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The external finance premium in the Euro area: A dynamic stochastic general equilibrium analysis

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ABSTRACT

In this paper I estimate a New Keynesian Dynamic Stochastic General Equilibrium model à la Smets and Wouters (2003, 2005, 2007) featured with financial frictions à la Bernanke, Gertler, and Gilchrist (1999) for the Euro Area. The main aim is to obtain a time series for the unobserved risk premium of entrepreneurs loans, with the further aim of providing a dynamic analysis of it (IRFs analysis and variance decomposition analysis). Results confirm in general what recently found for the US by De Graeve (2008), namely that the model with financial frictions can generate a series for the premium, without using any financial macroeconomic aggregates, highly correlated with available proxies for the premium (about 65% with the A graded corporate bonds spread). The advantage of using a structural model to obtain the premium lies in the fact that it allows for the dynamic analysis above mentioned, whose main achievement is to highlight that the estimated premium is not necessarily: (1) counter-cyclical (this depends on the shock considered) and (2) pro-cyclical during a recession.

1. Introduction

The main goal of the paper is to provide a time series for a relevant economic variable which is unobserved. This is the external finance premium, i.e. the premium that risky entrepreneurs (because of the uncertainty of the projects they undertake) have to pay when they borrow funds from the banks, because there is a problem of asymmetric information and costly state verification between the two types of agents. In other words agents operate in a world of credit frictions. The analysis concerns the Euro Area and covers the period from 1980 to 2008.

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The motivation behind the paper is surely related to the recent financial crises. It is very important during this time of heavy disruption of the financial markets to know about the dynamic properties of the variables pertaining those markets, among which the external finance premium is one of the most relevant. In addition to that financial markets play a relevant role also during "normal" times, so I think it is worth having a better understanding of their functioning.

In order to achieve my aim I base my analysis on a New Keynesian Dynamic Stochastic General Equilibrium model (NK DSGE henceforth) which closely follows the structure of the model developed by Smets and Wouters (2003, 2005, 2007) but with the addition of the so called financial accelerator mechanism developed in Bernanke and Gertler (1989), and already included in a basic DSGE model (Bernanke et al., 1999, BGG henceforth). The main advantage in using such a model is that, contrary to the last quoted theoretical contribution, several sources of nominal and real rigidities (which help in many ways in an estimated model[1]) and a large set of structural shocks are considered.

It is the use of a structural model and the presence of those numerous shocks which justifies the importance of this paper. In fact, many proxies for the financial premium are available, more often represented by the difference of some risky interest rates or yields (e.g. corporate bonds yields) and a measure of the risk free interest rate. Nevertheless, the use of a structural model to estimate such a series allows for a dynamic analysis of the premium. It is possible to highlight the stochastic forces explaining its behaviour through the variance decomposition and evaluate the impact that those forces have on its cyclical movements thanks to the impulse response functions analysis. Another advantage is that the proxies for the premium available for the Euro Area are short (they start in the first quarter of 2000). My approach gives an estimated series as long as the sample used, namely a series dating back to the 1980s.

The main result of the paper is that the estimated premium is not necessarily counter-cyclical as theoretically prescribed (BGG) and empirically found for the Euro Area by previous contributions (Queijo, 2005, 2008). That feature depends in a crucial way on both the nature of the shock considered and on the assumption on investments adjustment costs. This characteristic is at the basis of the explanation of the evidence that the estimated premium in the Euro Area does not display any relevant regularity either during a period of recession or immediately before it (it has been found to be always increasing before a recession and always pro-cyclical during it – with the exception of the two early eighties' recessions – in De Grove, 2008 for the US[2]). The variance decomposition suggests that many shocks are relevant for the explanation of the variability of the premium. Given that those shocks have different implications in terms of pro/countercyclicality of the premium and that at any point in time they are acting contemporaneously, it is not surprising that the premium behaves accordingly, being pro/countercyclical on the basis of the shocks which dominate the others in a particular period.

Further investigations are due in order to validate the estimated premium to guarantee its reliability before proceeding with its dynamic analysis. The same type of validation has been done by De Graeve (2008) who estimates the same model I am estimating in this paper using US data from 1954 to 2004. He finds that "the estimate – based solely on non financial macroeconomic data – picks up over the 70% of the dynamics of lower grade corporate bond spreads. . ..[in addition there is] A gain in fitting key macroeconomic aggregates by including financial frictions in the model". I confirm those main results for the Euro Area, finding that the correlation between the series for the premium and the A graded corporate bonds spread is about 0.65.

With respect to the confirmation of the empirical relevance of the financial frictions, a model for the Euro Area with such features has been already estimated by Queijo (2005, 2008). Her estimation ends at the fourth quarter of 2002, so in a sense my estimation is an up-date. But the important difference is that her paper is silent in terms of the analysis of the fitted risk premium series described in the text, because her focus is on the comparison of the relevance of the financial frictions in the US and the Euro

[1] See Christiano, Eichenbaum, and Evans (2005), CEE henceforth, and Smets and Wouters (2003, 2005, 2007) for a detailed discussion about their importance in an estimated model.

[2] See footnote 21 for a more detailed explanation of those findings.

Area. In addition, she assumes capital adjustment costs rather than investments adjustment costs, and as already said this assumption is at the basis of the different results in terms of pro/countercyclicality of the premium I obtain.

There are other two papers which are worth mentioning because they contain relevant ingredients supporting or contrasting some of my results. Levin, Natalucci, and Zakrajsek (2004) use nonlinear least squares to estimate the structural parameters of a canonical debt contract model with informational frictions. Using microdata for 900 US firms over the period 1997Q1 to 2003Q3, they reject the null hypothesis of frictionless financial markets. Meier and Müller (2006) is the only published paper finding a different empirical evidence for the US. In fact, using the same financial accelerator framework (but a different estimation method) they obtain sizeable points estimates for the relevant parameters governing the financial sector, but those fail to be statistically significant. The same conclusion is suggested in their analysis by their distance metric tests, which show financial frictions to have only a marginal impact on improving the model's fit with the data.[3]

The paper is structured as follows. In the first section I will present the model. In Section 3 I will discuss about the data I used for the estimation and the estimation methodology adopted. In the subsequent section, I present the estimation results. In the fourth section I provide the dynamic analysis of the risk premium and in the end the concluding remarks.

