month period (measured by 3-month USD LIBOR). The spread measures estimated risks that banks pose on each other (compared to the likelihood of default of the US Treasury, which is practically nil). The higher the perceived risk due to one or several banks having liquidity or solvency problems, the higher the lending rate in interbank markets. In this regard, the TED spread captures credit *and* liquidity risk in interbank markets. Moreover, for periods of high risk averseness during which investors seek for 'safe havens', the yield on risk-free rate would be pushed downward, resulting in a rise in the spread. In this regard, in times of high credit/liquidity risks, a portion of movements in the spread would be due to 'flight to quality'.

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[24]See Gonzales-Hermosillo (2008), and Gonzales-Hermosillo and Hesse (2009) for a thorough analysis on financial market indicators that are potentially global.

The yield spread between long-term US Treasury notes (e.g. 10- to 20-year Treasury notes) reflects how strong markets value the liquidity.[25] Since the two bonds have essentially the same default risk, the yield spread reflects expected average future yields (from 10 to 20 years) and a liquidity premium. To the extent the former is stable, changes in the spread capture changes in liquidity premium. I use the percentage change in the yield spread compared to the previous year.

The VIX, CBOE's Volatility Index, reflects the expected future volatility in S&P500 (over the next 30 days) implied by the current index option prices. It indicates how strong investors value insuring their portfolios (in a sense, capturing investors' fear gauge).

To explore potential regime changes in the relation between the global factor and the financial market indicators, I employ Hansen (2000)'s threshold regression model.[26] I use the following threshold regression specification:

$$\Delta G_t = \delta_1' \Delta x_t + e_t \quad \Delta G_t \leq \gamma \tag{2.8}$$

$$\Delta G_t = \delta_2' \Delta x_t + e_t \quad \Delta G_t > \gamma \tag{2.9}$$

where x_t is one of the financial market indicators mentioned above, $\Delta x_t = x_t - x_{t-1}$, ΔG_t is the threshold variable used to split the samples into two groups or "regimes", and γ is the (endogenous) threshold parameter. The method is a sequential OLS

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[25]See Gonzales-Hermosillo (2008) for other potential variables to capture market liquidity risk. Here I follow Gonzales-Hermosillo (2008), and use the yield spread between long-term US Treasury notes.

[26]I would like to thank Bruce Hansen for very helpful discussions on the methodology.

estimation, searching over all permissible γs such that sum of squared errors of the above system is minimized.[27]

While the method determines the regimes endogenously, it may be the case that the true data generating process admits a linear regression model, that is $H_0 : \delta_1 = \delta_2$ cannot be rejected (hence no threshold effect). Testing H_0, however, is not straightforward since γ is not identified under the null hypothesis. Hansen (2000) introduces a heteroskedasticity-consistent bootstrap F-test procedure to test the null of linearity. The procedure provides asymptotically correct p-values.

To further explore whether there are multiple regimes, I follow Hansen (2000) and first test whether there is a threshold in the whole sample. Then, given the estimated threshold, I explore whether there are further thresholds within each regime (sub-sample).

Table 2.4 presents the regression results, based on the whole sample as well for each estimated regime.

Using the whole sample, VIX turns out to be the most powerful indicator in

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[27]In particular, first write the equations above in a single equation form (by defining an indicator variable). In particular, let $I\{q_i \leq \gamma\}$ be an indicator function that takes a value 1 if $\{.\}$ is satisfied and 0 otherwise. And let $x_i(\gamma) \equiv x_i I\{q_i \leq \gamma\}$. Then the above model can be written as

$$y_i = \theta x_i + \delta'_n x_i(\gamma) + e_i \tag{2.10}$$

where $\theta = \theta_2$, and $\delta_n = \theta_2 - \theta_1$. The least-squares estimators $\widehat{\theta}$, $\widehat{\delta}$, and $\widehat{\gamma}$, jointly minimize

$$S_n(\theta, \delta, \gamma) = \sum_i \left(y_i - \theta x_i + \delta'_n x_i(\gamma)\right)^2 \tag{2.11}$$

Conditional on γ, equation (10) is linear in θ and δ_n. Conditional LS estimates $\widehat{\theta}(\gamma)$ and $\widehat{\delta}(\gamma)$ can be obtained by regression y_i on x_i and $x_i(\gamma)$. The conditional sum of squares is $S_n(\gamma) \equiv S_n(\widehat{\theta}(\gamma), \widehat{\delta}(\gamma), \gamma)$. As shown in Hansen (2000), $\widehat{\gamma}$ can be defined uniquely as

$$\widehat{\gamma} = \operatorname{argmin}_{\gamma \in \Gamma_n} S_n(\gamma) \tag{2.12}$$

where $\Gamma_n = \Gamma \cap \{q_1, ..., q_n\}$.

explaining movements in the global factor (of about 58%). A rise in the VIX (a decrease in investors' risk appetite) leads to a statistically significant increase in the global factor. Similarly, a rise in the TED spread (an increase in credit/liquidity risk) also induce a rise in the global factor. The TED spread can explain about 22% of the movements in the global factor. The yield spread (the liquidity premium) has the lowest explanatory power (of about 2%). Note that these results are based on whole sample, and further investigation is needed as there are indeed regime changes in the relation.

There are three regimes in the relation between the global factor and the financial market indicators: The high stress period (corresponding to large increases in G_t), the low-to-moderate stress period (corresponding to moderate changes in G_t), and the recovery period (corresponding to large declines in G_t). These regimes are determined based on estimated threshold values for ΔG: γ^{high} and γ^{low}.[28] The two thresholds are 'statistically significant': the null of linearity is rejected at a 0.000 significance level.[29] The estimated durations of these regimes are as follows: The high stress period in sovereign risk markets seems to prevail for 6 to 11 months (de-

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[28]In particular, I first test the significance of the threshold in the whole sample, which splits the sample into two regimes. The null of linearity is rejected with a p-value of 0.000. The threshold value splits the sample into a small one (including 11 observations using the TED spread as the independent variable, 6 observations using the yield spread, and 7 observations using the VIX), and large one (including 113, 118 and 117 observations, respectively). I label the threshold that splits the whole sample as γ^{high}. I have not pursued splitting the small one into subsamples, as that would imply excessively low degrees of freedom. I then test significance of a threshold in splitting the large sample, and the null of linearity is rejected at a p-value of 0.000. I label the threshold splitting the large subsample as γ^{low}.

