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WORKING PAPER

The External Finance Premium and the Macroeconomy: US post-WWII Evidence

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September 2007

2007/482

D/2007/7012/53

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Abstract

The central variable of theories of financial frictions -the external finance premium- is unobservable. This paper distils the external finance premium from a DSGE model estimated on US macroeconomic data. Within the DSGE framework, movements in the premium can be given an interpretation in terms of shocks driving business cycles. A key result is that the estimate -based solely on non-financial macroeconomic data- picks up over 70% of the dynamics of lower grade corporate bond spreads. The paper also identifies a gain in fitting key macroeconomic aggregates by including financial frictions in the model and documents how shock transmission is affected.

Keywords: external finance premium, financial frictions, DSGE, Bayesian estimation

JEL: E4, E5, G32

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1 Introduction

The external finance premium is a crucial variable in economics. Few economists would argue that firms can obtain external finance at the risk-free rate. While internal finance is available relatively cheaply, obtaining external funds -through loans, bonds or equity- implies possibly substantial costs. Probably the most prevailing explanation for costly external finance is the existence of asymmetric information, which gives rise to financial market imperfections. Not only with respect to firm investment, but also for macroeconomic fluctuations can financial frictions have substantial implications, as Bernanke and Gertler (1989) forcefully argue. A major problem for students of financial frictions is, however, that the central variable, the external finance premium, is unobservable.

There are currently two approaches toward tackling the unobservability of the external finance premium. The first approach relies on finding readily available financial market indicators that are arguably good indicators for the premium for external finance, such as corporate bond spreads. The fact that these indicators have substantial predictive content for business cycle fluctuations is often interpreted as evidence for the existence of financial frictions, e.g. Gertler and Lown (1999) and Mody and Taylor (2003). Another approach is adopted by Levin et al. (2004). Using the microeconomic financial friction embedded in Bernanke et al. (1999), along with balance sheet and bond market data, they estimate the external finance premium for a group of listed US firms.

This paper estimates the external finance premium for the US economy. We distil the premium from a medium-scale Dynamic Stochastic General Equilibrium (DSGE) model with financial frictions, estimated using Bayesian methods. We compare the model-consistent premium with readily available indicators of the external finance premium and find it has substantial realistic content. Our framework allows to interpret fluctuations in the external finance premium in terms of structural shocks driving the economy.

In order to study fluctuations in the external finance premium, we append the widely analyzed informational friction of Bernanke et al. (1999) to a state-of-the-art DSGE model, that -in the absence of financial frictions- successfully matches key features of the US economy. The baseline DSGE model is very similar to that of Christiano et al. (2005) and Smets and Wouters (2003, 2005, 2007). Their results indicate that the current strand of DSGE models is able to compete on empirical grounds with purely data driven approaches, such as (Bayesian) VAR's. The framework of Bernanke et al. (1999) has been used to investigate a variety of issues in the macroeconomic literature. Among those, Gertler et al. (2006) analyze the relevance of the financial accelerator in open economy crisis episodes. Christiano et al. (2003) incorporate financial frictions in their model to analyze the Great Depression. Christensen and Dib (2005), Meier and Müller (2006) and Queijo (2006) use the friction underlying the financial accelerator to study differences in the transmission of a number of structural shocks.

None of the above macroeconomic studies, however, investigate the implications for the external finance premium. The primary contribution of this paper lies in providing a model-consistent estimate of the external finance premium for the US economy. We compare our estimate to readily available proxies of the premium and find that it has substantial realistic content. In particular, even though the estimation uses no financial information, our estimate strongly comoves with proxies of the premium. Moreover, we also find that our estimate of the external finance premium bears close resemblance to other indicators of strain in the availability of external finance, such as credit standards (Lown and Morgan 2006). An advantage of our estimate relative to other proxies is that within our framework, fluctuations in the external finance premium can be interpreted in terms of shocks driving the economy. Existing research provides little insight into the macroeconomic factors that drive fluctuations in the premium for external finance. A second contribution of the paper is to show how embedding financial frictions alters the empirical performance of an otherwise standard DSGE model. We detail how the transmission of shocks is affected by fluctuations in the external finance premium. One feature of our model is that the cyclical properties of the premium change relative to existing research. We attribute this difference to the interaction of the financial friction with both the real frictions and the shocks in the model.

The paper is structured as follows. In Section 2 we present the log-linearized version of the model. Section 3 discusses the estimation procedure and results. The paper then focuses on the implications for the external finance premium (Section 4). Section 5 discusses the relevance of financial frictions for the overall model, for the transmission of shocks and for the cyclical properties of the external finance premium. We conclude in Section 6 and present a number of broader implications of our findings.

2 The Model

The model we propose is a version of the standard New Keynesian / New Neoclassical Synthesis model, analyzed in detail in Christiano et al. (2005) and Smets and Wouters (2003, 2005, 2007). The economy consists of households, final and intermediate goods producers, and a monetary authority. Moreover, as in Bernanke et al. (1999) and Christiano et al. (2003), we introduce a financial intermediary, capital goods producers and entrepreneurs[1]. Since these models are quite well-known, we refrain from a full-blown exposition of their first principles. To make the paper

[1] There are a number of reasons why we focus on the model of Bernanke et al. (1999), rather than alternative specifications of financial frictions. The Bernanke et al. (1999) model shares an important characteristic with the framework of Kyotaki and Moore (1997) in that asset price movements serve to enforce credit market imperfections. It is the absence of this mechanism that causes Gomes et al. (2003) to discard the Carlstrom and Fuerst (1997) framework. In particular, the countercyclical behaviour of the external finance premium this model implies is deemed to be at odds with the data. Faia and Monacelli (2005) and Walentin (2005) provide an insightful theoretical comparative analysis of the Bernanke et al. (1999) and Carlstrom and Fuerst (1997) frameworks.

self-contained, this section presents the log-linearized version of the model that we estimate. For details, we refer the reader to the original papers.

Households maximize utility by trading off current consumption with future consumption and current labour effort. Aggregate consumption[2] $\hat{C}_t$ evolves according to:

$$\begin{aligned}\hat{C}_t &= \frac{h}{1+h}\hat{C}_{t-1} + \frac{1}{1+h}E_t\hat{C}_{t+1} + \frac{\sigma_c - 1}{(1+\lambda_w)(1+h)\sigma_c}(\hat{L}_t - E_t\hat{L}_{t+1}) \\ &\quad - \frac{1-h}{(1+h)\sigma_c}\hat{R}_t + \frac{1-h}{(1+h)\sigma_c}(\hat{\varepsilon}_t^B - E_t\hat{\varepsilon}_{t+1}^B) \end{aligned} \tag{1}$$

Apart from the standard terms in future consumption and the real interest rate $\hat{R}_t$ $(= \hat{R}_t^n - E_t\hat{\pi}_{t+1})$, this particular consumption process derives from habit persistence (of the "catching-up with the Joneses" form) and non-separable utility in labour $(\hat{L}_t)$ and consumption. Consumption is more persistent for larger values of the habit parameter h. Moreover, for $\sigma_c > 1$, there exists some complementarity between labour and consumption. The final term involving $\hat{\varepsilon}_t^B$ represents a shock to the discount factor β, affecting intertemporal substitution decisions.

Households' labour supply is differentiated which, in combination with partial indexation of non-reoptimized wages, gives rise to the following linearized wage equation:

$$\begin{aligned}\hat{w}_t &= \frac{\beta}{1+\beta}E_t\hat{w}_{t+1} + \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}(E_t\hat{\pi}_{t+1} - \bar{\pi}_t) - \frac{1+\beta\gamma_w}{1+\beta}(\hat{\pi}_t - \bar{\pi}_t) + \frac{\gamma_w}{1+\beta}(\hat{\pi}_{t-1} - \bar{\pi}_t) \\ &\quad - \frac{1}{1+\beta}\frac{(1-\beta\xi_w)(1-\xi_w)}{(1+\frac{(1+\lambda_w)\sigma_l}{\lambda_w})\xi_w}\left[\hat{w}_t - \sigma_l\hat{L}_t - \frac{\sigma_c}{1-h}(\hat{C}_t - h\hat{C}_{t-1}) - \hat{\varepsilon}_t^L\right] + \eta_t^W \end{aligned} \tag{2}$$

where $\hat{w}_t$ and $\hat{\pi}_t$ denote wage and price inflation, respectively. $\bar{\pi}_t$ is the central bank's inflation objective. With (Calvo) probability $1-\xi_w$ a household gets to reoptimize its wage in period t. It does so taking into account both current and future marginal costs. The term in square brackets bears some resemblance to an error-correction term, in which the actual wage is drawn towards its flexible price counterpart. The intratemporal trade-off between consumption and work is subject to a labour supply shock $\hat{\varepsilon}_t^L$. The lagging terms in the wage equation result from the

[2] We assume a negligible role for entrepreneurial consumption, as in Christiano et al. (2003).

partial indexation assumption, parametrized through γ_w. Finally, this specification also allows for temporary deviations from the equilibrium wage mark-up λ_w, as captured by the shock η_t^W.

The firm sector consists of a continuum of monopolistically competitive intermediate goods firms. Their output is combined to produce final goods, which are sold in a perfectly competitive market. The aggregate conditions resulting from these agents' optimization are standard. Aggregate supply stems from the typical Cobb-Douglas production function augmented with fixed costs and variable capital utilization:

$$\hat{Y}_t = \phi\hat{\varepsilon}_t^A + \phi\alpha\hat{K}_{t-1} + \frac{\phi\alpha}{\psi}\hat{r}_t^k + \phi(1-\alpha)\hat{L}_t \tag{3}$$

where ϕ is one plus the share of fixed costs in production, α the capital share in the production function, and ψ represents the elasticity of the capital utilization cost function. $\hat{K}_t$ denotes capital and $\hat{r}_t^k$ its rental rate. Variation in total factor productivity is captured by $\hat{\varepsilon}_t^A$.

Labour demand increases with the rental rate of capital and decreases with that of labour:

$$\hat{L}_t = -\hat{w}_t + (1 + \frac{1}{\psi})\hat{r}_t^k + \hat{K}_{t-1} \tag{4}$$

Similar to wages, non-reoptimized prices are partially (γ_p) indexed to past inflation. Due to Calvo-signals, each period only a fraction $1-\xi_p$ of firms gets to reoptimize. The resulting inflation dynamics are captured by the following process:

$$\begin{aligned} \hat{\pi}_t - \bar{\pi}_t \quad = \quad & \frac{\beta}{1+\beta\gamma_p}(E_t\hat{\pi}_{t+1} - \bar{\pi}_t) + \frac{\gamma_p}{1+\beta\gamma_p}(\hat{\pi}_{t-1} - \bar{\pi}_t) \\ & + \frac{1}{1+\beta\gamma_p}\frac{(1-\beta\xi_p)(1-\xi_p)}{\xi_p}\left[\alpha\hat{r}_t^k + (1-\alpha)\hat{w}_t - \hat{\varepsilon}_t^A\right] + \eta_t^P \end{aligned} \tag{5}$$

In an environment of price rigidity firms will, in addition to current marginal costs (in square brackets), take into account expected future marginal costs, giving rise to the forward looking inflation term. The backward looking part follows from partial indexation. The term η_t^P represents a price mark-up shock.

As in Christiano et al. (2003), capital goods producers work in a perfectly competitive environment and face costs to changing the flow of investment. The capital stock evolves according to:

$$\hat{K}_{t+1} = (1-\tau)\hat{K}_t + \tau\hat{I}_t + \tau\hat{\varepsilon}_t^I \tag{6}$$

where τ is the depreciation rate, $\hat{I}_t$ stands for investment and $\hat{\varepsilon}_t^I$ represents a shock to the investment technology. Investment dynamics are governed by:

$$\hat{I}_t = \frac{1}{1+\beta}\hat{I}_{t-1} + \frac{\beta}{1+\beta}E_t\hat{I}_{t+1} + \frac{1/\varphi}{1+\beta}(\hat{Q}_t + \hat{\varepsilon}_t^I) \tag{7}$$

where $\hat{Q}_t$ is the real value of installed capital and φ is the investment adjustment cost parameter.