2. The model

The model is based on two previous contributions. The main structure is taken from Smets and Wouters (2003, 2005, 2007). That model is then extended introducing the financial accelerator mechanism as in BGG. Those reference papers are well known, hence I will present the model mainly in its log-linear form.[4]

2.1. Households

Household i maximizes its intertemporal utility function choosing how to consume ($\hat{c}_t^i$), the hours it wants to work ($\hat{l}_t^i$), and the amount it wants to deposit in the banks ($\hat{d}_t^i$), subject to its budget constraint. Deposits pay a one period nominal interest rate $\hat{r}_t^n = (1 + \hat{\imath}_t^n)$. Hence, Aggregate consumption evolves according to the following Euler equation

$$\hat{c}_t = \frac{h}{1+h}\hat{c}_{t-1} + \frac{1}{1+h}E_t\{\hat{c}_{t+1}\} - \frac{1-h}{\sigma_c(1+h)}\hat{r}_t + \frac{1-h}{\sigma_c(1+h)}\hat{\varepsilon}_t^{\beta}$$

where $\hat{\varepsilon}_t^{\beta} = \rho_{\beta}\hat{\varepsilon}_{t-1}^{\beta} + u_t^{\beta}$ with $u_t^{\beta} \backsim N(0, \sigma_{\beta}^2)$ is the discount factor shock (or preference shock). The real interest rate is simply defined as $\hat{r}_t = \hat{r}_t^n - E_t\{\pi_{t+1}^c\}$, where π_t^c is the gross inflation rate $1 + (P_t^c - P_{t-1}^c/P_{t-1}^c)$ or equivalently P_t^c/P_{t-1}^c, with P_t^c the CPI. The household behaviour is characterized by external habit formation, whose degree is established by parameter h. Households have a positive utility in period t only if they are able to consume something more that what was consumed last period on average. The inverse of the intertemporal elasticity of substitution in consumption (or equivalently the coefficient of relative risk aversion) and the inverse of the elasticity of work effort with respect to the real wage are σ_c and σ_l, respectively.

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[3] I think that the explanation for those results is that they use, differently from all the quoted papers and from mine as well, a series for the corporate profits in the estimation as a proxy for the financial tightening. We are currently working on the same issue and it seems from preliminary results that using a series for the premium in the estimation strongly affect the ability of the model with financial frictions to improve the fit with the data. See Gelain, Rodriguez-Palenzuela, and Világi (2009) for details.

[4] Hatted variables refer to the percentage deviation from their steady state value. For instance $\hat{c}_t = (C_t - C)/C$, where C_t is the level of consumption at time t and C is its steady state level.

2.1.1. Labour supply

Each household is a monopolistic supplier of a differentiated labour service requested by the domestic firms.[5] This implies that the households can determine their own wage. After having set their wages, households inelastically supply the firms' demand for labour at the going wage rate.

There is a firm which hires labour from the households and transforms it into a homogenous input good $\hat{l}_t$. It is assumed that not all households can optimally set their wage each period. On the basis of the Calvo assumption (see Calvo, 1983), only a fraction $1-\xi_w$ of households can re-optimize. For those who cannot, wages evolve accordingly to $W_{t+1}(i)=(\pi_t^c)^{\tau_w}W_t(i)$. Given this set up, households optimize their wages conditionally upon the fact that there is a certain probability that they cannot re-optimize in the future. The resulting wage equation is as follows

$$\hat{w}_t = \frac{\beta}{1+\beta}E_t\{\hat{w}_{t+1}\} + \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}E_t\{\hat{\pi}_{t+1}^c\} - \frac{1+\beta\tau_w}{1+\beta}\hat{\pi}_t^c + \frac{\tau_w}{1+\beta}\hat{\pi}_{t-1}^c + \\ -\frac{1}{1+\beta}\frac{(1-\beta\xi_w)(1-\xi_w)}{\left[1+((1+\lambda_w)\sigma_l/\lambda_w)\right]\xi_w}\left[\hat{w}_t - \sigma_l\hat{l}_t - \frac{\sigma_c}{1-h}(\hat{c}_t - h\hat{c}_{t-1}) + \hat{\varepsilon}_t^L\right] + u_t^w$$

where $u_t^w \backsim N(0,\sigma_w^2)$ is the wage mark up shock, λ_w is the steady state value of the latter, and $\hat{\varepsilon}_t^L = \rho_L\hat{\varepsilon}_{t-1}^L + u_t^L$ with $u_t^L \backsim N(0,\sigma_L^2)$ is the labour supply shock.

2.2. Firms

There are three types of producers: entrepreneurs, capital producers and retailers. Entrepreneurs produce intermediate goods. They borrow from a financial intermediary that converts household deposits into business financing for the purchasing of capital. The presence of asymmetric information between entrepreneurs and lenders creates a financial friction that makes the entrepreneurial demand for capital dependent on their financial position. Capital producers buy final goods to produce capital to be sold to the entrepreneurs. Retailers are described in the following section.

2.2.1. Retailers

Firms in this sector operate in a perfectly competitive market. That is, products of individual firms, $y_t(j)$, are not perfect substitutes and they are aggregated by the following Dixit-Stiglitz technology

$$Y_t = \left(\int_0^1 y_t(j)^{(\theta-1)/\theta}\,dj\right)^{\theta/(\theta-1)},$$

where $\theta > 1$ measures the elasticity of substitution. This implies that the demand for the product of an individual firms is determined by

$$y_t(j) = \left(\frac{P_t^c}{P_t(j)}\right)^{-\theta} Y_t, \tag{1}$$

where P_t^c is the aggregate price index, $P_t(j)$ is the price of firm j.

2.2.2. Capital producers

Capital producers are competitive and take prices as given. They buy final consumption goods at price P_t^c, transforming them into investment goods to be sold to the entrepreneurs at price P_t^I. They face investment adjustment costs, hence with I_t units of consumption goods purchased they produce $[1-S(I_t/I_{t-1})]I_t x_t$ units of investment good, where $\hat{x}_t = \rho_x\hat{x}_{t-1} + u_t^x$ with $u_t^x \backsim N(0,\sigma_x^2)$ is a shock to the marginal efficiency of investments, and $S(I_t/I_{t-1})$ is the investment adjustment costs function.

[5] The main references are Kollmann (2001), Erceg, Henderson, and Levin (2000), CEE (2005). Most recent references are Adolfson, Laséen, Lindé, and Villani (2007a,b) and Fernandez-Villaverde and Rubio-Ramirez (2007). The latter has very good mathematical derivations.

It has the same properties assumed in many previous papers (see for instance CEE 2005), namely $S(1) = S'(1) = 0$ and $S''(1) > 0$.

The dynamics of investments is then described by the following equation

$$\hat{\imath}_t = \frac{1}{1+\beta}\hat{\imath}_{t-1} + \frac{\beta}{1+\beta}E_t\{\hat{\imath}_{t+1}\} + \frac{1}{\varphi(1+\beta)}\hat{q}_t + \hat{x}_t \tag{2}$$

where φ is the inverse of investment adjustment cost and $\hat{q}_t = (Q_t - 1) \equiv \frac{P_t^I}{P_t^c} - 1$.