[29]For the likelihood ratio sequence used to construct the confidence bands for the thresholds, see Figure 2.13 in the Appendix. The likelihood ratio (LR) statistic gives out the change in sum of squared errors under $\gamma = \gamma^1$ as compared to $\gamma = \gamma^0$. The threshold estimate is where the sequence reaches its minimum. The confidence band limits are where the critical value intersects with the LR sequence. The local minima in the first graph sort of implies a second threshold, as further validated by formal testing.

pending on which financial market indicator is used). The low-to-moderate period prevails for around 9 years. The estimated duration of this period seems to be rather long, as this period captures a range of tranquil to moderately stressed periods in the financial markets. The recovery period, fast declines in the global risk, appears to be for about 5 to 11 months.

The explanatory power of financial market indicators is the highest under the high-stress regime: The TED spread explains 49%, the yield spread 24%, and the VIX 86% of the variations in the global factor. An increase in the TED spread, which is potentially due to increased credit/liquidity risks in the interbank market and flight to safe US assets, leads to a rise in the global factor. An increase in the liquidity premium, which is captured by an increase in the yield spread, also implies an increase in the global factor (though the effect is statistically insignificant). An increase in the investors' risk sentiment also leads to a rise in the global factor. During the low-to-moderate stress period, all the three indicators explain the global factor significantly, though the explanatory power declines to 12%, 11%, and 35%, respectively. Still, the investors' risk sentiment (the VIX) stands out as the most powerful indicator to explain the global factor. For the recovery period, financial market indicators are statistically insignificant in explaining the global risk (though the point estimates with the expected sign). Fluctuations in the VIX explain 33% of the movements in the global risk factor, the TED spread 19%, and the yield spread 7%.

The lessons I derive from the analysis are the following: First, investors' risk sentiment (or uncertainty about the US economy) is the single and most powerful

indicator of global risk factor affecting the emerging markets. Second, power of financial market indicators in explaining the global factor depends on the state of the global financial markets. It is the high-stress period during which financial market variables have the highest explanatory power. Third, existence of flight to safe US assets appears to be a relevant ingredient for the increase in emerging markets' sovereign risk premium in the recent era.

2.5 Robustness (Including Advanced Economies & Using Higher Frequency)

How 'global' is the common driver of emerging markets' sovereign risk? Given many developed economies in Europe, how 'European' is the estimated European regional risk factor? Does using monthly frequency (rather than a higher frequency) miss important information? This section studies robustness of the results using a larger sample (including advanced economies) and higher frequency (using weekly data).

I include all the economies for which the CDS trading exists for at least one third of the sample period (October 2000 to February 2012). Additional countries included are Belgium, France, Germany, Italy, Latvia, Netherlands, Portugal, Slovakia, Spain and Sweden. Moreover, I use weekly (rather than monthly) average of daily 5-year sovereign CDS data.

The estimated evolution of global factor is very similar to the one estimated using the emerging markets alone (Figure 2.8).[30] As developed economies chimes

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[30]See Figure 2.12 in the Appendix for the estimated evolution of states. Note that estimated idiosyncratic factors are inline with major economic events in these economies. Regarding the

in the estimation mostly after 2005, it is more fair to compare the evolutions after 2005. The global factor hits record high levels in late 2008, gets stabilized after almost a year, and exhibits a further surge in mid 2011. While Latin American and Asian regional factors follow similar patterns with the ones estimated before, European regional risk factor is now noticeably higher due to including developed economies (Figure 2.9).

2.6   Conclusion

This paper studies global, regional and idiosyncratic components of emerging markets' sovereign credit risk premium, using a newly-developed data set, sovereign credit default swaps. I use dynamic factor modeling to extract these components rather than relying on restrictive assumptions on which variable would capture these components. Moreover, I explore the performance of global financial variables often used in the literature to proxy global risk in explaining the extracted global risk factor.

The results suggest that a large portion of emerging markets' sovereign risk premium is due to common external factors. On average, about 63% of the variations in the sovereign risk is due to the global factor, and about 21% due to regional factors. There is, however, substantial heterogeneity among the emerging markets.

Second, the global factor seems to be best reflected by the CBOE's VIX, a

idiosyncratic factor for the additional economies, for instance, the surge of the Italian CDS in mid 2011, of Portuguese and Spanish CDSs in 2010 are inline the unraveled fiscal solvency problems in these economies at the time. Swedish idiosyncratic factor keeps declining during the last few years, inline with the Swedish fiscal performance (maintaining very low levels of public debt to GDP).

reflection of investors' risk sentiment, regardless of the regimes considered (high-stress, low-to-moderate stress, or recovery regimes). VIX explains around 87% of the global factor during high stress times, and of around 55% on average, while the TED spread 50% during high stress times, and 20% on average. Furthermore, the results also suggest that in times of high stress, investors seek for safe US assets, which contributes to a rise in emerging markets' sovereign risk. The yield spread between long-term US Treasury notes which by-and-large reflects liquidity premium has a lower power in explaining the global factor (of about 7% to 25%).

Third, concerns about the future of Eurozone appear to go beyond the regional boundaries, and become a global risk factor after June 2010. Estimating a DFM with a single common driver, the results show that the common driver follows the European risk factor surprisingly well starting in June 2010.

The evolution of common factors are by and large robust to including developed economies and using higher frequency. This result suggests that emerging markets' sovereign risks are not decoupled from how the developed economies perform.

For future research, linking the regional factors to financial market variables in central economies would shed further light on the nature of regional factors. Moreover, to provide a further understanding on the contribution of regional factors, one can partition economies within the regions using clustering methods. These points are left to future research.

2.7 Appendix - Kalman Filter

Let y_t denote an $(nx1)$ vector of variables that are observable at t, and be driven by a $(kx1)$ vector of latent (unobserved) variables, s_t. The dynamics of y_t can be represented by a *state-space* representation given by the following system of equations:

$$y_t = As_t + u_t \quad \text{[Signal equation]} \tag{2.13}$$

$$s_{t+1} = Bs_t + v_{t+1} \quad \text{[State equation]} \tag{2.14}$$

where $u_t \sim N(0, R)$ and $v_t \sim N(0, Q)$, with $E[u_t u'_\tau] = R$ and $E[v_t v'_\tau] = Q$ if $t = \tau$, and 0 if $t = \tau$. The matrices A, B, R, and Q have the dimensions nxk, kxk, nxn, and kxk, respectively. Moreover, the disturbances u_t and v_t are assumed to be uncorrelated at all lags, $E[v_t u'_\tau] = 0 \ \forall \ t$ and τ. Also, the initial value of s_t, s_1, is assumed to be uncorrelated with v_t and $u_t \ \forall t$.