Entrepreneurs buy the capital stock K_{t+1} from capital goods producers at a given price Q_t, using both internal funds (net worth, N_{t+1}) and loans from the bank. After purchasing the capital stock entrepreneurs are hit by idiosyncratic shocks that affect each entrepreneur's capital holdings. Subsequently, they decide on capital utilization and rent out capital services to intermediate goods firms at a rate $\hat{r}_t^k$. The aggregate expected real return to capital is given by:

$$E_t\hat{R}_{t+1}^K = \frac{1-\tau}{\bar{R}^K}E_t\hat{Q}_{t+1} + \frac{\bar{r}^k}{\bar{R}^K}E_t\hat{r}_{t+1}^k - \hat{Q}_t \tag{8}$$

where $\bar{R}^K$ denotes the steady state return to capital and similarly, $\bar{r}^k$ the steady state rental rate. Thus far, the model is fairly standard and follows Smets and Wouters (2005), in particular, closely.

Following the costly state verification framework of Bernanke et al. (1999), however, entrepreneurs cannot borrow at the riskless rate. The cost of external finance differs from the risk-free rate because entrepreneurial output is unobservable from the point of view of the financial intermediary. In order to infer the realized return of the entrepreneur, the bank has to pay a (state verification) cost. The bank monitors those entrepreneurs that default, pays the cost and seizes the remaining funds. In equilibrium, entrepreneurs borrow up to the point where the expected return to capital equals the cost of external finance:

$$E_t \hat{R}_{t+1}^K = -\epsilon E_t \left[\hat{N}_{t+1} - \hat{Q}_t - \hat{K}_{t+1} \right] + \hat{R}_t \tag{9}$$

The parameter ϵ measures the elasticity of the external finance premium to variations in entrepreneurial financial health, measured by net worth relative to capital expenditures. The higher the entrepreneur's stake in the project (i.e. the higher N/QK), the lower the associated moral hazard. As shown explicitly in Bernanke et al. (1999), the premium over the risk-free rate the financial intermediary demands is a negative function of the amount of collateralized net worth. In case entrepreneurs have sufficient net worth to finance the entire capital stock, agency problems vanish, the risk-free rate and the return to capital coincide, and the model reduces to the model of Smets and Wouters (2005)[3].

Aggregate entrepreneurial net worth accumulates according to:

$$\hat{N}_{t+1} = \gamma \bar{R}^K [\frac{\bar{K}}{\bar{N}}(\hat{R}_t^K - E_{t-1}\hat{R}_t^K) + E_{t-1}\hat{R}_t^K + \hat{N}_t] \tag{10}$$

where γ is the entrepreneurial survival rate and $\frac{\bar{K}}{\bar{N}}$ is the steady state ratio of capital to net worth (or the inverse leverage ratio)[4].

[3] One difference with Smets and Wouters (2006) is the absence of an "equity premium shock" in our model. They include this shock as a non-structural proxy for fluctuations in the external finance premium. When we incorporate such a shock in the model with financial frictions, its variability is drawn to zero.

[4] We rewrite the model without the bankruptcy cost (μ) and default threshold ($\bar{\omega}$) parameters of Bernanke et al. (1999). There are a couple of reasons to do so. First, not all parameters of the contracting problem are separately identified. We therefore restrict to estimation of the more commonly analysed parameters. Moreover, it allows one to refrain from assumptions about the distribution of idiosynchratic productivity shocks, as well as its parameters. This approach avoids a number of computational difficulties, as in Meier and Müller (2005). Second, the remaining parameters can be thought of to arise in related frameworks. One particular strand of models we have in mind is that of limited enforcement (e.g. Kiyotaki and Moore 1997). Although the underlying microeconomic assumptions are entirely different, these models give rise to similar acceleration phenomena.

The standard goods market equilibrium condition is augmented with terms capturing the costs of variable capital utilization and bankruptcy[5]:

$$\hat{Y}_t = c_y \hat{C}_t + \tau k_y \hat{I}_t + \varepsilon_t^G + c_{util,t} + c_{bankrupt,t} \tag{11}$$

where c_y and k_y denote the steady state ratio of consumption and capital to output, and ε_t^G can loosely be interpreted as a government spending shock.

As in Smets and Wouters (2003) the model is closed with the following empirical monetary policy reaction function:

$$\begin{aligned} \hat{R}_t^n &= \rho \hat{R}_{t-1}^n + (1-\rho)\left\{\bar{\pi}_t + r_\pi(\hat{\pi}_t - \bar{\pi}_t) + r_Y(\hat{Y}_t - \hat{Y}_t^p)\right\} \\ &\quad + r_{\Delta\pi}(\hat{\pi}_t - \hat{\pi}_{t-1}) + r_{\Delta Y}(\hat{Y}_t - \hat{Y}_t^p - (\hat{Y}_{t-1} - \hat{Y}_{t-1}^p)) + \eta_t^R \end{aligned} \tag{12}$$

where the central bank output objective $\hat{Y}_t^p$ is the flexible price, flexible wage, frictionless credit market, equilibrium. The first two terms capture the standard Taylor rule. The terms involving first differences can be seen as the allowance for "speed limit policies", as in Walsh (2003). The reaction function also contains two monetary policy shocks. The first is a temporary interest rate shock η_t^R. The second policy shock, η_t^π, captures persistent changes in the authority's inflation target $\bar{\pi}_t$ $(= \bar{\pi}_{t-1} + \eta_t^\pi)$.

3 Estimation Results

3.1 Estimation strategy

The log-linearized version of the model is estimated using Bayesian methods. These methods use information from existing microeconometric and calibration evidence on behavioural parameters

[5] The terms $c_{util,t} = \frac{(\bar{R}^K - 1 + \tau)}{\psi k_y} \hat{r}_t^k$, and $c_{bankrupt,t} = k_y(\bar{R}^K - \bar{R})(1 - \frac{\bar{N}}{\bar{K}})(\hat{R}_t^K + \hat{Q}_{t-1} + \hat{K}_t)$ measure the costs associated with variable capital utilization and bankruptcy. Both are small under reasonable parametrizations of the model, and are therefore typically neglected (e.g. Smets and Wouters, 2005; Bernanke et al., 1999).

and update it with new information as captured by the likelihood. While estimation serves to increase the degree of dynamic fit of DSGE models it is not guaranteed to provide insight in the structural parameters of the underlying models. By contrast, purely calibration based approaches are unlikely to provide a good time-series characterization of the data relative to likelihood-based approaches. The combination of prior and sample information into a posterior distribution provides a meaningful compromise between calibration and (likelihood-based) estimation.

We use the priors of Smets and Wouters (2005) for the parameters we share with their model[6]. The first three columns of Table 1 present the prior distributions. For a thorough discussion of prior elicitation, identification and estimation methodology, we refer the reader to Smets and Wouters (2003). We discuss the priors on the financial accelerator parameters in more detail. For the steady state premium on external finance ($\bar{R}^K - R$) we use a Normal distribution with mean equal to 200 basis points, a value commonly used in calibration exercises (e.g. Bernanke et al. 1999). Its prior standard deviation is set at 80 basis points. In terms of the (quarterly) model, we assume $\bar{R}^K \sim Normal(1.0149, 0.002)$[7]. We assume flat priors for the remaining parameters pertaining to financial frictions. In particular, for ϵ, γ and $\frac{\bar{K}}{\bar{N}}$ we set Uniform priors. The standard deviations are set large enough to cover the relevant domains. We set such disperse priors on the financial accelerator parameters, since we hope the data are informative in this respect.

We estimate the model on quarterly US data from 1954:1 to 2004:4. The set of observable variables consists of real GDP, consumption, investment, wages, hours worked, prices and the

[6] With respect to the shock variances, we divert from the priors of Smets and Wouters (2005). They employ Inverse-Gamma prior distributions. When we estimate the model using their priors, the posterior distribution of one of the shocks' variance is bimodal, with one mode purely driven by the prior. Since most of the shock variances do not have clear economic interpretations, we set uniformative priors by means of the Uniform distribution.

[7] The steady state level of the risk-free interest rate is undisputed throughout current macroeconomic research. Here too, it is calibrated (or given a very strict prior) such that $R = 4\%$ annually.

short-term interest rate (Y, C, I, W, L, P, R). These variables constitute the set of observables in Smets and Wouters (2005). Nominal variables are deflated by the GDP-deflator. Aggregate real variables are expressed in per capita terms. All variables -except hours, inflation and the interest rate- are linearly detrended. The data are plotted in Figure 1.

In principle, one could estimate the model on an extended dataset. That is, since the model describes the evolution of financial variables, the estimation could try to match their behaviour as well. There are a number of reasons why we refrain from such a strategy. First, it allows to assess whether the mere allowance for financial frictions, and thus a more substantiated transmission of shocks, delivers a better description of macroeconomic dynamics. Incorporating financial variables would substantially burden any model comparisons, since the model without financial frictions is silent about their dynamics. In Section 5, the significant increase in the model's marginal likelihood relative to model without credit market imperfections suggests that the dynamics implied by financial frictions are indeed consistent with the data. Second, there is no straightforward analog between the model variables and the data. While the model assumes a simple loan contract, we interpret the consequent premium to pertain to all forms of external finance, not just bank loans. The results in Section 4 suggest that this does not seem an unreasonable approximation. Third, a particular feature of almost all financial series is that they pertain to subsets of firms (e.g. listed). This would introduce a discrepancy between those series and the economy-wide macroeconomic aggregates whose behaviour we are trying to match. Fourth, we have experimented with numerous financial variables that could proxy for net worth or the external finance premium, while introducing additional measurement error in order to capture the mismatch in firm coverage. We found that their dynamics are not necessarily consistent with those prescribed by the model (e.g. unrealistic structural parameters) or give rise to such substantial measurement error that one could doubt the use of incorporating them in the first place[8]. We therefore dispose of the inclusion of additional financial variables in the estimation procedure.

Posterior simulation is done via a random walk Metropolis-Hastings algorithm on three chains of 500000 draws. We monitor convergence in a variety of ways. Within-chain convergence is assessed following Bauwens et al. (2003). In particular, we track the standardized CUMSUM statistic and perform an equality in means test between the first and last 30% of posterior draws for each parameter. Between-chain convergence is evaluated using the statistics proposed by Brooks and Gelman (1998).

3.2 Parameter estimates

We present the financial parameter estimates in the upper part of Table 1. The estimated steady state rate of return to capital is 1.0133 on a quarterly basis. Converted to a yearly basis, this implies a premium for external finance of approximately 130 basis points. Moreover, we estimate ϵ to be substantial at 10%. The estimated value of the elasticity is very close to that of Christensen and Dib (2005). The posterior sample indicates that a value for ϵ of 5%, frequently used in calibration exercises, is plausible, yet on the low side.

The estimates of the non-financial parameters are reported in the lower part of Table 1. The table also contains the estimated parameters for the model in the absence of financial frictions. Overall, the non-financial parameters are fairly similar across both models[9]. Among the similarities, we find a considerable amount of rigidity in both wages and prices. Investment

[8] Useful proxies of the premium are typically only available for smaller, more recent samples. The external validation performed in the next section, shows that these could turn out to be informative for estimation of DSGE model parameters in longer samples.

[9] Differences between our estimates and those of e.g. Smets and Wouters (2005) arise because of differences in sample period, priors for the shock variances, detrending procedure and minor modelling differences (such as a timing difference in the Taylor rule, or the presence of capital utilization costs in the resource constraint).

adjustment costs are substantial. We also estimate a significant elasticity of the capital utilization cost function. These estimates are in the ballpark of those in the literature (e.g. Smets and Wouters, 2005). The parameters that change substantially due to the inclusion of financial frictions are those of the preference shock process and the utility function. In particular, we observe a higher risk aversion and lower habit parameter in the model with financial frictions. Both parameters serve to make the consumption process (and impulse responses) less persistent. Apparently, the inclusion of financial frictions generates sufficient internal propagation to account for such persistence. The preference shock is substantially less volatile, yet also more persistent. The estimated standard deviation of the investment specific technology shock, $\sigma(\hat{\varepsilon}_t^I)$, in the model without financial frictions lies below the highest posterior density region of the baseline model.