The stock of capital evolves as follows

$$\hat{k}_t = \delta(\hat{\imath}_t + \varphi\hat{x}_t) + (1-\delta)\hat{k}_{t-1}$$

where δ is the depreciation rate of capital.

2.2.3. *Entrepreneurs*

The activity of entrepreneurs is at the heart of the model, therefore I will focus on their behaviour in a greater detail than the other two types of firms. They are involved into two kind of activities: the production of wholesale goods and the stipulation of financial contracts to obtain funds to finance the former activity. I will describe those two activities, starting with the production activity.

Entrepreneurs operate in a monopolistically competitive market. They hire labour $\hat{l}_t$ from households, paying the salary $\hat{w}_t$, and capital at price $\hat{q}_t$ with a marginal productivity equal to $\widehat{re}_t^k$. Entrepreneurs produce output $\hat{y}_t$ on the basis of the following Cobb–Douglas production function

$$\hat{y}_t = (1+\phi)[\hat{a}_t + \alpha\hat{k}_{t-1} + \alpha\psi\widehat{re}_t^k + (1-\alpha)\hat{l}_t]$$

where $\psi = \Psi'(1)/\Psi''(1)$ is the inverse of the elasticity of the capital utilization cost function, $\hat{a}_t = \rho_a\hat{a}_{t-1} + u_t^a$, with $u_t^a \backsim N(0, \sigma_a^2)$, is the technology shock, and ϕ is the share of fixed cost in production.[6]

Using the f.o.c.s from the minimization cost problem I have an expression for the real marginal cost

$$\widehat{mc}_t = \alpha\widehat{re}_t^k + (1-\alpha)\hat{w}_t - \hat{a}_t$$

Together with the following condition on the return on capital

$$(1+\psi)\widehat{re}_t^k = \hat{l}_t + \hat{w}_t - \hat{k}_{t-1}$$

it is possible to determine the marginal productivity of all the input factors, and their demand schedule as a consequence.

[6] Adjustment cost of capital utilization is represented by the following function,

$$\Psi(z_t) = Re^k\psi\left[\exp\left(\frac{z_t-1}{\psi}\right) - 1\right],$$

where $\Psi(1) = 0$, $\Psi'(1) = Re^k$ and $\Psi'(1)/\Psi''(1) = \psi$. The degree of capital utilization is determined by condition $\Psi'(z_t) = Re_t^k$. This implies that

$$z_t = \psi\ln\left(\frac{Re_t^k}{Re^k}\right) + 1,$$
$$\Psi(z_t) = \psi(Re_t^k - Re^k).$$

The above two expressions are used to replace variable z_t by Re_t^k.

Entrepreneurs decide also the level of capital utilization according with the following first order condition[7]

$$\widehat{re}_t^k = \psi z_t$$

Turning to the problem of setting the loan contract with the financial intermediaries, the entrepreneurs' behaviour follows the one proposed by BGG. Entrepreneurs are risk neutral and have a finite expected horizon for planning purposes. The probability that an entrepreneur will survive until the next period is ϑ^e, so the expected lifetime horizon is $1/(1-\vartheta^e)$. This assumption ensures that entrepreneurs' net worth $\widehat{nw}_{t+1}$ (the firm equity) will never be enough to fully finance the new capital acquisition.

In essence, they issue debt contracts to finance their desired investment expenditures in excess of net worth. The capital acquisition is financed then partly by their net worth and partly by borrowing from a financial intermediary. This intermediary obtains its funds from household deposits and faces an opportunity cost of funds equal to the economy's riskless rate of return, $\hat{r}_t^n$. Thus, in order to acquire a loan entrepreneurs have to engage in a financial contract before the realization of an idiosyncratic shock ω^j (with a payoff paid after the realization of the same shock).[8]

The ex-post return on capital for firm j is $\omega^j \hat{r}_{t+1}^k$,[9] where $\hat{r}_{t+1}^k$ is the ex-post aggregate return to capital (i.e. the gross return averaged across firms). The latter is related with the price of capital as follows

$$\hat{r}_{t+1}^k = \frac{Re^k}{R^k}\widehat{re}_{t+1}^k + \frac{(1-\delta)}{R^k}\hat{q}_{t+1} - \hat{q}_t \qquad (3)$$

Eq. (3) is nothing more that the term structure of interest rate if taken in expectations and solved forward.

Turning to the loan contract, the entrepreneur chooses the value of firm capital and the associated level of borrowing prior to the realization of the idiosyncratic shock. Given that, the optimal contract is characterized by a gross non-default loan rate and by a threshold value of the idiosyncratic shock ω^j, call it $\bar{\omega}^j$, such that for values greater than or equal to $\bar{\omega}^j$, the entrepreneur is able to repay the loan at the contractual rate. A defaulting entrepreneur receive nothing.

The values of $\bar{\omega}^j$ and of the gross non-default loan rate under the optimal contract are determined by the requirement that the financial intermediary receive an expected return equal to the opportunity cost of its funds $\hat{r}_{t+1}^n$.

From the first order conditions of the optimal contract a key aggregate relationship for the financial accelerator mechanism is obtained

$$\hat{s}_t = -\varkappa(\widehat{nw}_{t+1} - \hat{q}_t - \hat{k}_{t+1})$$

where $\hat{s}_t \equiv E_t\hat{r}_{t+1}^k - \hat{r}_t$ is the external finance premium and $\varkappa$ is the elasticity of external finance premium with respect to the leverage ratio, the key parameter to be estimated. This summarizes the idea underlying the financial accelerator. This idea is that the external financial premium is negatively related with the net worth of potential borrower. The intuition is that firms with higher leverage (lower net worth to capital ratio) will have a greater probability of defaulting and will therefore have to pay a higher premium. Since net worth is pro-cyclical (because of the pro-cyclicality of profits and asset prices), the external finance premium becomes counter-cyclical and amplifies business cycles through an accelerator effect on investment, production and spending.

[7] The problem they solve is

$$\max_{\{z_t\}} Re_t^k z_t K_{t-1} - \Psi(z_t)K_{t-1}$$

where $\Psi(z_t)$ is the cost of capital utilization function.

[8] The idiosyncratic shock has positive support, is independently distributed (across entrepreneurs and time) with a cumulative distribution function $F(\omega^j)$ with unitary mean ($E\{\omega^j\} = 1$), and density function $f(\omega^j)$. As in BGG I assume a log normal distribution which has a positive support.

[9] The return of the entrepreneurial investment is observable to the outsider only through the payment of a monitoring cost $\mu\omega^j R_{t+1}^k Q_t K_{t+1}^j$, where μ is the fraction of lender's output lost in monitoring costs.