The Kalman filter is an iterative algorithm whereby an initial estimate of the latent factors is obtained from the state equation. This estimate is then used to compute an estimate of the observable variables, y_t. Using the observed and the estimated values of y_t, s_t is updated through the Kalman gain.

In particular, denote conditional means of y_t and s_t by

$$y_{t|t-1} = E_{t-1}[y_t] = As_{t|t-1} \tag{2.15}$$

$$s_{t|t-1} = E_{t-1}[s_t] = Bs_{t-1|t-1} \tag{2.16}$$

and the conditional variables by

$$V_{t|t-1} = E_{t-1}[(y_t - y_{t|t-1})(y_t - y_{t|t-1})'] = AP_{t|t-1}A' + R \tag{2.17}$$

$$P_{t|t-1} = E_{t-1}[(s_t - s_{t|t-1})(s_t - s_{t|t-1})'] = BP_{t-1|t-1}B' + Q \tag{2.18}$$

Given $s_{1|0}$ and $P_{1|0}$, one can deduce the adjustment to the factor estimate using the observables. That is,

$$s_{t|t} - s_{t|t-1} = P_{t|t-1}A'V_{t|t-1}^{-1}(y_t - y_{t|t-1}) \tag{2.19}$$

$$P_{t|t} - P_{t|t-1} = P_{t|t-1}A'V_{t|t-1}^{-1}AP_{t|t-1} \tag{2.20}$$

where $G_t = P_{t|t-1}A'V_{t|t-1}^{-1}$ is the Kalman gain, the adjustment to the latent factor given the difference between the actual and estimated values of observables.

Initial values $s_{1|0}$ and $P_{1|0}$ are given by

$$s_{1|0} = 0 \tag{2.21}$$

$$vec(P_{1|0}) = (I_{kxk} - (B \otimes B))^{-1}vec(Q) \tag{2.22}$$

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2.8   Appendix - Tables and Figures

Table 2.1: Descriptive Statistics for Sovereign Credit Default Swap (10/2000 - 4/2012)

	Mean	Std. Dev.	Minimum	Median	Maximum	Start	N
Argentina	909.24	933.95	193.55	616.56	4271.17	6/2005	81
Brazil	476.22	659.90	65.68	177.12	3549.73	10/2001	125
Bulgaria	220.68	169.98	13.86	207.65	641.30	10/2000	137
Chile	70.20	55.03	12.98	61.43	259.14	1/2003	110
China	59.35	47.77	10.65	40.70	230.22	1/2003	110
Colombia	250.75	165.22	76.07	164.61	825.31	1/2003	110
Croatia	183.01	142.75	15.77	128.00	536.20	10/2000	137
Greece	285.91	603.89	5.46	13.93	3515.85	3/2003	104
Hungary	147.41	166.78	12.71	42.41	635.71	3/2002	120
Indonesia	230.84	141.00	100.90	193.63	805.69	10/2004	86
Korea	88.44	79.51	15.15	69.65	414.03	2/2002	121
Lithuania	313.15	174.72	6.00	285.65	765.38	12/2006	47
Malaysia	87.15	62.50	13.84	78.06	276.18	10/2001	125
Mexico	144.29	88.05	30.28	117.09	411.81	10/2001	125
Panama	171.28	84.07	65.20	143.37	435.00	10/2001	100
Peru	188.38	100.77	65.30	151.92	555.91	10/2003	101
Philippines	289.35	143.54	101.39	231.83	620.28	4/2002	119
Poland	77.86	76.38	8.34	46.87	360.63	10/2000	137
Romania	210.44	162.88	17.68	192.69	711.58	10/2002	113
Russia	283.35	252.89	39.42	189.68	1015.50	10/2000	137
Thailand	91.04	61.82	27.03	83.30	302.43	4/2002	118
Turkey	404.22	289.85	134.40	268.34	1212.50	10/2000	137
Ukraine	659.07	798.73	131.80	353.50	4280.02	8/2004	91
Venezuela	811.84	592.91	132.69	694.44	2824.82	1/2003	110
Vietnam	240.23	130.21	58.66	249.03	501.09	5/2006	67

Notes. The values are based on monthly average of daily 5-year sovereign CDS spreads. The spreads are in basis points.

Table 2.2: Cross-correlations between Common External Factors

	Global	Europe	Latin America	Asia
Global	1			
Europe	0.10	1		
Latin America	0.19	-0.53	1	
Asia	-0.09	0.80	-0.61	1

Table 2.3: Contribution of Factors to the Sovereign CDS

	Global	Regional	Idiosyncratic
Argentina[a]	**0.92**	0.05	0.04
Brazil	0.11	**0.82**	0.07
Bulgaria	0.79	**0.17**	0.04
Chile	**0.93**	0.00	0.07
China	0.77	**0.20**	0.03
Colombia	0.33	**0.67**	0.00
Croatia	0.47	**0.52**	0.02
Greece	0.01	**0.21**	**0.78**
Hungary	0.44	**0.18**	**0.38**
Indonesia	**0.85**	0.00	**0.14**
Korea	**0.78**	0.05	**0.17**
Lithuania	**0.82**	0.08	0.10
Malaysia	**0.81**	0.16	0.03
Mexico	**0.85**	0.08	0.07
Panama	0.60	**0.39**	0.01
Peru	0.41	**0.56**	0.03
Philippines	0.41	0.02	**0.57**
Poland	0.36	**0.33**	**0.30**
Romania	0.53	**0.29**	**0.18**
Russia	**0.85**	0.01	**0.14**
Thailand	0.73	**0.27**	0.00
Turkey	0.51	0.07	**0.43**
Ukraine	**0.91**	0.01	0.08
Venezuela	0.69	0.01	**0.30**
Vietnam	**0.74**	0.06	**0.19**
Average	0.63	0.21	0.17
Median	0.73	0.16	0.08

Notes. Values in **bold** correspond to those above the median.

[a] The values for Argentina are based on a rather recent period (Argentinean CDS trading starts in 2005 after a 4-year default period). As there is no data for the default period, Argentinean CDS seems to be driven only negligibly by the idiosyncratic factor, though the default itself is mostly idiosyncratic.