Several diagnostics suggest the individual chains of posterior draws converges. In particular, after a sufficiently long burn-in period, the standardized CUMSUM statistic for all parameters fluctuates around the final estimate with a relative error of below 10%. Moreover, for each parameter, a test between the mean of the first 30% (after burn-in) and last 30% of draws never rejects the hypothesis of equality. This reinforces the evidence in favour of stability of the draws. Moreover, different initializations of the chain converge to the same stationary distribution. The algorithm attains an acceptance rate of approximately 30%.

4 The External Finance Premium

One of the reasons why macroeconomic evidence on financial frictions is scarce is because one of the central variables of these theories, *viz.* the external finance premium, is unobservable. In the present section, we first estimate the model-consistent premium. As a form of external validation, we then compare our estimate with a number of observable proxies of the premium.

Finally, we interpret movements in the premium in relation to shocks driving the business cycle.

4.1 A time series of the premium

Figure 2 plots the smoothed estimate of the external finance premium implied by the model. Shaded areas denote NBER recessions. From the figure, it is evident that all of the post-war recessions are preceded by substantial increases in the premium. The premium is low relative to its steady state level during most of the seventies and eighties[10]. Following this prolonged period of relatively low external financing costs, the premium experiences a steady rise peaking prior to the early nineties recession. After this recession the external finance premium returns towards its steady state level. Starting in the middle nineties, another surge initiates, ending with the early millennium slowdown.

4.2 External validation

To what extent does this estimate of the external finance premium relate to other indicators of the premium suggested in the literature? On the one hand, there are a number of readily available series that bear on the premium for external finance. Among these are the prime spread (prime loan rate - federal funds rate) and the corporate bond spread (Baa-Aaa), which are available over a long time span. Gertler and Lown (1999) argue that in the last two decennia, the high-yield bond spread (<Bbb-Aaa) emerges as a particularly useful indicator of the external finance premium and financial conditions more generally. On the other hand, using microeconomic data on a sample of US firms, Levin et al. (2004) provide an estimate of the premium over the most recent business cycle. Table 2 and Figure 3 compare these indicators with our estimate of the

[10]The fact that the premium is occasionaly negative in the late seventies, early eighties episode follows from the dramatic rise in the Federal Funds rate, relative to which the premium is computed in the model. In the data for this episode, negative spreads can also be observed when corporate bond rates are compared to the Funds rate, rather than relative to a safe corporate bond rate.

external finance premium[11].

Consider first the prime loan and corporate bond (Baa-Aaa) spreads. Overall, the relation between our estimate of the premium and the former two series is weak. The contemporaneous correlations amount to −37% (corporate) and −4% (prime). Nevertheless, they share a number of important characteristics. For one, they all rise around the time of a recession. There is, however, a difference in timing, especially with respect to the prime spread, which lags a couple of quarters[12]. Second, the hike in the mid-sixties that was not followed by a recession is observable in all three indicators. Similarly, the substantial decrease in the premium following the 1973-75 recession is also apparent. In the late eighties, with the emergence of a market for below investment grade corporate bonds, additional indicators come to the fore. Gertler and Lown (1999) show that the high-yield spread is strongly associated with both general financial conditions and the business cycle (as predicted by the financial accelerator). Along the lines of their arguments, we believe this spread to be a more thorough indicator of the external finance premium, relative to the two proxies discussed above. In particular, the prime loan spread provides a poor indication of financing conditions of firms typically considered vulnerable to financial frictions. It focuses on firms of the highest credit quality, to which financial constraints pertain the least. The (Baa-Aaa) corporate bond spread accounts for this discrepancy to some extent, by isolating developments specific to firms that have a less solid financial status. Evidently, this argument holds *a fortiori* for the spreads of lower grade firms. Hence, lower grade spreads should

[11] To ease comparison, all indicators are standardized by subtracting the mean and dividing by the standard deviation.

[12] The lagging character of the prime spread is noticeable over the entire sample. In Table 2 the correlation increases with lags of the premium (to 8% at a four quarter horizon), confirming the loan spread's lagging behaviour. The sluggish response of retail bank interest rates has spurred a vast amount of independent research (see e.g. De Graeve et al., 2007, and the references therein). Moreover, starting in 1994, the prime spread ceases to be a useful indicator of fluctuations in the external finance premium. From then onwards the prime loan rate is set as the federal funds rate plus 3 percent.

be especially informative with respect to the external finance premium. As shown in Table 2 and Figure 3, our estimate of the external finance premium is more closely related to both the Bbb-Aaa and the high-yield spread. Although our estimate misses most of the high frequency movements in these spreads, the longer frequencies have more aligned patterns. Table 2 shows that the correlation of our estimate with the Bbb-Aaa spread is 76% and amounts to as much as 85% with the high-yield spread, which lags movements in our estimate considerably.

From the perspective of credit spreads, Table 2 has the following implications. First, the high correlation with our estimate of the premium suggests that much of the movement in credit spreads is related to macroeconomic fluctuations. The model can be used to understand where aggregate fluctuations in credit spreads originate. Section 4.3 pursues this route by means of variance and historical decompositions. Second, the fact that our estimate is leading with respect to high-yield spreads indicates the model could also be useful in forecasting their aggregate component.

We also compare our estimate of the external finance premium with the one obtained by Levin et al. (2004). They estimate the premium on the basis of micro data by exploiting the microeconomic friction underlying the model of Bernanke et al. (1999). As in the case of the high-yield spread, its behaviour and relation to our estimate of the premium are similar. In particular, the correlation between the two spreads is again positive, with our estimate leading. Admittedly, due to the limited overlap in sample period this observation should be treated with caution. However, given the enormous difference in empirical approach, as well as the fact that our estimate uses no financial market information, the similarity is comforting.

Finally, Table 2 and Figure 3 compare our estimate of the premium with two substantially different types of series, *viz.* non-interest rate series. First, we consider the change in credit standards, which measures the net percent of loan officers reporting tightened credit standards[13].

[13] This measure is based on the Federal Reserve's Senior Loan Officer Opinion Survey.

Although a survey of changes in credit standards provides little quantitative evidence on premia that firms need to pay for external finance, it provides a clear indication of the strain that firms face in attaining external funds (Lown and Morgan, 2006)[14]. A post-1990 comparison between the external finance premium and the credit standards again reveals a high level of comovement. In particular, the correlation is about 70%.[15] Figure 3 shows that high frequency movements aside, both series convey very similar information. Second, we consider the debt-to-GDP ratio. Here, too, long frequency movements are very much aligned. While the correlation does not exceed 61%, Figure 3 shows that, the late seventies aside, the debt-to-gdp ratio and our estimate of the premium have very similar cycles.

In sum, our estimate of the premium for external finance seems to have substantial realistic content, even though the model estimation incorporates no information about the evolution of financial variables. Moreover, our estimate of the external finance premium is closely related to readily available proxies of the premium and other indicators of strain on corporations' access to external finance. Using macroeconomic data we establish roughly the same behaviour of the external finance premium as Levin et al. (2004), who estimate firm-level premia. Due to the span of the data in the present analysis, however, we are able to generalize these properties

[14]Note that the credit standards pertain to non-price terms. Lown and Morgan (2006) interpret it as a summary measure that can provide information about the availability of credit. The Bernanke et al. (1999) model essentially excludes credit rationing equilibria. As a result, if rationing were important over the sample, the model would absorb this by a rise in the premium. Disentangling movements between price and non-price terms is beyond the scope of this paper.

[15]In the second half of the eighties, the survey was not conducted. Prior to this period the comovement with the premium is also apparent, yet to a lesser extent. One possible reason is that in the first decades the survey was contaminated by a number of biases. One of these is that in the early years almost no contractions in credit standards were reported (see Lown et al., 2000). This could explain the widening gap in the second half of the seventies. That notwithstanding, within the pre-1984 period, the two series exhibit a number of similar peaks and troughs, as well as correlations above 40%.

over a more comprehensive set of economic cycles. Additionally, by estimating the premium on the basis of macroeconomic data, it should cover the entirety of US firms. By contrast, other indicators typically pertain to a specific subset of firms[16]. An interesting byproduct of our approach follows from distilling the premium out of a full-fledged DSGE model. Hence, one can interpret movements in the premium in relation to structural shocks driving the economy, as the next section illustrates.

4.3 Decomposing the premium

Table 3 and Figures 4 and 5 provide variance and historical decompositions of the external finance premium and GDP. Such decompositions provide insight into the manner in which the model interprets movements of the premium and the business cycle.

First, it seems that investment supply shocks are the primary source of fluctuations in the premium. In the short run they account for about two-thirds of the forecast error variance of the premium. At longer horizons, this percentage increases to over 90%. The historical decomposition of the premium in Figure 4 confirms that investment supply shocks are responsible for the bulk of variations in the external finance premium. The graph traces the low frequency component of the premium very closely. Not only for the premium, but also for the business cycle the role of investment supply shocks is substantial. We find that the contribution of these shocks to GDP ranges from a lower bound of 14% (at long horizon) to an upper bound of 37% (immediate). This is in line with the findings of Greenwood et al. (2000). They attribute up to 30% of business cycle fluctuations to these shocks. Moreover, the substantial increases in the premium due to ε^I in the second half of the sample (Figure 4) are consistent with the increased role of technological

[16] This economy-wide coverage can rationalize a number of observations related to the model. First, by means of the law of large numbers, it is consistent with our estimate of the premium not sharing high-frequency movements observed in indicators for subsets of firms. Second, this wide coverage possibly generates the wide range of the highest posterior density region of the steady state cost of external finance, $\bar{R}^K$.

investment since the mid-seventies (Greenwood and Yorukoglu, 1997).

Second, monetary policy shocks also cause a great deal of movements in the premium. Table 3 shows that the inflation objective (η^{π}) and monetary policy (η^{R}) shock jointly account for up to 25% of the short run fluctuations of the premium.

Historical contributions, shown in Figures 4 and 5, also shed light on the properties of the model and the external finance premium. For instance, the economic expansion in the second half of the nineties is mostly driven by investment specific technological progress and a favourable stance of monetary policy. During the same episode, the investment supply shock was the main factor in driving the external finance premium up to its peak prior to the 2001 recession. Going back further in time, monetary policy played a major role in the two early eighties' recessions. The model attributes both the fall in GDP and the rise in the premium to restrictive monetary policy shocks.

Finally, we also find a small, yet significant contribution of preference shocks ($3 - 10\%$) to the short horizon variance decomposition of the premium. Another minor portion (6% on average) of the high frequency movements in the premium is generated by labour supply shocks. Productivity, government spending as well as both mark-up shocks have only minor effects on the premium. The price and wage mark-up shocks also have a small effect on output fluctuations. The government spending shock, by contrast, generates most of the short horizon and a substantial part of the long horizon forecast error variance of GDP.

5 Financial frictions and the macroeconomy

The previous section highlighted that a DSGE model with financial frictions can generate plausible implications for the external finance premium. This section assesses the contribution of financial frictions to macroeconomic fluctuations more generally. We first measure the model's statistical performance relative to a more standard New Keynesian DSGE model without financial market imperfections and to a reduced form VAR. Next, we document the contribution of financial frictions to the transmission of shocks. Finally, we discuss the cyclical behaviour of the external finance premium in the model.

5.1 Comparing fit across models

In order to assess statistical model performance, we first compute marginal densities and root mean squared errors (RMSE) for three different models. In particular, Table 4 compares the performance of the DSGE model with financial frictions to the DSGE model without financial frictions, as well as with a reduced form VAR(1)[17].

This comparison suggests the model with the financial accelerator performs best in matching the dynamic behaviour of (Y, C, I, W, L, P, R). In particular, both DSGE models clearly outperform the VAR, as witnessed by the substantial reduction in RMSE for all variables. The marginal likelihood of the VAR is also substantially lower than that of both DSGE models. Turning to the DSGE models we observe a better overall performance when the model incorporates financial frictions, as indicated by the marginal likelihood. Table 4 shows that for the RMSE the picture is mixed, with relative gains at some horizons and losses at others for consumption, interest rates and inflation. Nevertheless, in overall terms, the model with financial frictions seems to forecast better. For investment, GDP, wages and hours worked the model with financial frictions performs best at all forecast horizons.