The aggregate entrepreneurial net worth at the end of period t is given by

$$\widehat{nw}_{t+1} = \vartheta^e \left[\frac{K}{NW} R^n (S\hat{r}_t^k - \hat{r}_t) + \frac{K}{NW} R^n (S-1)(\hat{q}_{t-1} + \hat{k}_t) + R^n(\hat{r}_t + \widehat{nw}_t) \right] \quad (4)$$

Eq. (4), which is the second basic ingredient of the financial accelerator, states that the entrepreneurial net worth is equal to the return on capital minus its cost minus the cost of an eventual default.

Intermediate goods producers face another type of problem. Each period, only a fraction $1-\xi_\pi$ of them, randomly chosen, can optimally adjust their prices. For those who cannot re-optimize, prices are adjusted accordingly to $P_{t+1}^c = (\pi_t^c)^{\tau_\pi} P_t^c$, where τ_π is the parameter which governs the degree of price indexation to past inflation.

Maximizing the expected discounted profits subject to the constraint represented by the demand expressed by the final good producers for the intermediate goods (Eq. (1)) it is possible to derive the condition for the optimal price and consequently the NKPC[10]

$$\hat{\pi}_t^c = \frac{\beta}{1+\beta\tau_\pi} E_t\{\hat{\pi}_{t+1}^c\} + \frac{\tau_\pi}{1+\beta\tau_\pi}\hat{\pi}_{t-1}^c + \frac{1}{1+\beta\tau_\pi}\frac{(1-\beta\xi_\pi)(1-\xi_\pi)}{\xi_\pi}(\widehat{mc}_t) + u_t^{\lambda\pi}$$

where $u_t^{\lambda\pi} \backsim N(0, \sigma_{\lambda\pi}^2)$ is the price mark up shock.

2.3. Monetary policy

As a benchmark rule,[11] the empirical interest-rate rule of the SW model is added:

$$\hat{r}_t^n = \phi_m \hat{r}_{t-1}^n + (1-\phi_m)[r_\pi(\hat{\pi}_{t-1}) + r_y(\hat{y}_{t-1} - \hat{y}_{t-1}^*)] + r_{\Delta\pi}(\hat{\pi}_t - \hat{\pi}_{t-1})$$
$$+ r_{\Delta y}[\hat{y}_t - \hat{y}_t^* - (\hat{y}_{t-1} - \hat{y}_{t-1}^*)] + u_t^{ru}$$

where $y_t^\star$ is the flexible-price level of output and $u_t^{ru} \backsim N(0, \sigma_{ru}^2)$ is the monetary policy shock.

2.4. Government

Fiscal policy is exogenous and is described by $\hat{g}_t = \rho_g \hat{g}_{t-1} + u_t^g$, where $u_t^g \backsim N(0, \sigma_g^2)$. In addition there is the equilibrium condition that $G_t = T_t$.

2.5. Aggregation

The resource constraint

$$\hat{y}_t = \frac{C}{Y}\hat{c}_t + \frac{I}{Y}\hat{\imath}_t + \frac{G}{Y}\hat{g}_t + \frac{K}{Y}\psi Re^k \widehat{re}_t^k + \frac{K}{Y} S\left(1 - \frac{NW}{K}\right)(\hat{r}_t^k + \hat{q}_{t-1} + \hat{k}_t)$$

3. Data and estimation methodology

Some parameters are fixed prior to estimation because the data used contain little information about them. The remaining not mentioned in the text are computed accordingly with the steady state relationships reported in Appendix A. The discount factor β is set equal to 0.99, implying an annual steady state real interest rate of 4% (or equivalently a quarterly rate of 1%). The parameter θ is set equal to 6, implying a steady-state price markup of 20%, a common value used in the literature. The depreciation rate, δ, is assigned the commonly used values of 0.025. The parameter of the Cobb–Douglas function, α, is set equal to 0.3. As in BGG, in order to have an annualized business failure rate, $F(\bar{\omega})$, of

[10] In order to maintain the paper self-contained I do not report the derivation of the New Keynesian Phillips curve. Moreover, it has been derived in many papers and books, so I refer to them. See Adolfson et al. (2007a,b) and Fernandez-Villaverde and Rubio-Ramirez (2007) among others.

[11] I have chosen this rule to make the model as comparable as possible with the previous contributions. In particular it is the same rule used in Smets and Wouters.

Table 1
Calibrated parameters.

Parameter	Value	Parameter	Value	Parameter	Value
Discount factor (β)	0.99	Capital share on output (α)	0.3	Payoff lost in bankruptcy (μ)	0.12
Goods elasticity of substitution (θ)	6	Annualized business failure rate ($F(\bar{\omega})$)	0.03	Consumption-output ratio ($\frac{C}{Y}$)	0.6
Steady state wage mark up (λ_w)	3	Annual steady state risk premium ($R^k - R$)	0.02	Variance of ω (σ_ω)	0.07
Capital depreciation rate (δ)	0.025	Capital to net worth ratio ($\frac{K}{NW}$)	2		

3% (0.75% quarterly), a steady state risk spread, $R^k - R^n$, equal to 200 basis points, and a ratio of capital to net worth, K/NW, of 2 (or equivalently a leverage ratio of 0.5), I take the idiosyncratic productivity variable, $\log(\omega)$, to be log-normally distributed with variance equal to 0.07, and I set the fraction of realized payoffs lost in bankruptcy, μ, to 0.12. The steady state share of consumption is set equal to 0.60. Table 1 summarizes the calibrated parameters.

3.1. Data

I used aggregate data for the Euro Area. I took them from the Area Wide Model (AWM) database.[12] The sample period goes from the first quarter of 1980 to the third quarter of 2008; hence I have 115 quarterly observations. Given the number of shocks in the model, I have chosen the following seven observable variable for the estimation: real GDP, real consumption, real gross investment, hours worked,[13] nominal short term interest rate, real wages per head and inflation rate. As in Smets and Wouters (2003) all real variables are in per capita terms (obtained dividing real aggregate variables by the labour force). Inflation rate is the quarter by quarter variation in the GDP deflator. In the end all variables are demeaned and detrended using a linear trend, with the exception of the nominal interest rate which is detrended with the same trend as inflation and then demeaned.

3.2. Methodology

The first step before the estimation is solving the model for the rational expectations (see Sims, 2000). After that the aim of the estimation is to obtain the posterior distributions of the parameters and make inference out of them. Since the posterior distributions are unknown, I used a Markov Chain Monte Carlo (MCMC) simulation method, namely the so-called random walk Metropolis–Hasting algorithm, which uses an acceptance/rejection rule to converge to the posterior distribution.[14] Before the simulation the maximization of the posterior kernel has been done in order to find the posterior modes and the variance-covariance matrix to be used in the initialization of the Metropolis–Hasting algorithm.[15] The entire procedure is implemented in Dynare for Matlab (see Juillard, 2004). For a detailed description of it see An and Schorfheide (2007) and Canova (2007).