Table 2.4: Global Factor - Global Financial Market Indicators

		ΔTED Spread	ΔT-Bill Spread (20y-10y)	ΔVIX
Whole Sample	β	1.811** [1.210,2.411]	0.002** [0.000,0.004]	0.160** [0.158,0.162]
	R^2	0.225	0.021	0.585
	N	124	124	124
Regime 1 (High Stress) $(\Delta G > \gamma^{\text{high}})$	β	2.556** [0.301,5.991]	0.0261 [-0.031,0.080]	0.213** [0.125,0.295]
	R^2	0.493	0.244	0.858
	N	11	6	7
	γ^{high}	0.675†† [0.613,1.111]	1.036†† [1.036,1.116]	0.947†† [0.947,1.111]
Regime 2 (Low-to-moderate Stress) $(\gamma^{\text{low}} \leq \Delta G \leq \gamma^{\text{high}})$	β	0.535** [0.219,0.851]	0.002** [0.000,0.003]	0.067** [0.042,0.089]
	R^2	0.116	0.115	0.351
	N	106	107	112
	γ^{low}	-1.096†† [-1.139,-1.096]	-0.772†† [-1.353,-0.638]	-1.338†† [-1.353,-0.354]
Regime 3 (Recovery) $(\Delta G < \gamma^{\text{low}})$	β	3.707 [-0.124,7.539]	0.004 [-0.006,0.014]	0.237 [-0.10,0.49]
	R^2	0.192	0.073	0.331
	N	7	11	5

Notes. ** indicates significance level at 1%. †† indicates the null of linearity is rejected at a 1% level. The TED spread is the difference between the 3-month U.S. Treasury bill and 3-month USD LIBOR. The VIX is the Chicago Board of Options Exchange index of percentage implied volatility.

Figure 2.1: 5-year Sovereign CDS Spreads
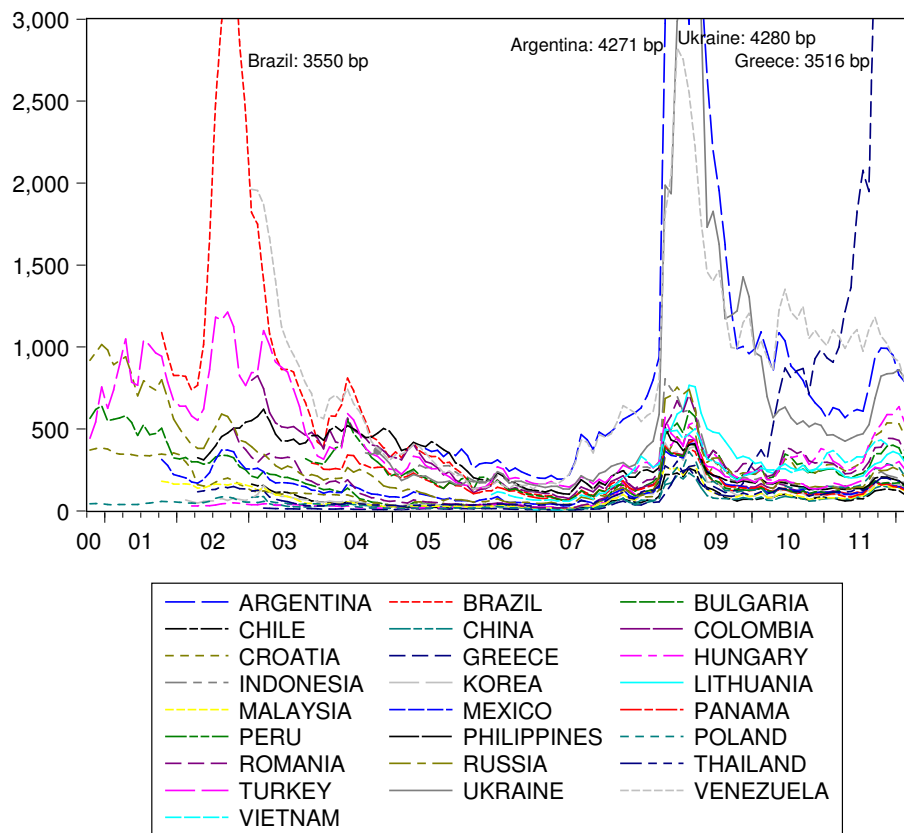
Figure 2.2: Global Factor and Major Events

Latin American Crisis
(Brazil: Debt Crisis, Elections, 6/2002)
(Argentina*: Default, Inflation
and Banking Crises, 2001-)
(Uruguay*: Banking Crisis, 7/2002-)
(contagious effects on the region)

IMF Programs-
(Brazil: 2001-2002)
(Argentina: 2001-2005)
(Colombia: 2003, 2005)

TARP; CPFF; TALF;
extending PDCF, AMLF, TSLF;
swap lines among major CBs;
IMF's liquidity facility
(10/11/12/2008)

Lehman Brothers
files for bankruptcy
(9/2008)

Fed's extension of
liquidity facilities
(AMLF, CPFF,
PDCF, TSLF)
(6/2009)

Freddie Mac
announces
not buying
most risky MBSs
(2/2007)

1st bailout package
of 110bn to Greece
(5/2010)

3rd Greek
bailout (10/11)

Increased concerns
about Italy and Spain
(8/11)

Abbreviations. AMLF: Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility. CPFF: Commercial Paper Funding Facility. PDCF: Primary Dealer Credit Facility. MBS: Mortgage-backed security. TARP: Troubled Asset Relief Program. TALF: Term Asset-Backed Securities Loan Facility. TSLF: Term Securities Lending Facility.