To pinpoint more precisely which variables are better captured by incorporating financial frictions, Figure 6 compares empirical cross-correlations between the observable data series with those implied by the two estimated DSGE models[18]. Perhaps not surprisingly, the largest dif-

[17] A one period lag length is optimal both in terms of data density and RMSE.

[18] The cross-correlation functions are calculated based on VAR's estimated on 100000 simulated datasamples (see e.g. Smets and Wouters 2003).

ference between the model with financial friction and the one without relates to investment dynamics. The autocorrelation and cross-correlation patterns of investment seem to be better captured by the model with financial frictions. The confidence bands for the baseline model always contain the empirical correlations, which is not the case for the model without financial frictions. A second difference suggests that incorporating financial frictions may also come at a cost. The correlations of consumption with wages and labour become borderline when the model incorporates financial frictions. The substantial width of the bands for the model without financial frictions, however, should caution for drawing too sharp inference in this respect. At the least, the overall increase in marginal likelihood suggests the gain in fitting the dynamics of investment is much larger than the latter cost. For the remaining correlations, incorporating financial frictions does not seem to affect the DSGE model's properties significantly.

In sum, financial frictions help the DSGE model in the overall description of macroeconomic data. The largest gain is obtained in capturing investment dynamics. Christensen and Dib (2005) and Queijo (2006) also favour model specifications that incorporate financial frictions. Meier and Müller (2006), by contrast, find the financial accelerator to contribute only marginally to describing the effects of monetary policy shocks. Since the latter study matches a conditional moment of the data (i.c. the response to a monetary policy shock) and the former unconditional moments, our result that monetary policy shocks are not the predominant source of fluctuations in the external finance premium can reconcile the two seemingly opposing results.

5.2 Comparing transmission across models

To better appreciate the contribution of financial frictions to the DSGE model, we here study the transmission of shocks more deeply. Figures 7 through 10 plot impulse responses to a variety of structural shocks for three different models. The first model considered is the baseline model with financial frictions. The second model is the same as the first, but in which the financial transmission channel is shut down. Impulse responses for this model are computed at the estimated values of the baseline model under the additional restriction that $\epsilon = 0$ and $R^K = \frac{1}{\beta}$.[19]. The third model is a model in which there are no financial frictions, and is estimated under that assumption. This model corresponds to the DSGE model without financial frictions of the previous section.

Figure 7 shows the response to a preference shock in the three models. The responses of asset prices, consumption and output are largely similar for each model. The major difference is observed in the responses of net worth, the external finance premium and investment. In particular, the fall in asset prices reduces net worth in the baseline model, and thereby raises the premium. As a result, the drop in investment is much larger relative to both models without financial frictions, in which the premium is zero. This response is the prototype effect of the financial accelerator documented by Bernanke et al. (1999).

Next, Figure 8 plots the response to a temporary monetary policy impulse. Similar to VAR-type responses, investment, consumption and output all rise. In the baseline model this is accompanied by a low premium for external finance. At the peak, the investment response is amplified relative to the model where the financial channel is shut off. This is again the mechanism documented by Bernanke et al. (1999). Different from the latter is that the baseline investment response is no longer uniformly stronger than the response in the model with financial frictions shut down. The figure reveals that investment peaks earlier in the model with financial frictions, relative to the same model with the financial channel shut down. This result differs from Bernanke et al. (1999) and other existing research (e.g. Walentin 2005, Meier and Müller 2005, Christensen and Dib 2005, Queijo 2006). It turns out that one of the real frictions, in

[19] Conditional on credit frictions being absent, the values of γ and $\frac{\bar{K}}{\bar{N}}$ are irrelevant. In this case, they only contribute to the evolution of net worth, which is then immaterial. Moreover, the latter ratio is, by the Modigliani-Miller theorem, indeterminate. The figures therefore contain no response for both net worth and the premium.

particular *investment* adjustment costs, is at the root of this difference. The above literature invariably works with *capital* adjustment costs.

In general, investment adjustment costs make it optimal to postpone the investment peak for some time. As a result, DSGE models can mimick the gradual, hump-shaped response of investment to a monetary impulse found in the data (see Christiano et al. 2005). The financial friction of Bernanke et al. (1999) provides no alternative mechanism for such a response. However, the two frictions do interact. In particular, the fall in the external finance premium -which lasts only so long- induces investment to peak sooner relative to the model without financial frictions. Part of the increased cost of raising the flow of investment is compensated by the low cost of external finance.

Put differently, because changing the flow of investment is costly, temporary fluctuations in the external finance premium will have less impact on the economy, relative to a model with capital adjustment costs. To that extent, investment adjustment costs serve as a substitute for the financial friction. However, it should be clear from the increase in model performance due to the inclusion of financial frictions that there is a role for them in addition to investment adjustment costs.

Next, consider the response to investment supply shocks in Figure 9. In the standard model without financial frictions, the innovation in the investment technology serves to increase investment, while lowering the price of capital (hence the term investment *supply* shock). This holds irrespective of whether the model is re-estimated or not. A similar response is also observed for the model with financial frictions. However, the fall in asset prices now also reduces net worth, thereby increasing entrepreneurial borrowing needs. The resulting rise in the cost of external finance dissuades investment *relative to the case without financial frictions*.[20]

[20] After a number of periods, the response of investment to an investment supply shock becomes negative. This pattern is similar to the credit cycles of Kyotaki and Moore (1997) and is also found in Greenwood et al. (2000).

Finally, consider the effects of productivity shocks, shown in Figure 10. The most remarkable difference in responses among all models is that of investment, which is substantially lower in the model with financial frictions. This constrasts sharply with results in Bernanke et al. (1999) or Walentin (2005), in which favourable productivity shocks reduce the premium and therefore boost investment relative to a model without financial frictions. Once more, the primary reason for the different responses lies in the form of adjustment costs.

Investment adjustment costs make the investment decision a dynamic one, contrary to the case of capital adjustment costs. If investment is positive today, it will be positive for a prolonged period, in order to minimize costs associated with changing its flow. In case of the productivity shock, investment that is high for a long time, implies that the capital stock outgrows net worth, thereby increasing borrowing needs. The result is an increase in the external finance premium. Because long lasting positive investment will be costly due to a high *future* premium for external finance, investment will be lower in all periods, including current ones where the premium is low. The similar investment response in both models without financial frictions shows that the rise in the premium is the source of this change. The lower response of investment in the model with financial frictions is compensated by a larger consumption response, resulting in not too different output responses over the different models.

5.3 The cyclical behaviour of the external finance premium

A final noteworthy feature of the model is that the premium is not necessarily countercyclical. This finding contrasts with earlier studies of the Bernanke et al. (1999) model, such as Walentin (2005). The latter finds a countercyclical external finance premium, both conditionally and

The reason is that the substantial fall in the price of capital (or rise in relative efficiency of investment) advances the optimal timing of investment. That is, investment takes place when capital and productivity gains are highest, which is directly after the shock hits the economy.

unconditionally. The impulse responses provided above help to understand the source of this difference in cyclicality.

For the monetary policy shock, the impulse responses are qualitatively similar to those of Bernanke et al. (1999): an exogenous rise in the interest rate lowers asset prices and net worth. Since firms are leveraged, net worth falls more than asset prices and firms' borrowing needs ($BN = \hat{Q} + \hat{K} - \hat{N}$) increase. Because the stake of the entrepreneur in the project is now relatively low, the premium required by the financial intermediary rises, thus depressing investment and ultimately output. As a result the premium is countercyclical conditional on a monetary policy shock. Moreover, because of additional real and nominal frictions relative to Bernanke et al. (1999) the model produces hump shaped responses for the real variables. As a result, the leading character of the premium relative to the business cycle arises naturally in the model: while output responds relatively slowly due to real (and nominal) frictions, the premium reacts instantaneously to shocks hitting the economy.

For the investment supply shock, the previous section already documented how the rise in investment is not as strong in the model with financial frictions. Note, however, that the positive effect of the shock on investment is not overturned by the increase in the premium. As a result, both investment and the premium rise. These impulse responses explain economic expansions in the wake of increases in the external finance premium or, in other words, the possibility of a procyclical premium.

There are a number of additional reasons why the cyclical behaviour of the premium in the present model is not clear cut a priori. First note that, on impact, all shocks induce an opposite movement between investment and the external finance premium (except ε^I, which exogenously raises investment and simultaneously raises the premium, see above). Shocks that increase asset prices, reduce borrowing needs and therefore the premium. Holding everything else constant, investment will rise in order to equalize the cost of external finance and the return to capital.

This is the mechanism documented by Walentin (2005) and works for a countercyclical premium.

Second, as time passes the capital stock grows and capital gains vanish. However, it is not necessary in the model for borrowing needs to immediately revert to their mean. The response of the external finance premium (a function of $\hat{N}$, $\hat{Q}$ and $\hat{K}$) depends on the estimated financial parameters as well as the other frictions in the model. While the financial parameters determine the persistence of net worth ($\hat{N}$), the other frictions in the model influence, among other things, the responses of the capital stock and its price ($\hat{K}$ and $\hat{Q}$). Hence, the relative response of QK versus N and thereby the cyclicality of the premium is affected by the types of real and nominal frictions present in the model. The previous section documented, for instance, the crucial role of adjustment costs.

A third and more obvious reason why GDP and the premium do not always move in opposite directions is the presence of other shocks. In particular, a number of shocks generate output effects via channels other than investment. In the present model, for instance, the government spending shock plays virtually no role in the variance decomposition of the premium while affecting GDP substantially (Table 3). In the data, where all shocks operate simultaneously, the negligible effect of ε^G on the external finance premium can be easily offset by any other shock. At the same time, this other shock may find it hard to counter the output effect of the government spending shock. The role of other shocks in the cyclicality in the premium can also be inferred from related studies. In Christensen and Dib (2005), the preference shock boosts consumption more than it crowds out investment, implying a conditionally procyclical external finance premium. Related, Faia and Monacelli (2007) and Meeks (2007) have introduced additional stochastics within the framework of Carlstrom and Fuerst (1997) that alter the cyclical behaviour of the premium.

6 Conclusion

The main objective of this paper lies in providing an estimate of the external finance premium. Existing research has tackled the unobservability of the premium in two ways. On the one hand, the literature has suggested indicators from financial markets, such as corporate bond spreads, to study fluctuations in the external finance premium. On the other hand, combining corporate bond and balance sheet data with a micro model of financial frictions, Levin et al. (2004) provide an estimate of the premium for a sample of US firms.

Our approach infers the external finance premium from a DSGE model estimated on US macroeconomic data. The estimate provides insight into historical fluctuations of the external finance premium. Distilling the premium from a full-fledged DSGE model allows to interpret these fluctuations in terms of shocks driving business cycles.

The estimated average post-WWII premium for external finance is 130 basis points. We find substantial variation in the premium. In particular, the premium typically rises prior to a recession. The sources of these fluctuations can be mainly attributed to the effects of investment-specific technological progress and monetary policy shocks. Overall, we find strong comovement with high-yield corporate bond spreads, existing micro estimates and non-price indicators of financial strain in the corporate sector. More specifically, the model seems to capture lower frequency movements in these indicators particularly well.

The analysis also shows that there may be interactions between the various types of shocks and frictions in the model. In particular, concerning the transmission of shocks, we find that incorporating the financial friction of Bernanke et al. (1999) in a model with investment adjustment costs may give rise to a financial "decelerator", conditional on some shocks. This differs from models which assume capital adjustment costs and invariably generate a financial accelerator mechanism, irrespective of the shock considered. In addition, the paper highlights how this feature may affect the cyclicality of the external finance premium.

Our results have a number of broader implications: First, the estimate of the external finance premium is derived from pure macro data and the internal restrictions of the DSGE model, with no use of financial information whatsoever. The consequent surprisingly high degree of realism that the estimated external finance premium displays, suggests that DSGE models could go a long way in capturing financial phenomena. Second, the relative importance of the various structural shocks in explaining fluctuations in the premium, provides a framework for thinking about ways to improve micro models that aim to capture corporate bond spreads. In particular, firm-specific corporate credit spread changes are notoriously difficult to explain. Collin-Dufresne et al. (2001) attribute around 75% of these changes to a common, yet unknown factor. The strong commonalities between average credit spreads and our estimate of the premium, suggest that a significant portion of that unknown component can be traced back to structural economic shocks driving business cycles.