[12] See Fagan, Henry, and Mestre (2001).

[13] As for the hours worked, there are not available data. Assuming that in any period only a fraction of firms, ξ_E, is able to adjust employment to its desired total labour input, they are obtained using the following formula (see Adolfson et al., 2007a for further details)

$$\Delta\hat{E}_t = \beta E_t \Delta\hat{E}_{t+1} + \frac{(1-\xi_E)(1-\beta\xi_E)}{\xi_E}(\hat{l}_t - \hat{E}_t)$$

where E_t is the total employment at time t and $\hat{E}_t$ is the percentage deviation of the employment from the mean ($\hat{E}_t = E_t - E/E$). The parameter ξ_E is estimated.

[14] I run two chains of 500000 draws each, the acceptance rate has been tuned to be around 25% and the convergence of the chains has been evaluated with the checks proposed by Brooks and Gelman (1998).

[15] Dynare allows for different kind of optimization procedure. Here, I used the Sims' optimizer.

Table 2
Bayes factor decision rule.

Support for M_{NOFA}	Very slight evidence against M_{NOFA}	Slight evidence against M_{NOFA}	Strong evidence against M_{NOFA}	Decisive evidence against M_{NOFA}
$B_{FANOFA} < 1$	$1 < B_{FANOFA} < 3$	$3 < B_{FANOFA} < 10$	$10 < B_{FANOFA} < 100$	$B_{FANOFA} > 100$

Table 3
Log data density.

Log data density	Model with FA	Model without FA	Bayes factor $\left(\frac{\text{FA}}{\text{NOFA}}\right)$
Laplace approximation	−281.85	−285.77	$\exp^{3.92.}$
Harmonic mean	−281.20	−285.44	$\exp^{4.24.}$

3.2.1. Priors

Priors are taken from Smets and Wouters (2003) for the common parameters. It is common to assign a beta distribution to the coefficients defined in the range 0–1, typically the autoregressive coefficients.

In what concerns the BGG parameters, I assign a beta distribution also to the entrepreneur's rate of survival. As for the elasticity of the external finance premium with respect to firm leverage, I assume an inverse gamma distribution with mean 0.05 and infinite variance.

Table 4 summarizes the distributions assigned with their mean and the standard deviation.

3.3. Model comparison

There are many ways to evaluate the goodness of the fit between the model with financial frictions and without them. The main two are comparing the fitted values with the actual data and computing some test statistics. In this section I explain how a specific statistic of the Bayesian econometrics, the Bayes factor, is built and I will comment out the results in the next section. First, the models' marginal data density must be calculated. Let us label a model with financial frictions by M_{FA} and an alternative specification of the model without financial frictions by M_{NOFA}.

The Bayes factor is $B_{FANOFA} = p(Y|M_{FA})/p(Y|M_{NOFA})$.[16]Jeffreys (1961) suggested rules of thumb to interpret the Bayes factor as follows (Table 2):

4. Estimation results

4.1. Fit

Figs. 1 and 2 report the fitted and the actual values of the series used in the estimations.

The graphical analysis is quite intuitive, but it gives no clear understanding of which model better fits the data in this case. That is the reason why I need a statistics to properly judge the fit. As anticipated I use the Bayes factors. They are reported in Table 3 and I can see that there is (strong) evidence against the model without the financial accelerator effect. Thus, the introduction of the accelerator mechanism improves the model's ability to fit the data.

[16] The marginal data density for each model will be ($i = FA, NOFA$)

$$p(Y|M_i) = \int p(Y|\Im_i, M_i)p(\Im_i|M_i)d\Im_i$$

where $\Im_i$ is a vector of parameters of model i, p($Y|\Im_i, M_i$) is the sample density of model i and p($\Im_i|M_i$) is the prior density of the parameters for model i. See Kass and Raftery (1995) for details.

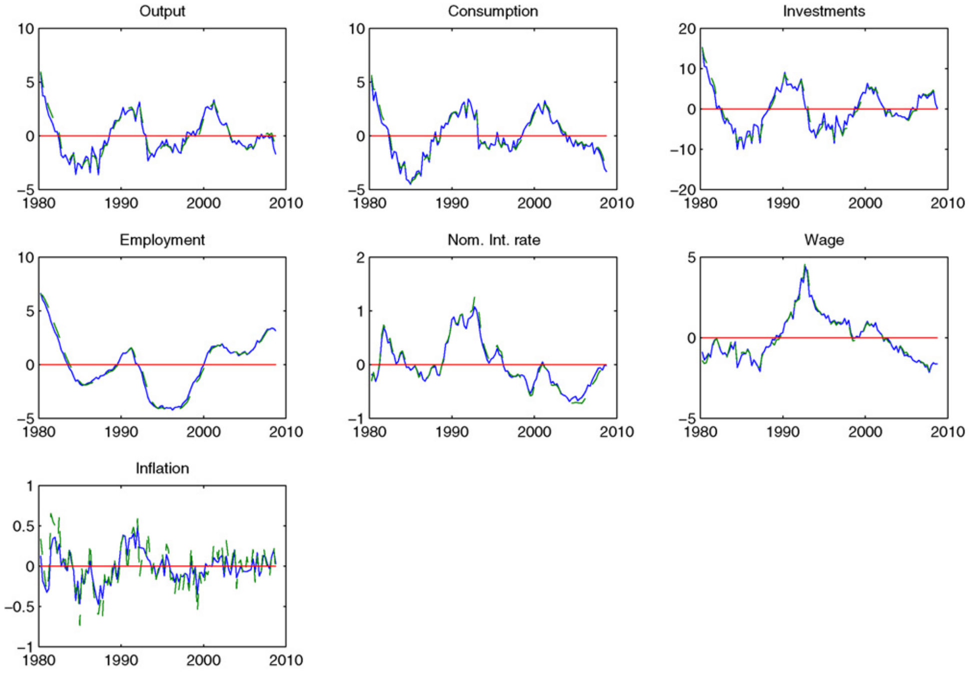

Fig. 1. Data (dashed green line) and fitted values (solid blue line) from the model FA. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