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Figure 2.3: Sovereign CDS and Regions

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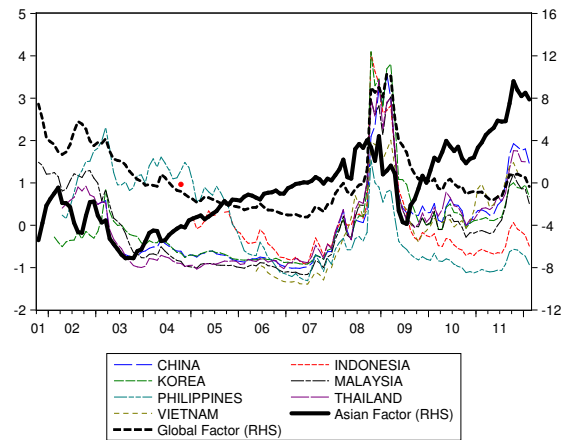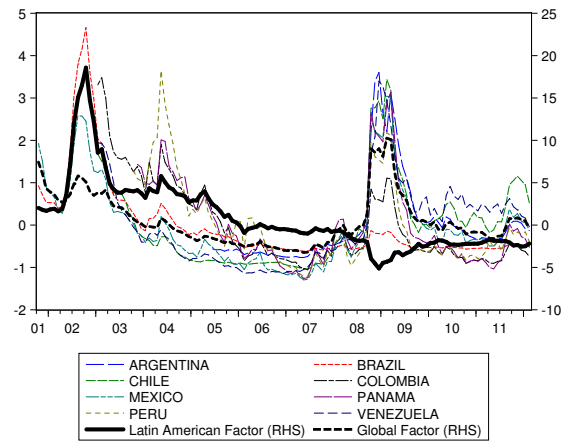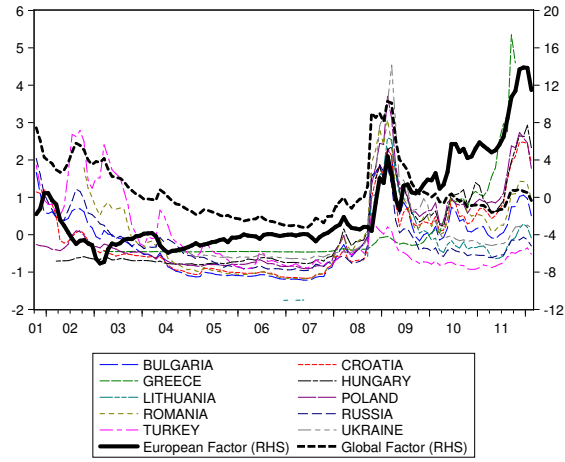
Figure 2.4: Common Factor versus the European Factor
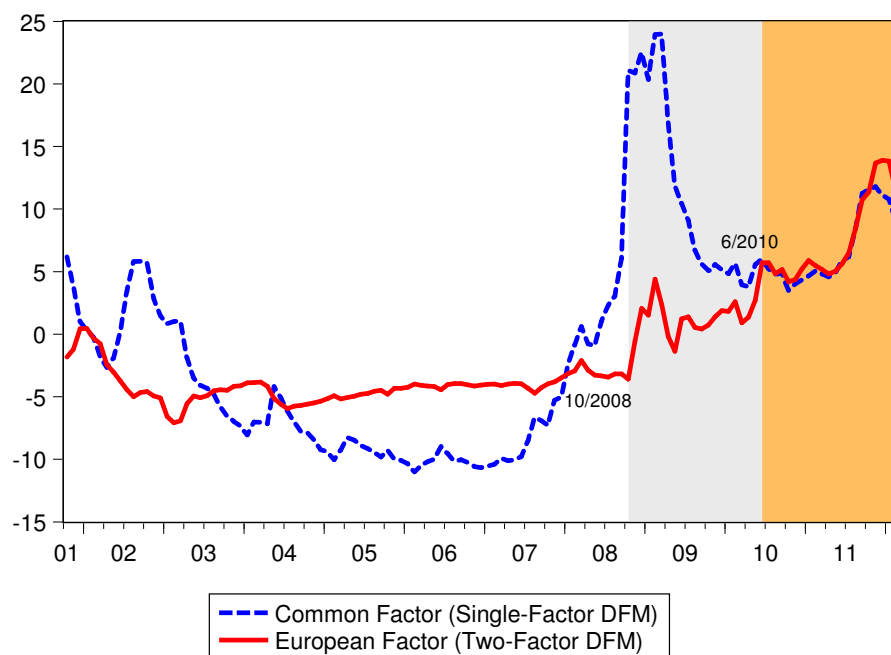
Figure 2.5: Decomposing Sovereign CDS

Chilean CDS, Standardized (LHS)
Global Factor (RHS)
Regional Factor, Latin America (RHS)
Idiosyncratic Factor (LHS)

Contribution of Factors:
Global: 93%
Regional: 0%
Idiosyncratic: 7%

Greek CDS, Standardized (LHS)
Global Factor (RHS)
Regional Factor, Europe (RHS)
Idiosyncratic Factor (LHS)

Contribution of Factors:
Global: 1%
Regional: 21%
Idiosyncratic: 78%

Philippines' CDS, Standardized (LHS)
Global Factor (RHS)
Regional Factor, Asia (RHS)
Idiosyncratic Factor (LHS)

Contribution of Factors:
Global: 41%
Regional: 2%
Idiosyncratic: 57%

Turkey's CDS - Standardized (LHS)
Global Factor (RHS)
Regional Factor, Europe (RHS)
Idiosyncratic Factor (LHS)