Acknowledgement

I would like to thank two anonymous referees, John Duca, Viktoria Hnatkovska, Gert Peersman, Frank Schorfheide, Rudi Vander Vennet, Raf Wouters, seminar participants at the Federal Reserve Bank of Dallas and the National Bank of Belgium as well as participants at the 2006 meetings of the Financial Management Association (Stockholm, PhD Paper Award), Computational Economics and Finance (Limassol), European Economic Association (Vienna), Money, Macro and Finance Group (York) and the Dynare-conference (Paris) for stimulating comments and insightful discussions. Fabio Natalucci kindly provided some data.

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Figure 1: Data

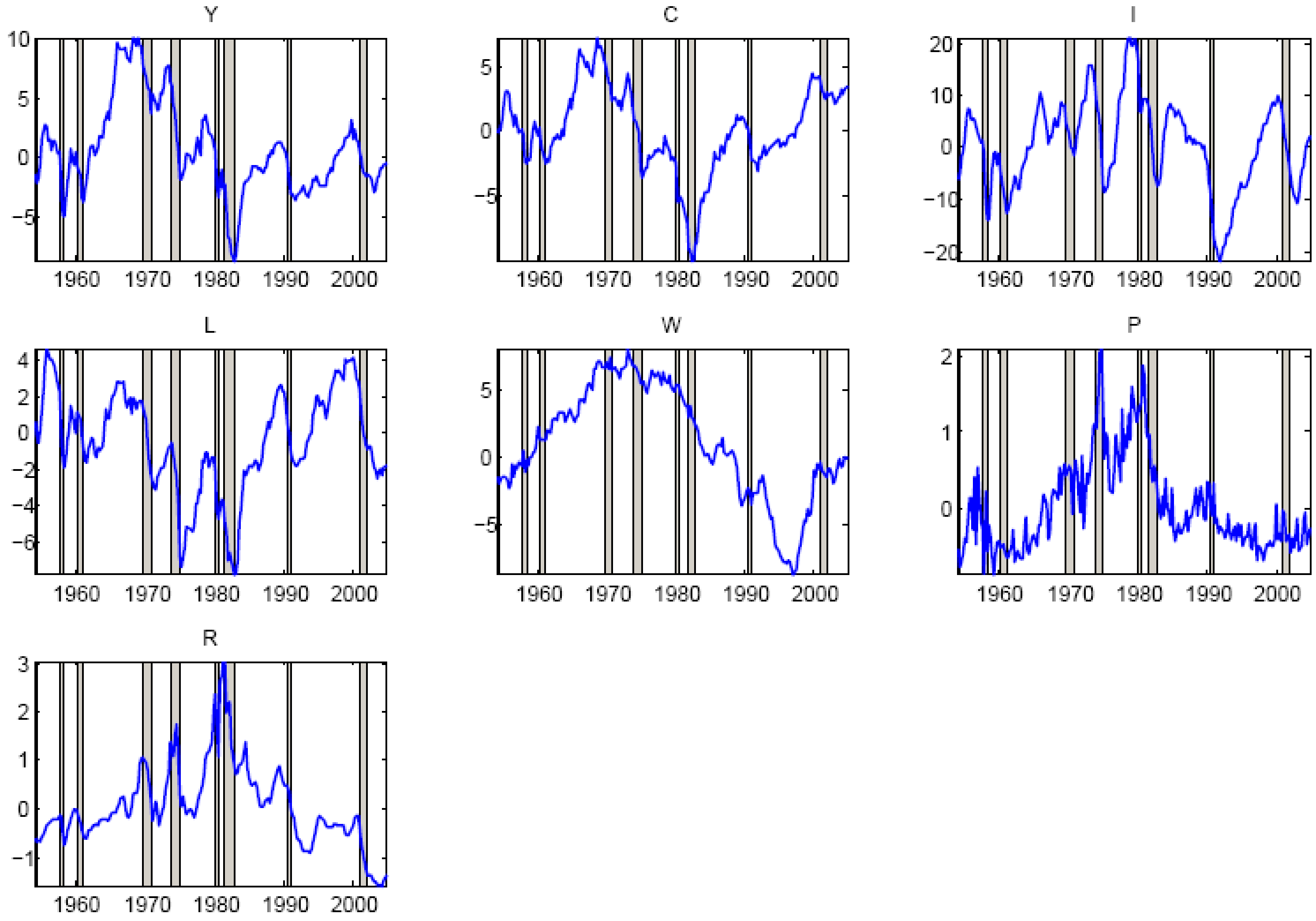

Figure 2: The External Finance Premium

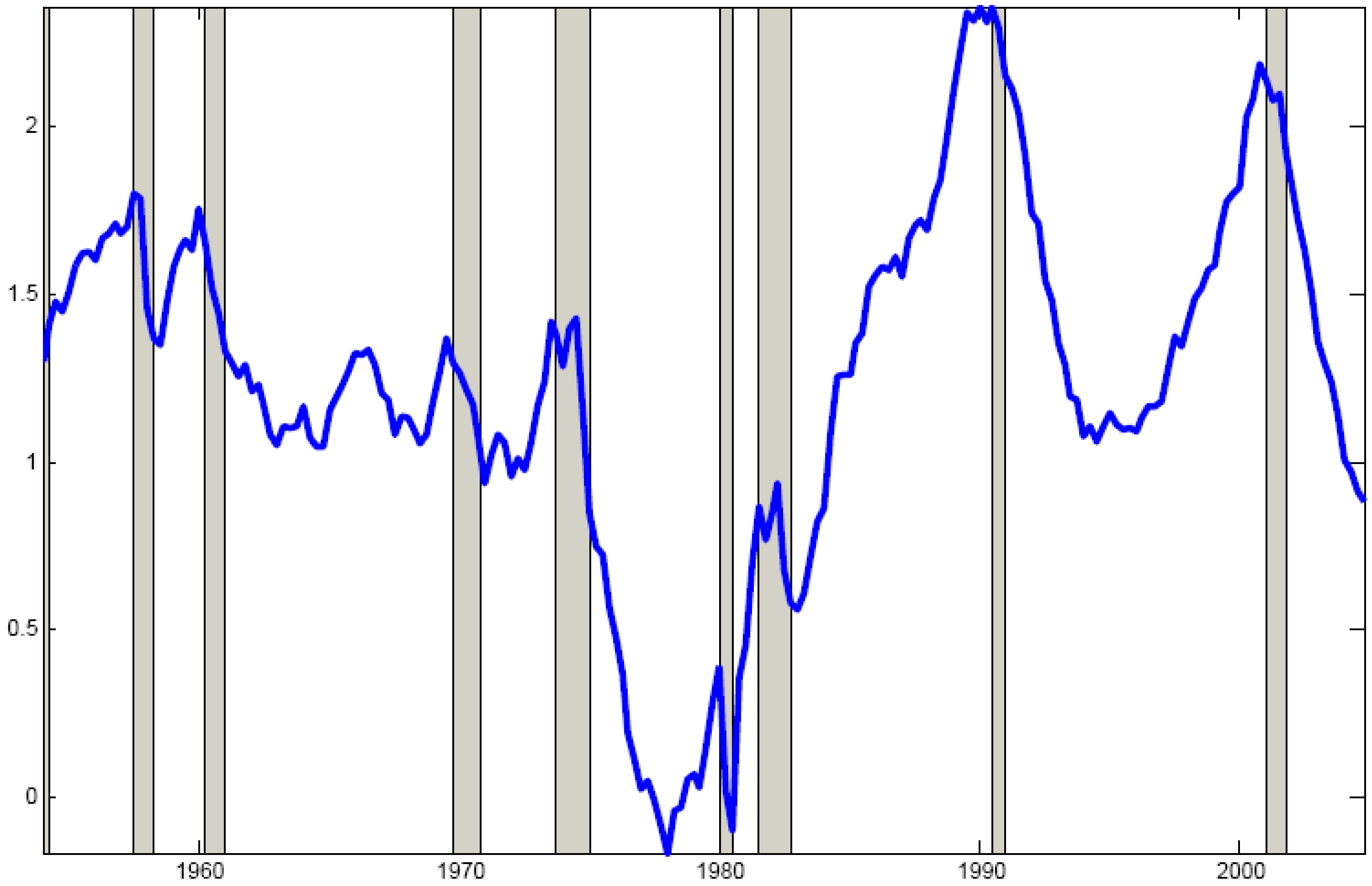

Figure 3: The External Finance Premium (solid line) and Alternative Indicators (+)

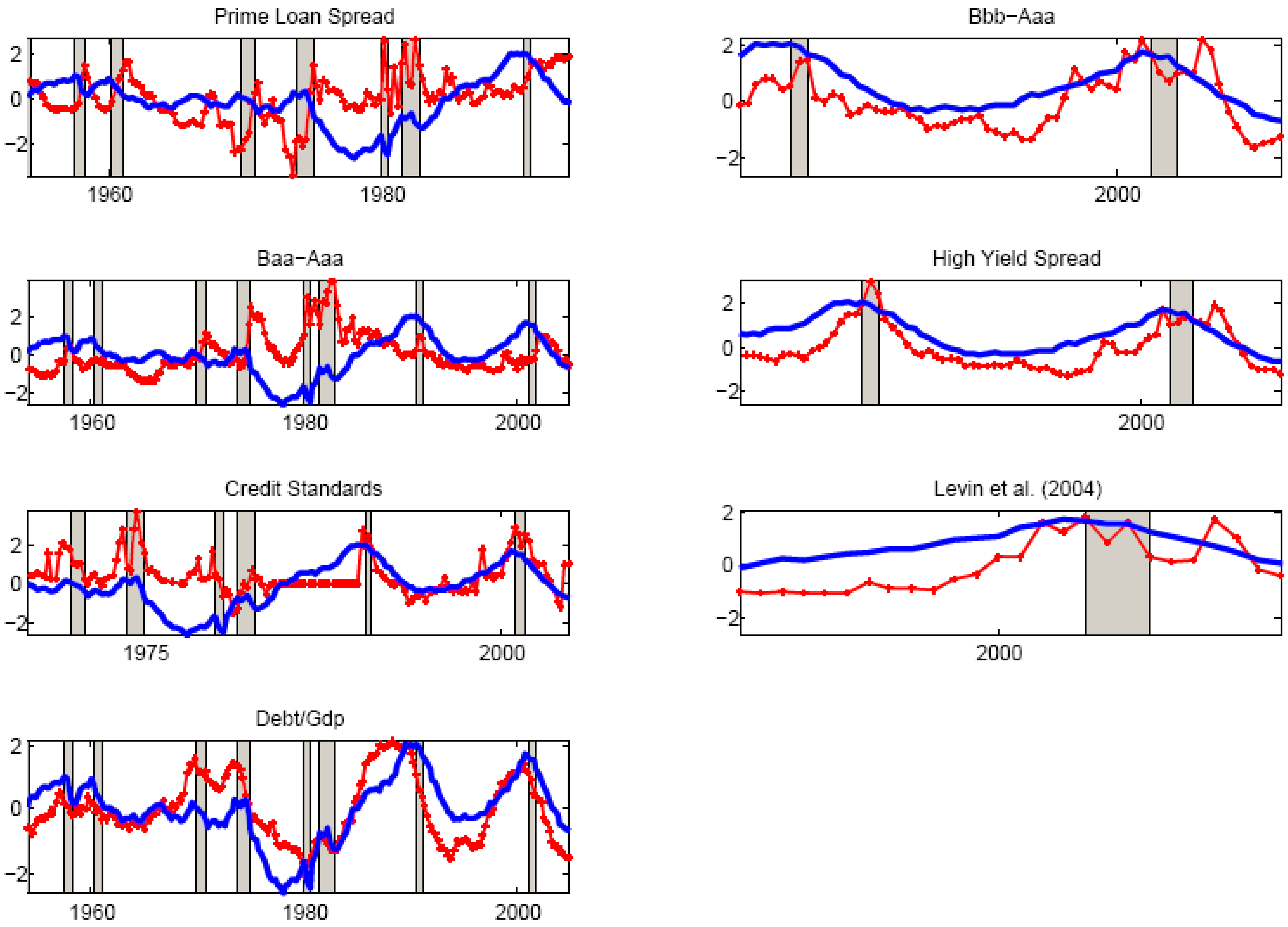

Figure 4: Historical Contributions to External Finance Premium (90% probability bands)