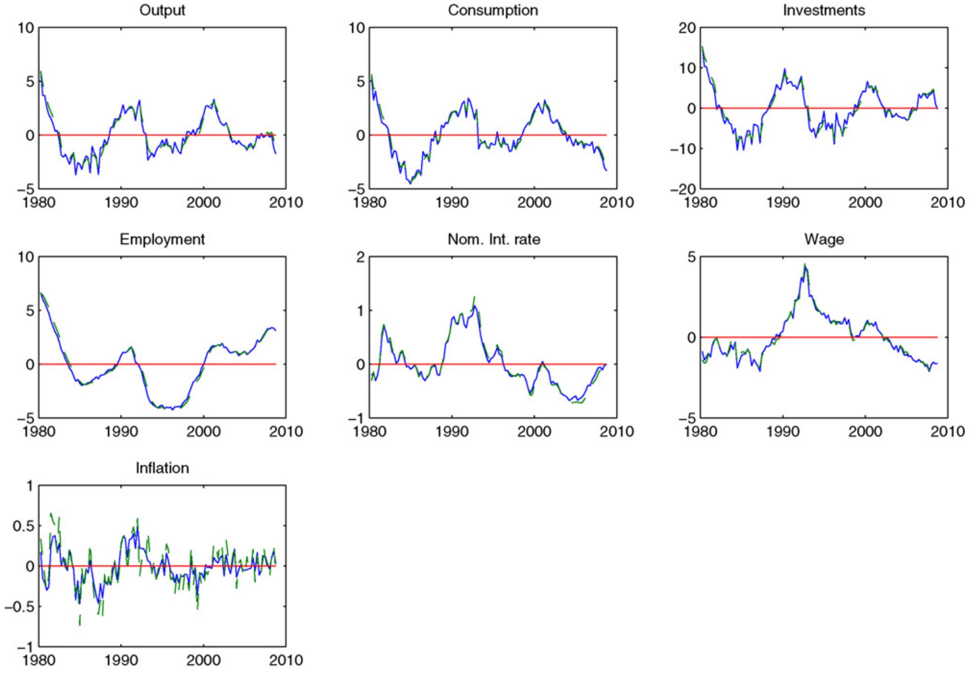

Fig. 2. Data (dashed green line) and fitted values (solid blue line) from the model with NOFA. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

Table 4
Prior and posterior distributions. 90% probability intervals are displayed.

Parameters	Prior			Posterior mean	Probability interval		Posterior mean	Probability interval	
	Distribution	Mean	Std. dev.	With FA			Without FA		
Std. dev. preference shock (σ_β)	Inv. Gamma	0.2	Inf.	0.2665	0.1528	0.3767	0.2762	0.1472	0.4053
Std. dev. labour supply shock (σ_L)	Inv. Gamma	1	Inf.	1.415	0.6415	2.1975	1.7888	0.6072	2.9702
Std. dev. inv. specific shock (σ_x)	Inv. Gamma	0.1	Inf.	0.3237	0.2355	0.4138	0.3284	0.2105	0.4374
Std. dev. technology shock (σ_a)	Inv. Gamma	0.4	Inf.	0.7534	0.6153	0.8895	0.7911	0.6327	0.9438
Std. dev. monetary policy shock (σ_{ru})	Inv. Gamma	0.1	Inf.	0.1325	0.1133	0.1528	0.12	0.0822	0.1517
Std. dev. gov. spending shock (σ_g)	Inv. Gamma	0.3	Inf.	1.2456	1.0433	1.4444	1.4183	1.1497	1.6823
Std. dev. wage mark up shock (σ_w)	Inv. Gamma	0.25	Inf.	0.2079	0.1817	0.2342	0.2106	0.1836	0.2369
Std. dev. price mark up shock (σ_{λ_π})	Inv. Gamma	0.15	Inf.	0.1743	0.1502	0.1974	0.1746	0.1508	0.1974
Persistence param. preference shock (ρ_β)	Beta	0.85	0.1	0.8969	0.8444	0.9502	0.8683	0.8022	0.9378
Persistence param. labour supply shock (ρ_L)	Beta	0.85	0.1	0.9707	0.9458	0.9979	0.9376	0.8763	0.9969
Persistence param. invest. specific shock (ρ_x)	Beta	0.85	0.1	0.6941	0.522	0.8707	0.6477	0.4437	0.8801
Persistence param. technology shock (ρ_a)	Beta	0.85	0.1	0.9644	0.9374	0.9937	0.9614	0.9314	0.9934
Persistence param. gov. spending shock (ρ_g)	Beta	0.85	0.1	0.8685	0.788	0.9538	0.8992	0.8335	0.9679
Elasticity of external finance wrt leverage ($\varkappa$)	Inv. Gamma	0.05	Inf.	0.0267	0.0128	0.0401	–	–	–
Entrepreneur's rate of survival (θ^e)	Beta	0.975	0.01	0.9797	0.9656	0.9938	–	–	–
Habit formation (h)	Beta	0.7	0.05	0.6551	0.5889	0.7213	0.6501	0.5856	0.7178
Inverse of the elasticity of work effort wrt real wage (σ_l)	Normal	2	0.75	2.0183	1.1392	2.8556	1.7213	0.9035	2.5011
Inverse of elasticity of substitution in consumption (σ_c)	Normal	1	0.375	1.5081	1.1081	1.8967	1.5297	1.1493	1.9161
Past wage indexation (τ_w)	Beta	0.75	0.15	0.3892	0.1877	0.5838	0.3969	0.199	0.5874
Past inflation indexation (τ_π)	Beta	0.75	0.15	0.2784	0.1398	0.4146	0.2961	0.1584	0.433
Calvo wage (ξ_w)	Beta	0.7	0.05	0.8768	0.8384	0.9194	0.9062	0.8729	0.9328
Calvo price (ξ_π)	Beta	0.75	0.05	0.8618	0.8403	0.8831	0.8737	0.8528	0.894
Inverse of investments adjustment cost (φ)	Normal	4	1.5	6.5431	4.5265	8.5728	6.2242	4.1166	8.267
Fixed cost over output (ϕ)	Normal	0.45	0.25	0.1657	0.0215	0.3067	0.156	0.0178	0.2969
Inverse elast. capital util. cost function (ψ)	Normal	0.2	0.075	0.0294	−0.0586	0.1195	0.0344	−0.0647	0.1328
Response of interest rate to inflation (r_π)	Normal	1.7	0.1	1.6633	1.5058	1.8281	1.6563	1.492	1.817
Response of interest rate to output (r_y)	Normal	0.125	0.05	0.1054	0.0303	0.1739	0.1527	0.0671	0.2304
Smooth parameter in instrument rule (ϕ_m)	Beta	0.8	0.05	0.9075	0.881	0.9348	0.8996	0.8509	0.9418
Response of interest rate to output growth (r_{Δ_y})	Normal	0.3	0.1	0.2061	0.1351	0.2751	0.2046	0.14	0.2704
Response of interest rate to infl. first diff. (r_{Δ_π})	Normal	0.063	0.05	0.1417	0.0856	0.1943	0.1812	0.1078	0.258
Calvo employment (ξ_E)	Beta	0.5	0.15	0.7458	0.7118	0.779	0.7445	0.7105	0.7798

4.2. Posteriors

In Table 4 I report the mean values of the posterior distributions, together with their 90% probability intervals, for both the model with and without financial frictions.