Contribution of Factors:
Global: 51%
Regional: 7%
Idiosyncratic: 43%

Figure 2.6: Chinn-Ito Index versus the Contribution of External Factors
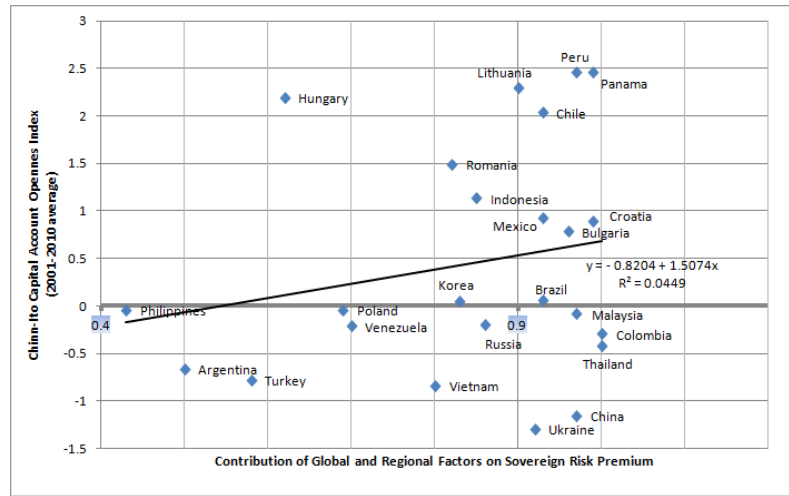
Figure 2.7: Financial Market Indicators
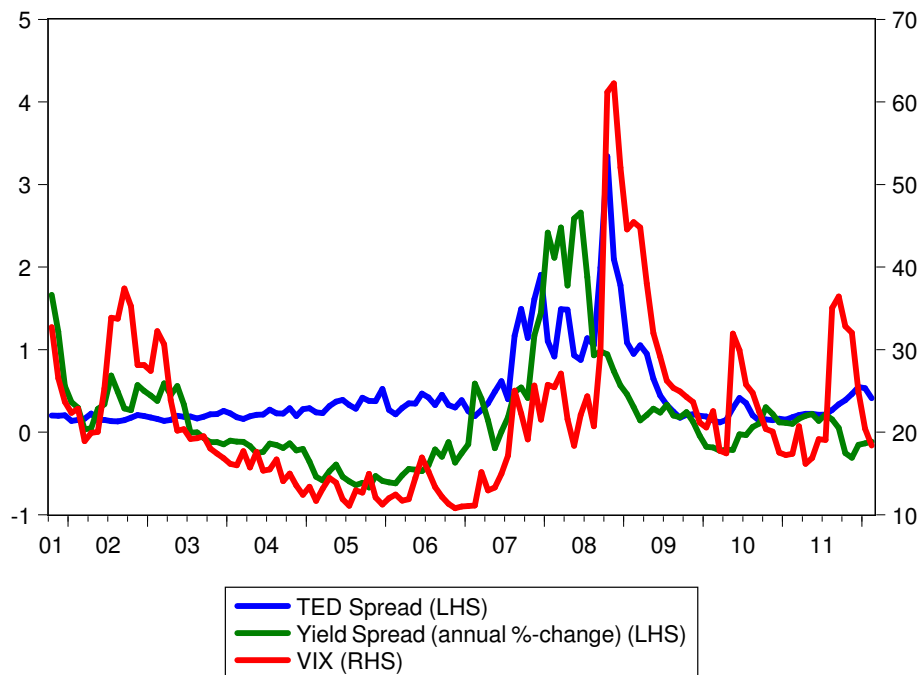
Figure 2.8: Global Factor -Including Developed Economies-