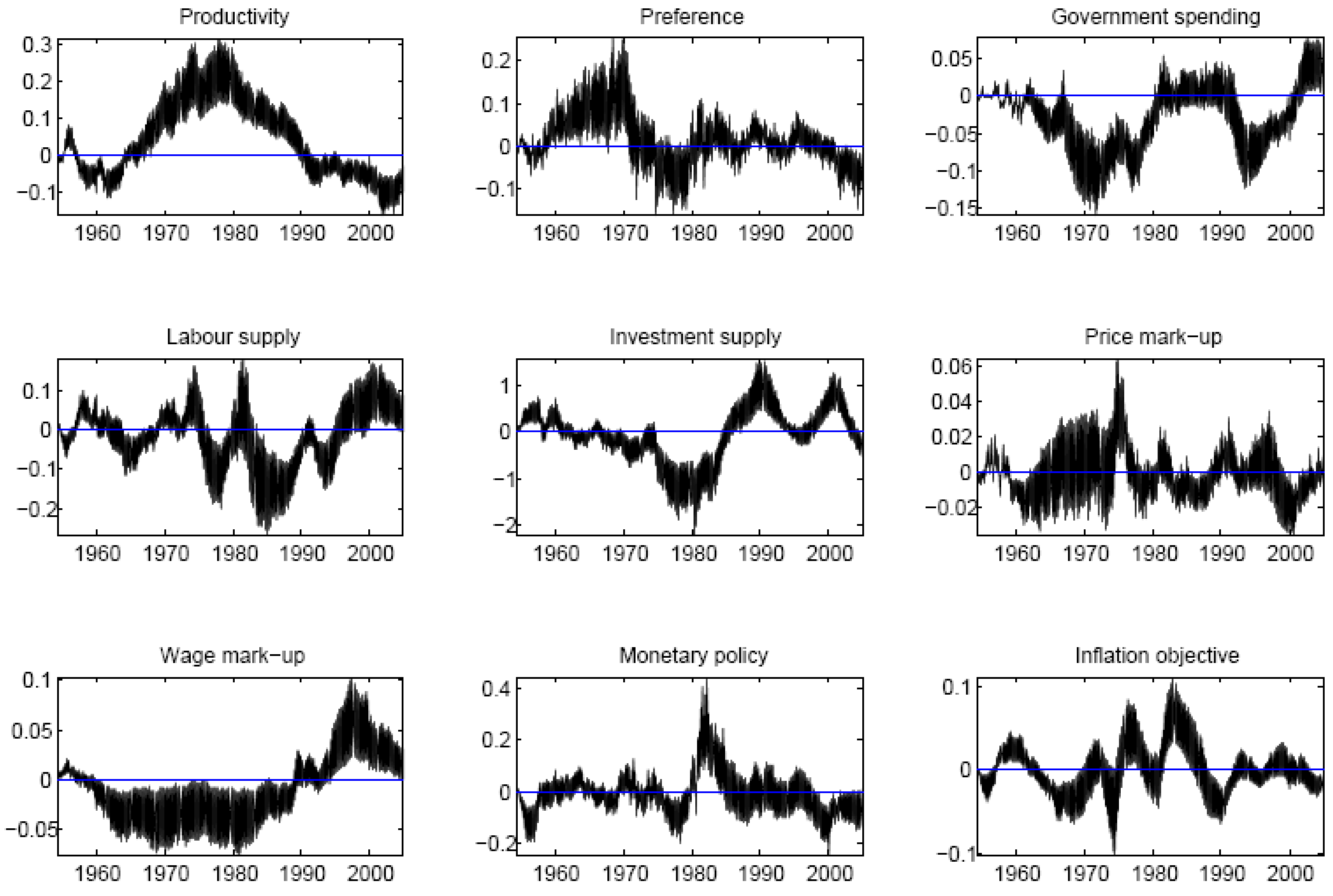

Figure 5: Historical Contributions to GDP (90% probability bands)

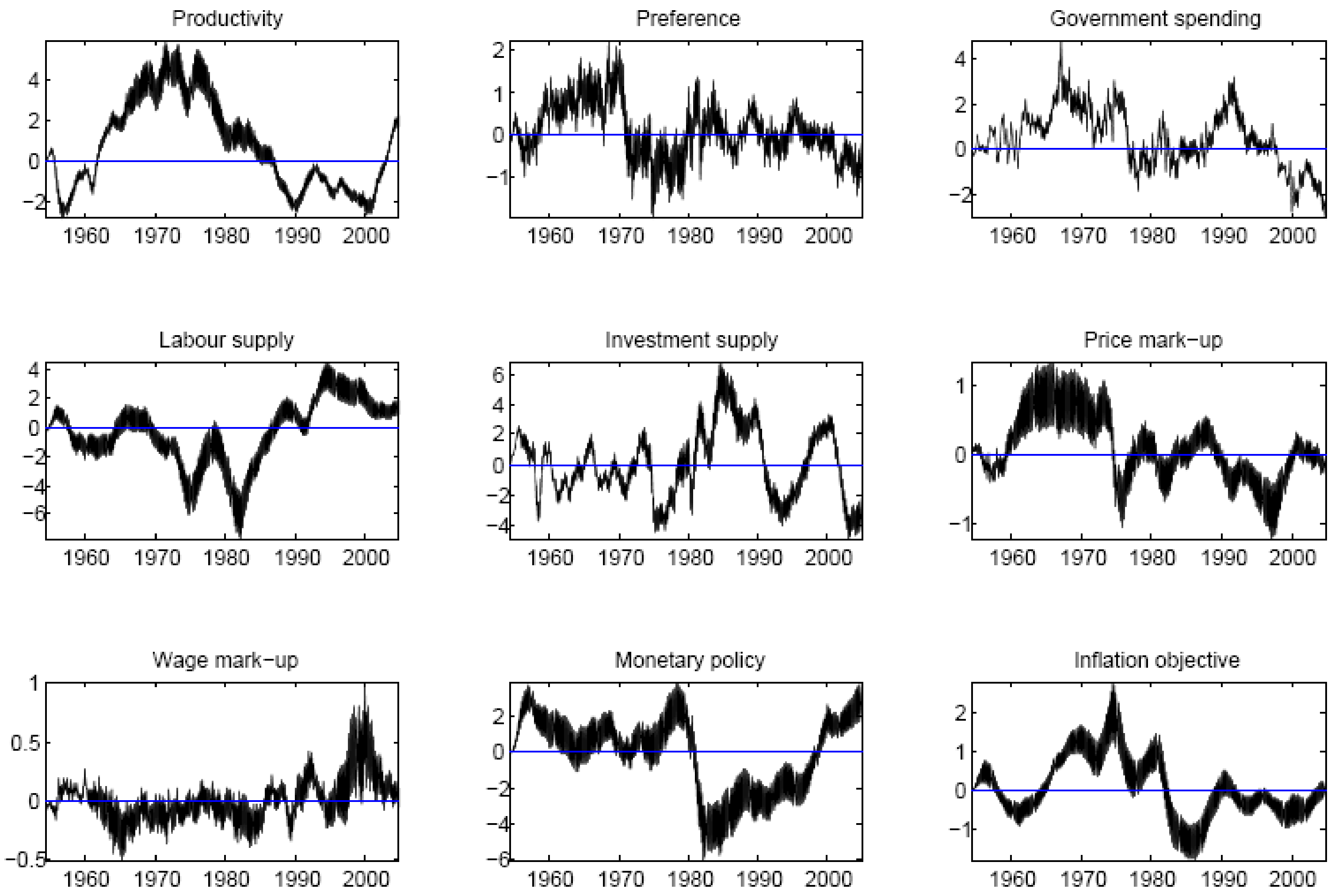

Figure 6: Cross-correlations: Data (x), Baseline (solid, 90% band), DSGE estimated without financial friction (--, 90% band).

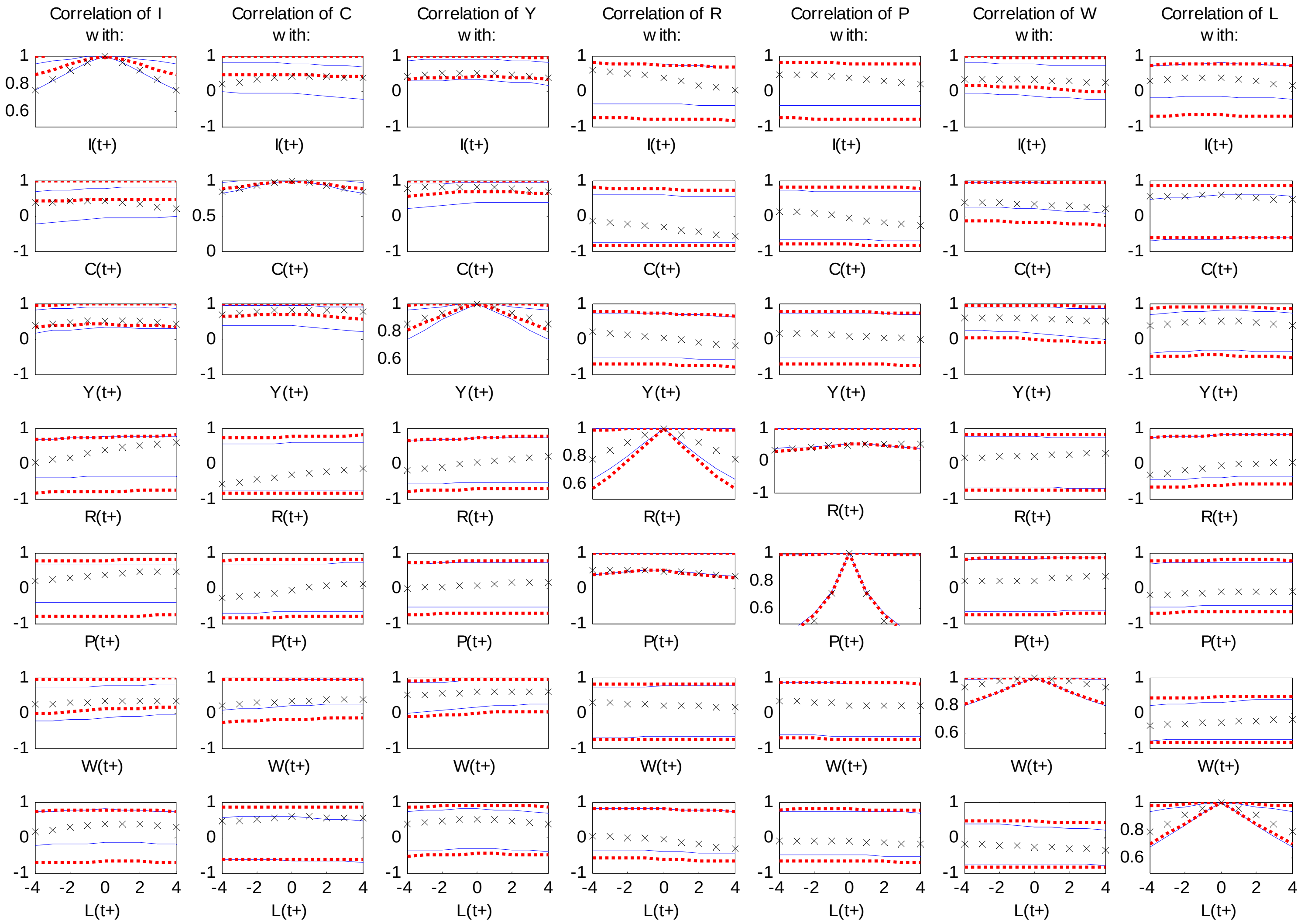

Figure 7: Preference Shock IRF: Baseline (solid), Baseline without financial friction (o), DSGE estimated without financial friction (--).