In general the posterior means are in line with the previous estimations for the Euro Area and they are not very different between the two specifications of the model.[17] I will not describe them because already extensively described in the previous literature and I will focus on the most relevant estimated parameter $\varkappa$.

It is estimated at about 0.03. This is lower than the BGG calibrated one for the US (0.05) but still in line with it and with the empirical evidence. In fact, the previous estimation for the Euro Area reports a value for that parameter of 0.05 in Queijo (2005) (revised at 0.04 in the 2008 version of her 2005 paper).[18] De Graeve (2008) finds a higher value for the US (a posterior mode of 0.1). Christensen and Dib (2008) estimate it at 0.042 for Canada. Lopez and Rodriguez (2008) 0.059 for Colombia. Elekdag, Justiniano, and Tchakarov (2005) 0.066 for Korea.

Gelain and Kulikov (in press) find a value of 0.13 for Estonia. This last result is due to the assumption of a higher steady state value for the premium (according to the Estonian evidence) which impacts on the value of $\varkappa$, and hence on its prior mean, since they are strictly correlated.[19]

5. Premium

5.1. A series for the premium

Fig. 3 reports the smoothed series for the risk premium obtained by the estimation of the DSGE model. I also included in the graphic the shaded areas corresponding to the recession periods.[20]

This figure clearly highlights that the premium enters the recession periods in a not straightforward way. Contrary to De Graeve (2008), who finds a sort of regularity in the premium's behaviour during recessions,[21] in my case the pattern is irregular. This is the first evidence that the premium might not be only either pro or counter-cyclical. The question is: which is the explanation behind that fact? I will answer in the next sections, making use of the variance decomposition and of the IRF analysis. To anticipate the answer, I can state that the premium's movements depend on the nature of the shock considered and on the dominant shock driving it at any point in time.

Before moving ahead, it is worth noting that the model fails to reproduce the observed huge increase in the premium starting from the third quarter 2007, when the financial crises began. This is not necessarily an argument against the goodness of my empirical results. In fact, I will show that in many other (more relevant) respects results are robust and meaningful. As for the failure, I would attribute it to the rather exceptional (outlier?) increase in the premium since 2007. The spreads increased by 3–5 times in one year (see Fig. 4). It is quite difficult to capture those type of events. I am currently evaluating this issue.

5.2. External validation

One of the main goal of the paper is to evaluate the strength of the model to produce a sensible and meaningful series for the unobserved risk premium. In order to evaluate that feature for my model

[17] The same is true in Queijo (2005, 2008), but for instance not in De Graeve (2008).

[18] The author does not estimate that parameter, but other structural parameters whose combination gives $\varkappa$.

[19] See BGG's appendix for details about that correlation.

[20] I adopted as the definition for a recession a negative GDP growth for at least two quarters in a row.

[21] The author shows that his model generates a premium always pro-cyclical. i.e. decreasing during recessions, with the exception of the two early eighties' ones. The reason is clear. His analysis highlights that the main driving shock of the premium is the investment specific shock. This explains almost 90% of its variability. In addition, with his shock decomposition he concludes that investment specific shock traces the low frequency components of the premium very closely. Given that his IRF analysis stresses that such shock generates a pro-cyclical premium, it is not surprising that during a recession it drops. As for the eighties, his model attributes both the fall in GDP and the rise in the premium to restrictive monetary policy shocks.

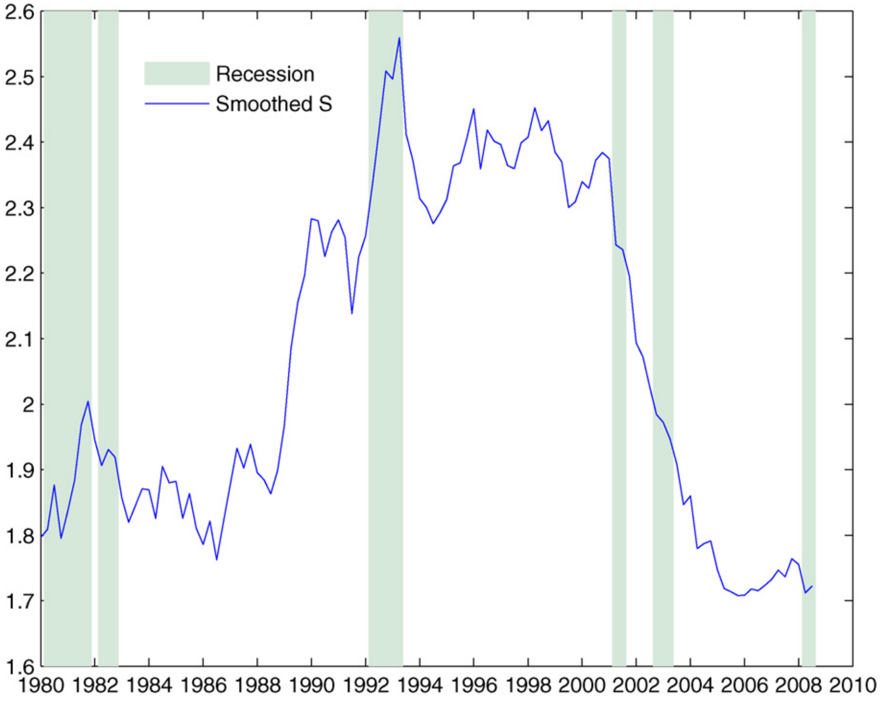

Fig. 3. Series for the premium generate by the model with financial frictions (smoothed values).

Table 5
Contemporaneous correlation between the series generated by the model and the proxies for the premium.

	AAA-GOVN.B.	AA-GOVN.B.	A-GOVN.B.	BBB-GOVN.B.
Corr. with premium 2000q1–2008q3	0.152	0.257	0.647	0.360

I compare the smoothed series generated by the DSGE model with some available proxies for the premium of the Euro Area. They are spreads computed as the difference between some risky interest rates and the risk free interest rate represented in my case by the rate on the ten years government bonds.

Unfortunately, those series are shorter that the sample period, so I have to consider only the last part of the generated series. In particular, the spreads are available only from the first quarter of 2000. Those spreads are computed as the difference between the AAA, AA, A and BBB rated bonds and the ten years government bonds.[22] Fig. 4 shows the series for those spreads compared with the last part of the series of the premium in Fig. 3.[23]

The graphical analysis suggests that the model has done a good job. A confirmation comes from the contemporaneous correlations among the series reported in Table 5. Not surprisingly the correlation with the higher graded corporate bonds spreads (AAA and AA) is low (0.15 and 0.26, respectively). On the contrary, it is very high (0.65) with the A graded spread, allowing me to conclude that the series obtained is a good proxy for the external finance premium.[24]

[22] Data from the ECB.
[23] All series are standardized to facilitate the comparison.
[24] If I do not consider the last three observations, i.e. the financial crises, the latter correlation is even 90%.