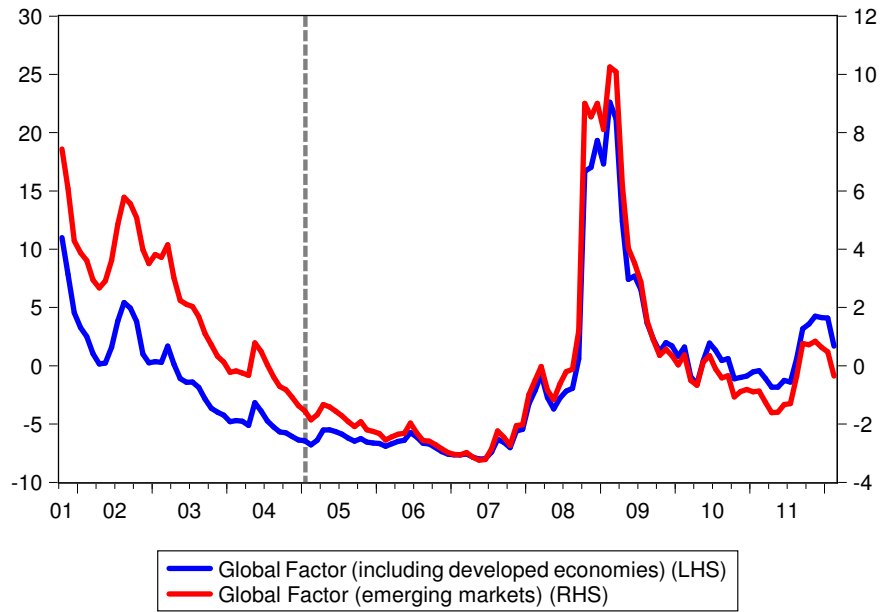
Figure 2.9: European Regional Risk Factor -Including Developed Economies-
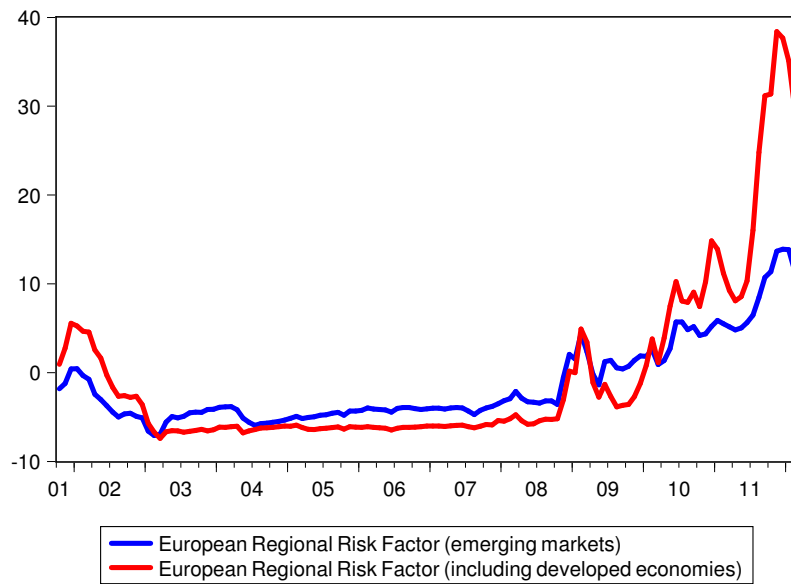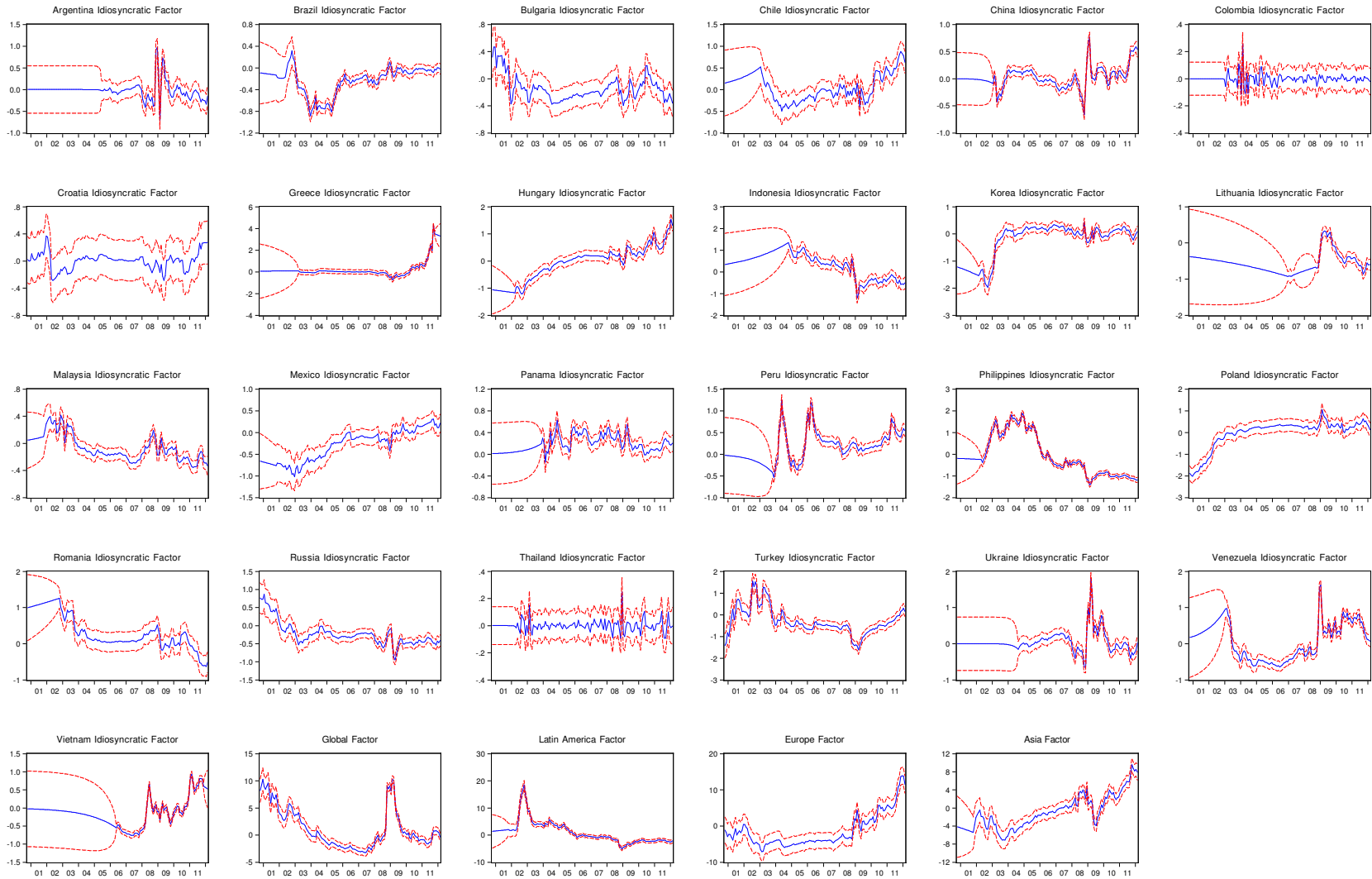
Figure 2.10: Smoothed States -Two-Factor DFM-
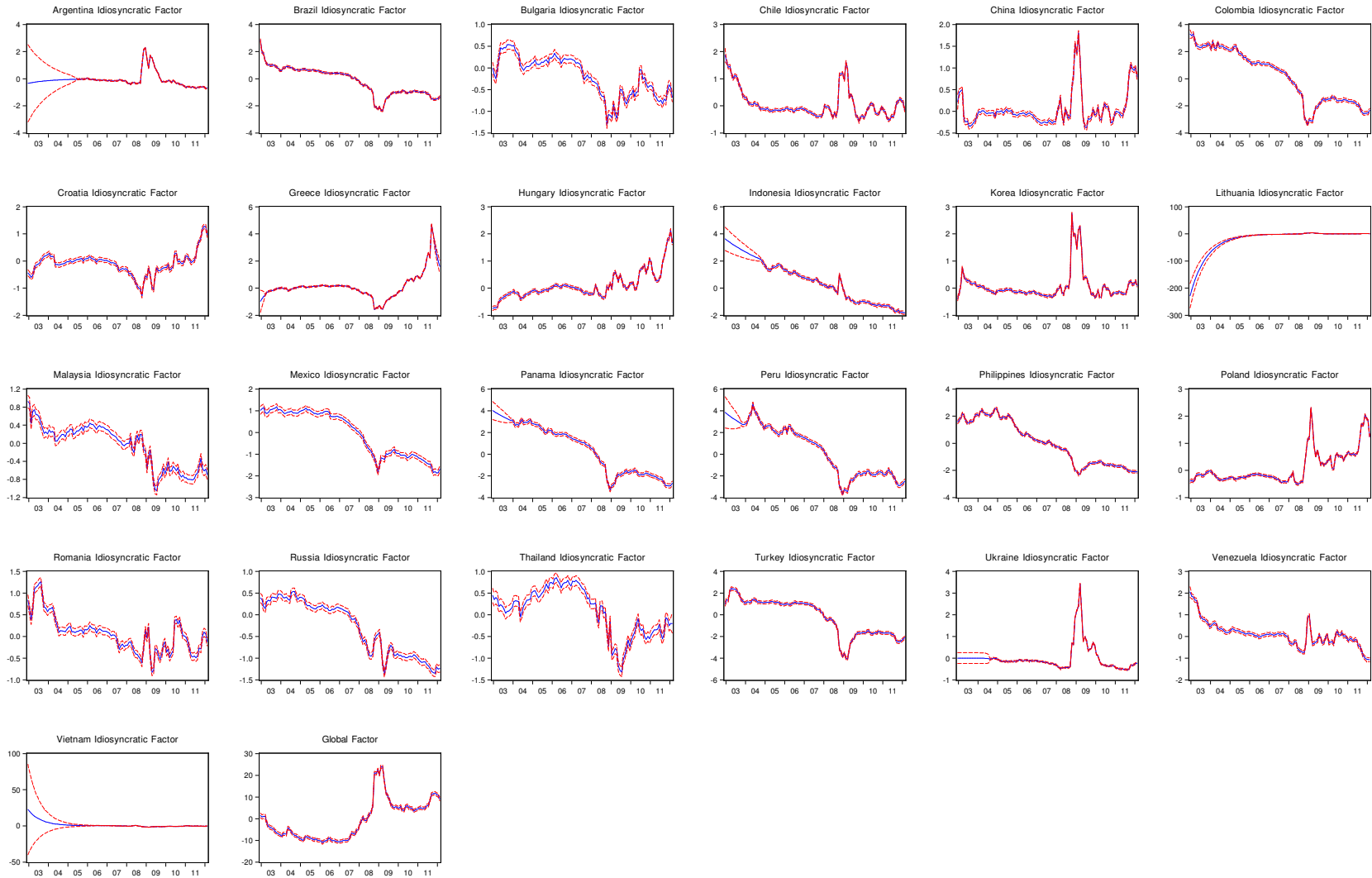
Figure 2.11: Smoothed States -Single-Factor DFM-