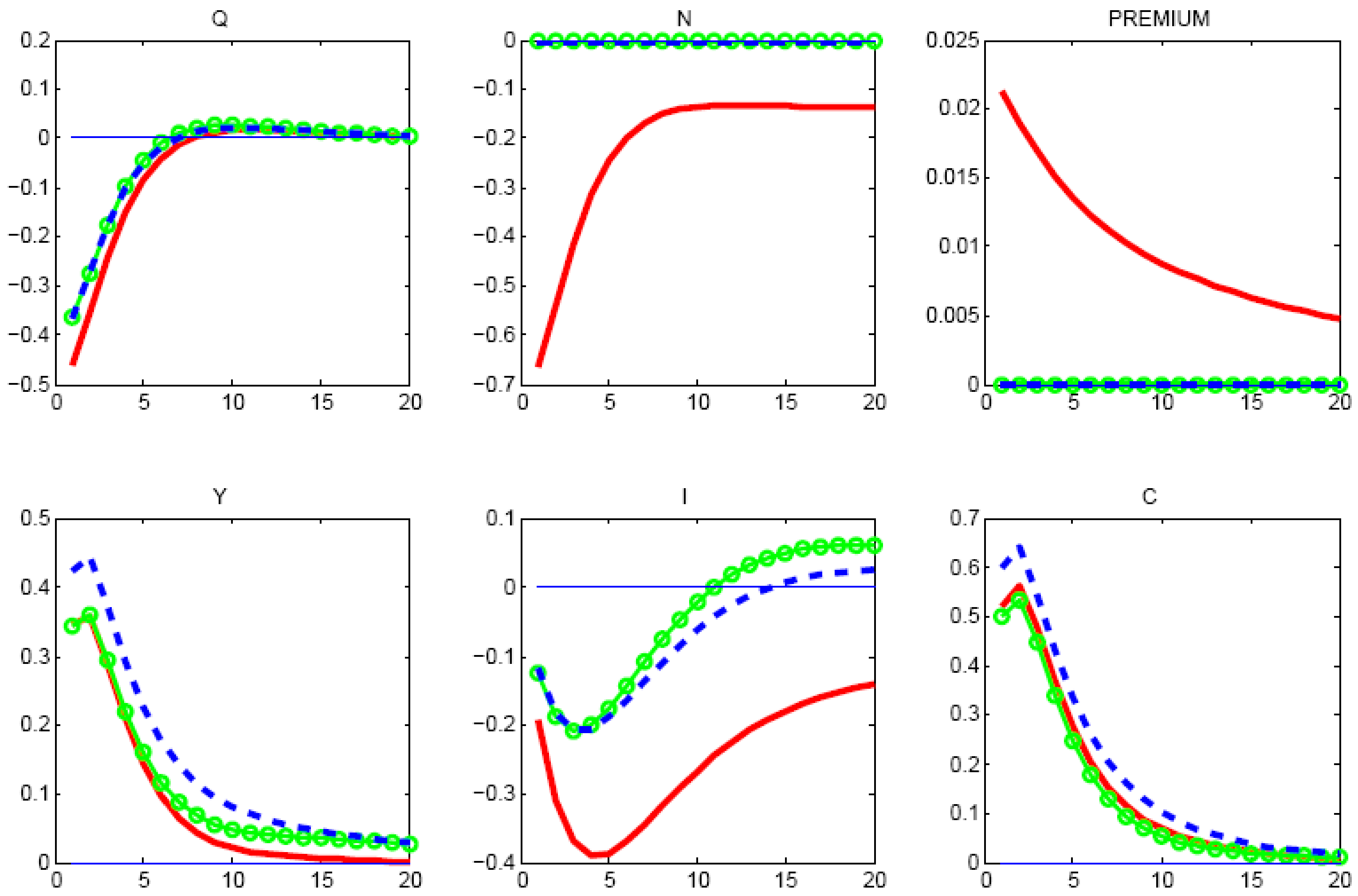

Figure 8: Monetary Policy Shock IRF: Baseline (solid), Baseline without financial friction (o), DSGE estimated without financial friction (--).

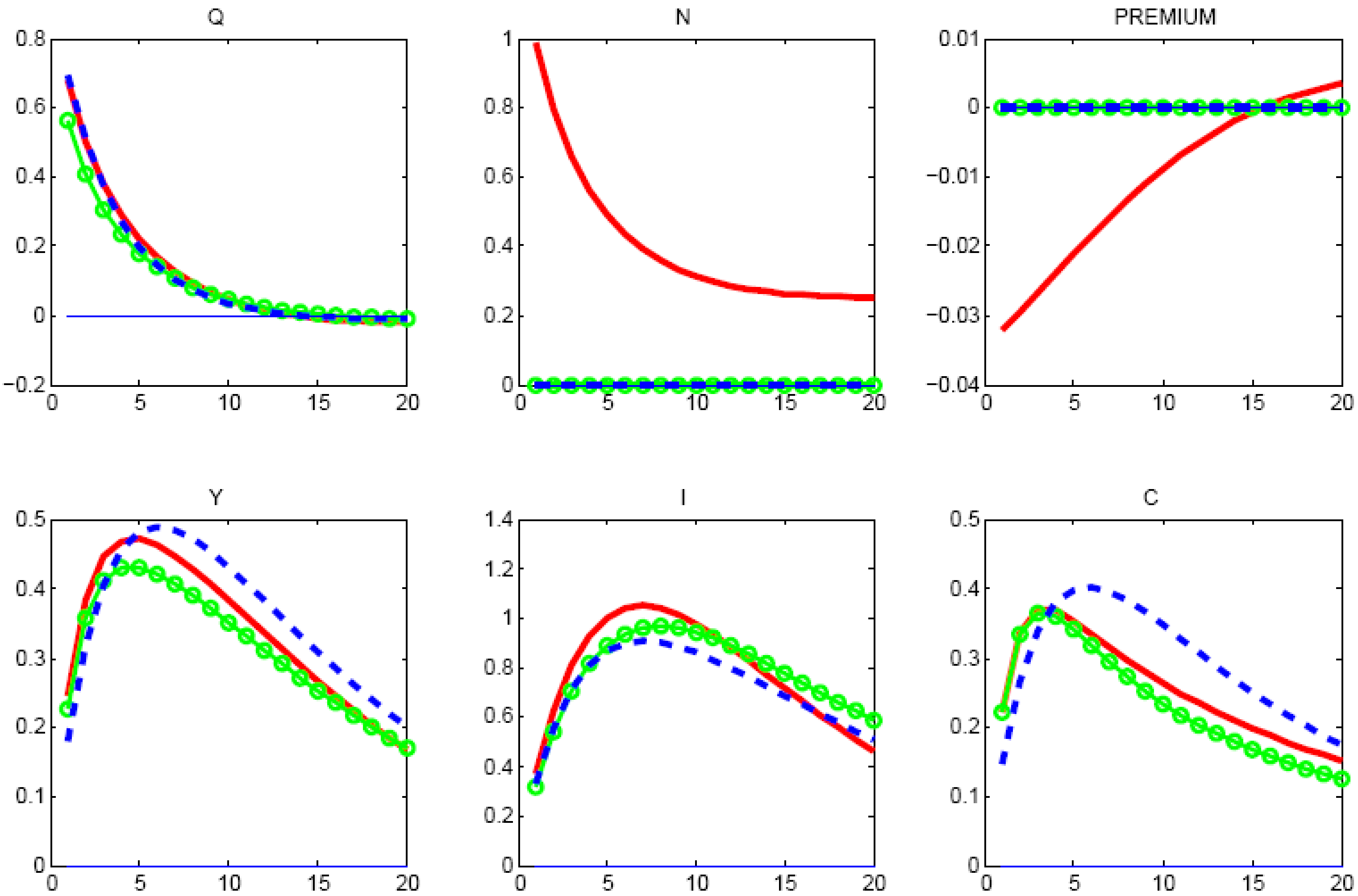

Figure 9: Investment Supply Shock IRF: Baseline (solid), Baseline without financial friction (o), DSGE estimated without financial friction (--).

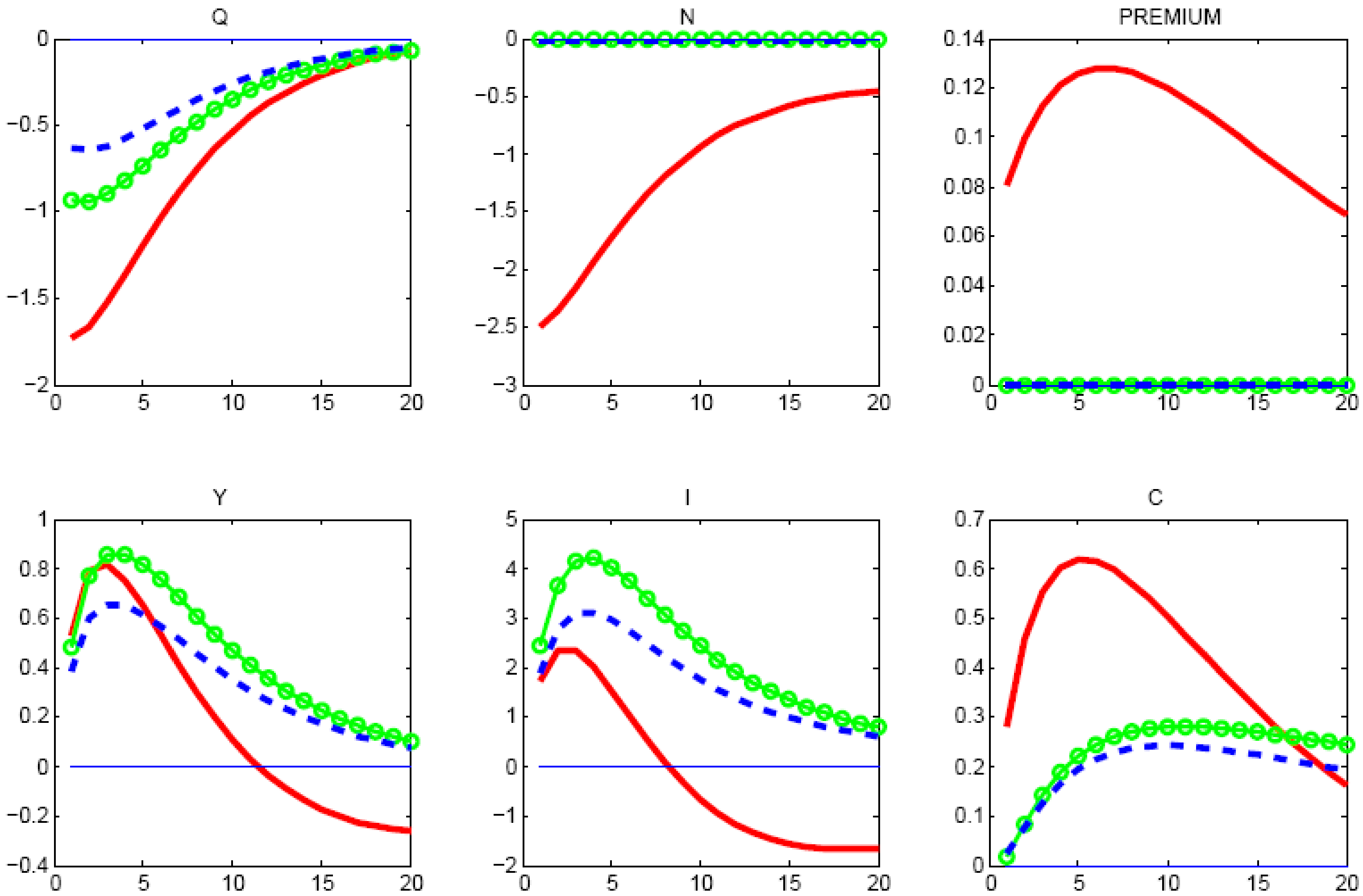

Figure 10: Productivity Shock IRF: Baseline (solid), Baseline without financial friction (o), DSGE estimated without financial friction (--).

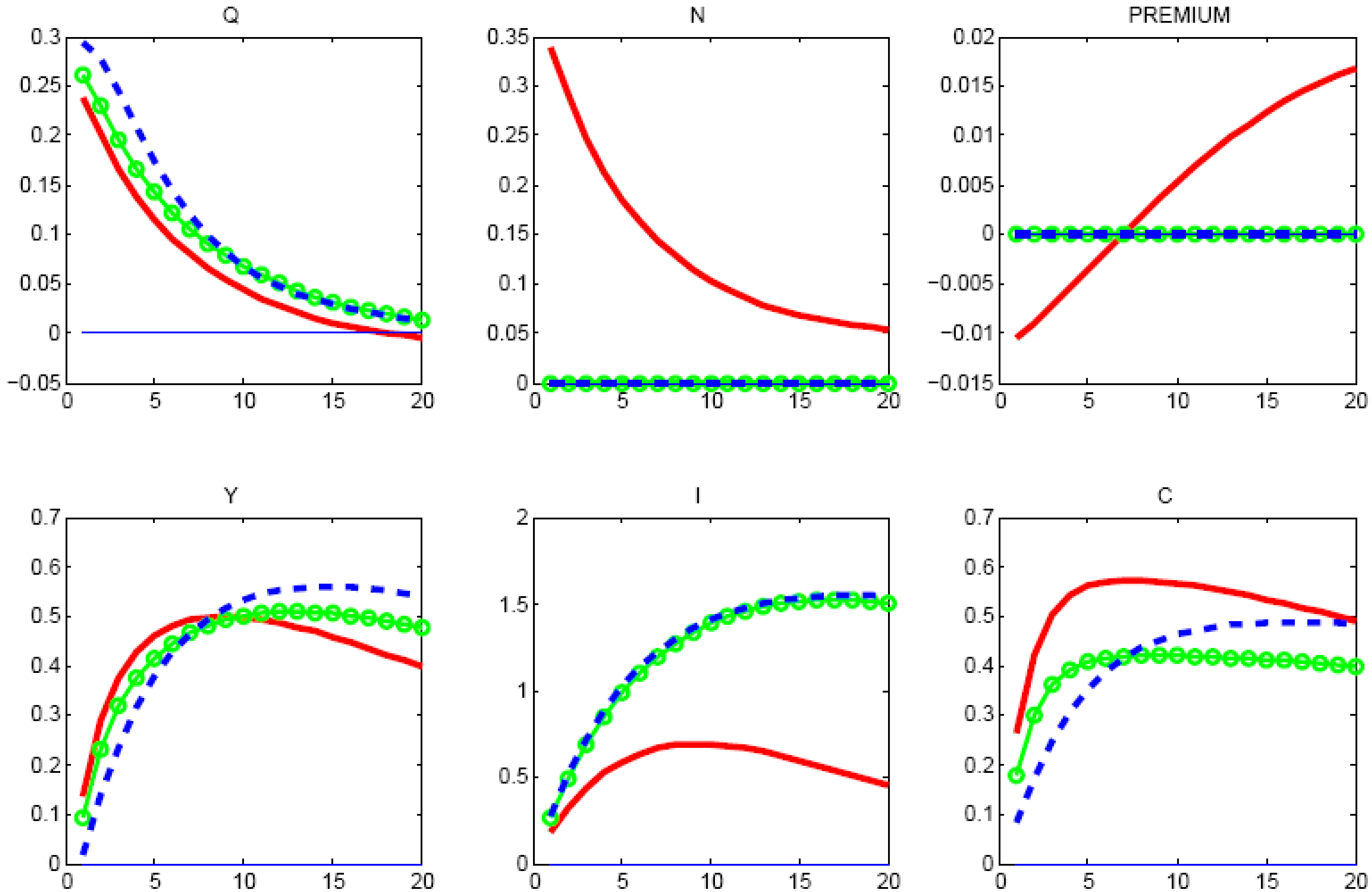

Table 1: Prior and posterior distribution for structural parameters

	Prior Distribution			Posterior Mode		Posterior Sample			No Financial Friction
	Type	Mean/LB	St. Dev./UB	Mode	St. Dev.	5%	50%	95%	Mode
$\frac{K}{N}$	uniform	0	5	1.4202	0.168	1.2354	1.5056	1.7683	n.a.
γ	uniform	0.8	1	0.9923	0.0102	0.973	0.9858	0.9982	n.a.
ϵ	uniform	0	0.5	0.1005	0.0349	0.0484	0.1047	0.1621	n.a.
$\bar{R}^K$	normal	1.015	0.002	1.0131	0.002	1.0099	1.0133	1.0164	n.a.
φ	normal	4	1.5	5.77	1.09	4.33	6.12	7.85	6.74
σ_c	normal	1	0.375	2.19	0.24	1.76	2.15	2.53	1.80
h	beta	0.7	0.1	0.41	0.07	0.33	0.43	0.54	0.70
σ_l	normal	2	0.75	2.32	0.58	1.52	2.50	3.43	2.48
ϕ	normal	1.25	0.125	1.69	0.08	1.57	1.70	1.82	1.71
ψ	gamma	0.2	0.075	0.40	0.10	0.26	0.43	0.61	0.31
ξ_w	beta	0.75	0.05	0.83	0.02	0.78	0.83	0.87	0.81
ξ_p	beta	0.75	0.05	0.92	0.010	0.90	0.92	0.94	0.92
γ_w	beta	0.5	0.15	0.43	0.12	0.24	0.43	0.62	0.38
γ_p	beta	0.5	0.15	0.25	0.09	0.13	0.27	0.42	0.34
r_π	normal	1.5	0.1	1.49	0.09	1.33	1.49	1.65	1.50
$r_{\Delta\pi}$	gamma	0.3	0.1	0.08	0.03	0.04	0.08	0.13	0.10
r_Y	gamma	0.125	0.05	0.09	0.03	0.04	0.10	0.16	0.09
$r_{\Delta Y}$	gamma	0.063	0.05	0.27	0.03	0.21	0.26	0.32	0.22
ρ	beta	0.75	0.1	0.89	0.02	0.86	0.89	0.92	0.90
ρ_A	beta	0.85	0.1	0.98	0.01	0.97	0.98	0.99	0.98
ρ_B	beta	0.85	0.1	0.70	0.11	0.46	0.64	0.83	0.33
ρ_G	beta	0.85	0.1	0.96	0.01	0.92	0.95	0.98	0.95
ρ_L	beta	0.85	0.1	0.94	0.01	0.91	0.94	0.97	0.97
ρ_I	beta	0.85	0.1	0.64	0.05	0.55	0.64	0.73	0.61
$\sigma(\hat{\varepsilon}_t^a)$	uniform	0	5	0.46	0.02	0.43	0.47	0.51	0.47
$\sigma(\hat{\varepsilon}_t^B)$	uniform	0	5	0.52	0.22	0.28	0.68	1.06	2.31
$\sigma(\varepsilon_t^G)$	uniform	0	5	0.57	0.02	0.53	0.57	0.62	0.58
$\sigma(\hat{\varepsilon}_t^L)$	uniform	0	5	3.04	0.54	2.27	3.21	4.25	3.44
$\sigma(\hat{\varepsilon}_t^I)$	uniform	0	5	0.68	0.06	0.60	0.70	0.81	0.55
$\sigma(\eta_t^R)$	uniform	0	5	0.20	0.01	0.17	0.20	0.24	0.21
$\sigma(\eta_t^\pi)$	uniform	0	5	0.08	0.01	0.06	0.08	0.11	0.08
$\sigma(\eta_t^p)$	uniform	0	5	0.20	0.01	0.18	0.20	0.22	0.20
$\sigma(\eta_t^w)$	uniform	0	5	0.27	0.01	0.25	0.27	0.30	0.27

Note: For uniform priors the table shows lower (LB) and upper bound (UB) rather than mean and standard deviation.

Table 2: Correlation with alternative indicators

Correlation with EFP at date t	Prime spread 1954-1993	Baa-Aaa 1954-2004	Bbb-Aaa 1989-2004	High yield spread 1987-2004	Levin et al. (2004) 1997-2003	Credit standards 1967-1983	Credit standards 1990-2004	Debt/gdp 1967-2004
-4	0.08	-0.35	0.51	0.86	0.70	0.49	0.69	0.46
-3	0.07	-0.35	0.59	0.85	0.65	0.47	0.72	0.50
-2	0.06	-0.35	0.68	0.83	0.59	0.45	0.74	0.54
-1	0.03	-0.35	0.72	0.77	0.46	0.46	0.73	0.57
0	-0.04	-0.37	0.76	0.68	0.28	0.44	0.68	0.59
1	-0.05	-0.38	0.76	0.56	0.06	0.37	0.66	0.61
2	-0.01	-0.37	0.75	0.43	-0.15	0.27	0.62	0.61
3	-0.01	-0.36	0.70	0.29	-0.28	0.22	0.47	0.59
4	0.01	-0.34	0.61	0.11	-0.38	0.24	0.30	0.56

Table 3: Variance decompositions: 5%-95% bounds

	Output			Premium		
Shock	$t = 1$	$t = 10$	$t = 20$	$t = 1$	$t = 10$	$t = 20$
$\hat{\varepsilon}_t^A$	$0.01 - 0.04$	$0.11 - 0.24$	$0.16 - 0.33$	$0.00 - 0.03$	$0.00 - 0.01$	$0.00 - 0.02$
$\hat{\varepsilon}_t^B$	$0.08 - 0.16$	$0.02 - 0.05$	$0.01 - 0.03$	$0.03 - 0.10$	$0.00 - 0.03$	$0.00 - 0.02$
ε_t^G	$0.31 - 0.44$	$0.09 - 0.17$	$0.08 - 0.16$	$0.00 - 0.02$	$0.00 - 0.00$	$0.00 - 0.01$
$\hat{\varepsilon}_t^I$	$0.25 - 0.37$	$0.18 - 0.37$	$0.14 - 0.30$	$0.58 - 0.83$	$0.86 - 0.98$	$0.89 - 0.97$
$\hat{\varepsilon}_t^L$	$0.04 - 0.11$	$0.11 - 0.28$	$0.11 - 0.29$	$0.02 - 0.10$	$0.00 - 0.03$	$0.00 - 0.02$
η_t^π	$0.01 - 0.03$	$0.02 - 0.06$	$0.02 - 0.06$	$0.01 - 0.05$	$0.00 - 0.01$	$0.00 - 0.01$
η_t^R	$0.05 - 0.11$	$0.11 - 0.24$	$0.10 - 0.24$	$0.06 - 0.21$	$0.01 - 0.07$	$0.01 - 0.05$
η_t^P	$0.00 - 0.01$	$0.01 - 0.02$	$0.00 - 0.02$	$0.00 - 0.01$	$0.00 - 0.00$	$0.00 - 0.00$
η_t^W	$0.00 - 0.01$	$0.00 - 0.00$	$0.00 - 0.00$	$0.00 - 0.01$	$0.00 - 0.01$	$0.00 - 0.01$

Table 4: Percentage gain (+) / loss (-) in RMSE and marginal density

	Y	C	I	L	P	W	R
DSGE without financial friction vs. VAR(1)							
1Q	17.43	10.00	13.65	13.28	16.83	0.75	13.00
2Q	25.71	27.28	13.90	14.74	35.56	1.88	13.26
4Q	32.73	43.75	9.96	17.74	48.26	1.99	16.11
8Q	46.88	63.46	11.58	22.19	36.01	9.69	20.13
DSGE with financial friction vs. VAR(1)							
1Q	24.29	10.70	16.08	19.26	22.04	2.39	8.99
2Q	39.52	29.28	18.91	25.70	41.07	4.80	12.02
4Q	48.30	44.23	16.65	31.48	50.35	5.78	19.03
8Q	59.73	56.48	22.12	39.09	34.35	13.99	25.18
DSGE with vs. without financial friction							
1Q	8.30	0.77	2.82	6.91	6.27	1.65	-4.61
2Q	18.59	2.74	5.82	12.86	8.55	2.98	-1.43
4Q	23.15	0.86	7.43	16.71	4.04	3.87	3.47
8Q	24.20	-19.11	11.91	21.72	-2.60	4.77	6.32
Marginal likelihood							
VAR(1)	-1003.8						
DSGE without financial friction	-944.9						
DSGE with financial friction	-933.1						

Note: Sample period is 1954:Q1 to 2004:Q4. For the computation of RMSE the forecasting period is 1990:Q1 to 2004:4. The VAR is re-estimated every quarter, the DSGE models every four quarters. For the computation of the marginal likelihood the first ten years (1954:Q1 to 1963:Q4) serve as a training sample.