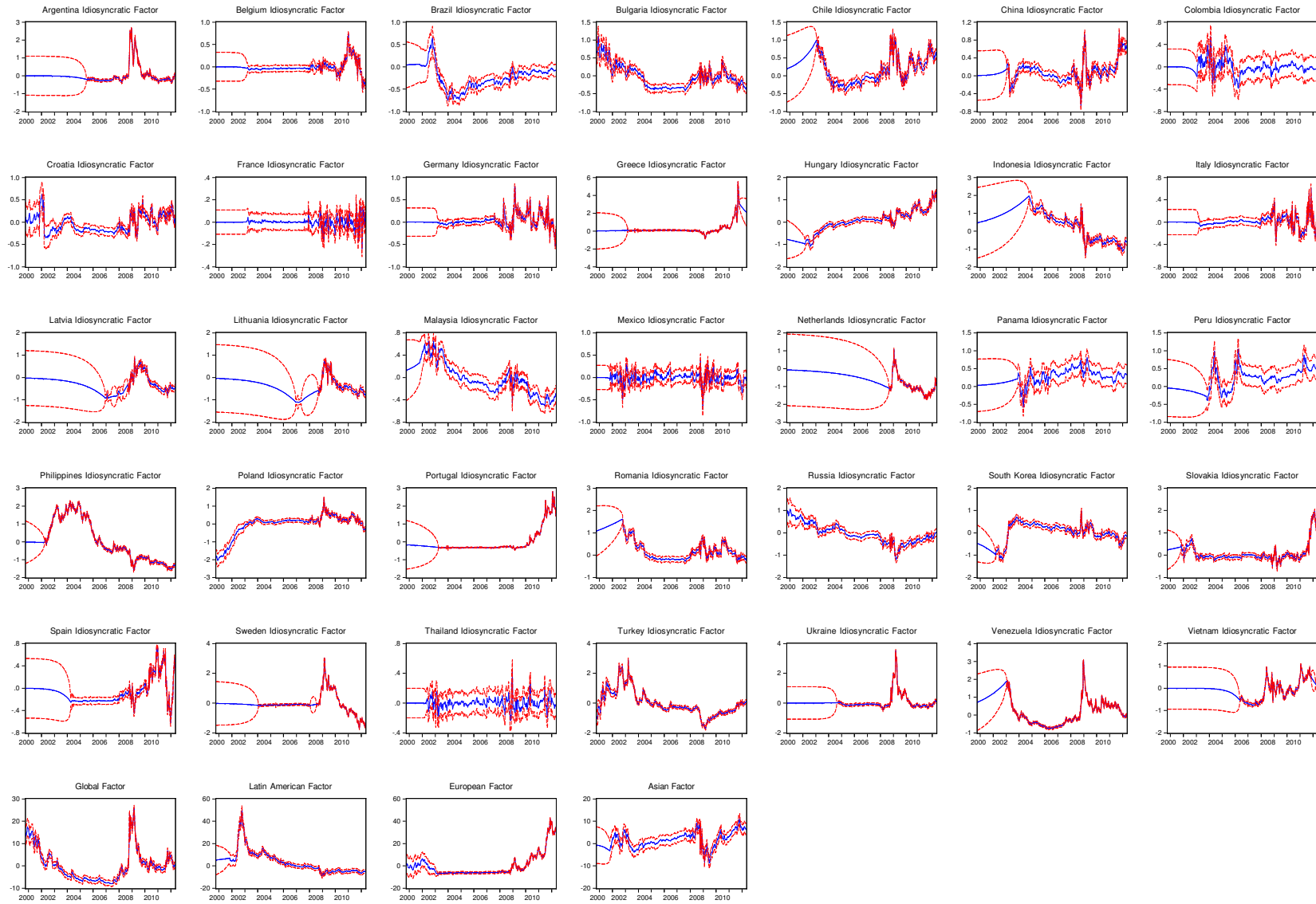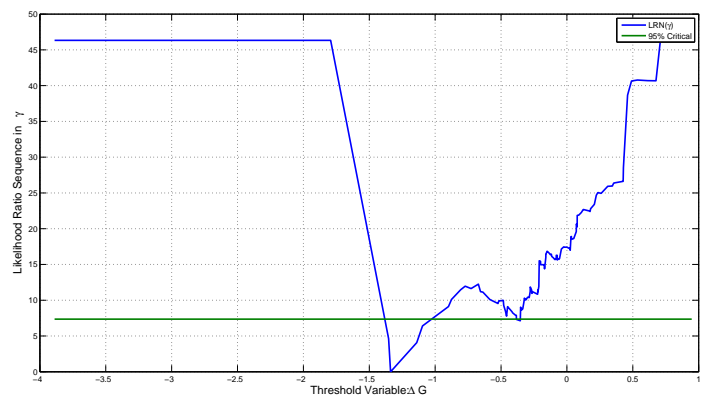Figure 2.12: Smoothed States -Two-Factor DFM- (Including Developed Economies and Weekly Frequency)
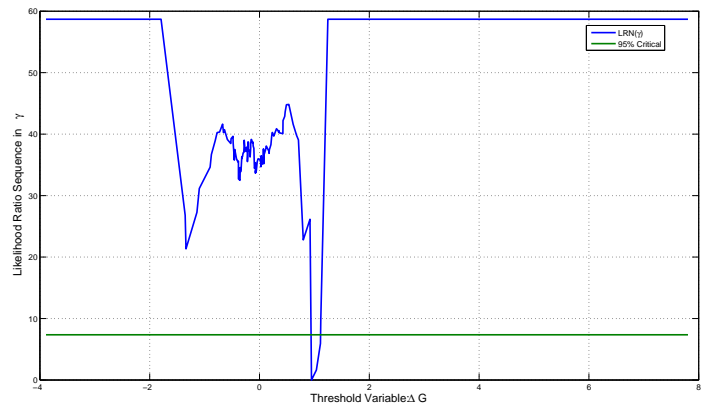
Figure 2.13: Confidence Interval Construction for the Thresholds (using the VIX)

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