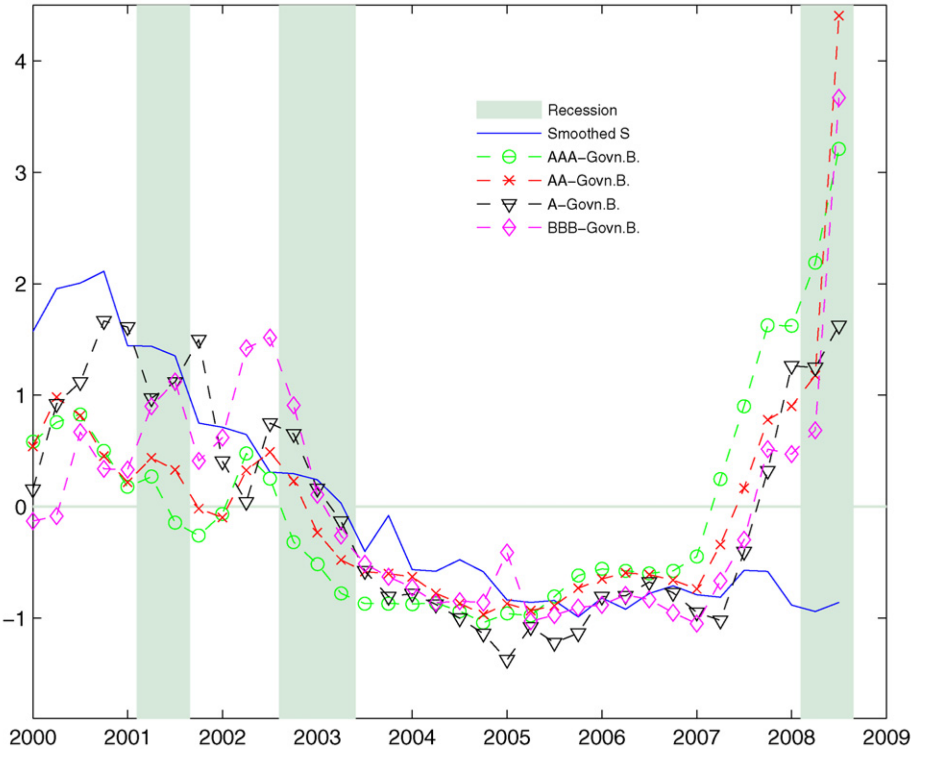

Fig. 4. Comparison of the risk premium with the proxies.

5.3. Variance decomposition

The variance decomposition presented in Table 6 well shows which shocks are more relevant in the Euro Area and which are the most responsible of the variance of the single variables. Two of them are of a particular interest, output and the premium, because this is the first step to understand why the premium moves as described in Section 5.1. The second step is to clarify the implications of those shocks for the premium through the IRF analysis in the next section.

Results are in line with the literature related to the Euro Area. I will first describe them in general, focusing afterwards on the most interesting decomposition of the premium.

In general in the long run the most important shock driving the variability of the real variables is the technology shock, whose role is calmed down by the presence of the investment specific shock. The latter is the second source of variability for the most part of the real variables, with the exception of consumption, which is driven by the preference shock. The monetary policy shock plays a relevant role for the nominal variables, except for inflation which is mostly driven by the price mark up shock and by the labour supply shock. The latter seems to play a relevant role also for the price of capital and the return on capital (accounting for around 20%). Government, price mark up and wage mark up shocks play no role except for the last one explaining almost the 30% of the variability on the real wages. In the end, the flexible price output is mostly driven by the technology shock (85%).

Turning to the risk premium, as in De Graeve (2008), the most responsible shocks for its variability in the long run are the investment specific and the technology shocks (90% in the US case). In my case they count for 54%. The remaining part is almost entirely explained by the monetary policy shock (38%), which represents a difference with respect to the US where that shock is less relevant

Table 6
Asymptotic variance decomposition FA (in percentage) based on posterior means.

	r	c	l	I	q	k	nw	r^k	y	π	re^k	mc	S	r^n	w	E	$y^\star$
u^x	6.6	1.13	17.11	41.52	20.06	46.95	17.42	13.92	12.45	0.91	13.55	1.31	23.23	12.41	2.65	20.23	3.12
u^β	4.9	40.13	11.68	4.45	2.77	4.76	2.73	2.34	9.03	5.17	7.97	2.73	3.82	29.97	3.36	13.38	2.66
u^L	29.32	3.14	11.73	8.5	21.65	6.82	25.11	26.54	7.15	33.11	11.75	3.53	23.44	13.07	4.59	16.7	8.48
u^a	7.32	48.75	37.96	35.57	27.99	33.53	21.13	20.31	57.65	7.38	42.56	73.42	15.59	8.09	53.4	22.05	83.69
u^{ru}	45.39	5.63	15.63	9.02	24.47	7.21	30.08	33.16	9.75	4.33	13.58	2.6	30.16	31.53	1.74	23.92	0
u^g	0.79	0.6	4.49	0.21	0.35	0.17	0.28	0.26	3.08	0.02	2.5	0.22	0.21	1.11	0.02	1.59	2.05
$u^{\lambda\pi}$	3	0.33	1.01	0.63	2.21	0.45	2.53	2.58	0.63	45.13	3.42	4.05	2.42	2.98	7.05	1.28	0
u^w	2.68	0.29	0.39	0.11	0.5	0.11	0.72	0.89	0.24	3.95	4.65	12.15	1.13	0.83	27.18	0.85	0

at these long horizons (around 10%). This difference is not trivial, because it is at the heart of the difference between the features of the premium in the US and in the Euro Area. In fact, as the IRFs will show the monetary policy shock has different implications for the premium than the investment and technology shocks. It is in this contemporaneous interaction of different shocks with opposite effects on the premium at any point in time that I find the explanation of the premium's trajectories during the crises.

In the end the labour supply shock is also relevant (about 25%) and this reinforce my results, because I will show that it has the same consequences for the premium as the monetary policy one.

5.4. Impulse response functions

This section focuses on the impulse response functions analysis. Although it may serve as a tool to evaluate the transmission channel of the monetary policy, the credit channel in my case, I use it to illustrate the dynamics implied by the financial accelerator to mainly shed light on the issue pro/countercyclicality of the premium.

I report here only those IRFs related to the most interesting shocks, i.e. those which allow me to highlight some specific aspects of the model. In other words, the shocks I found to be relevant in explaining the premium in the previous section, i.e. investment specific, technology, monetary policy and labour supply.

In Fig. 5, I report the consequences of a monetary policy shock. The mechanism of the financial accelerator is clearly represented and clearly showed by the response of investments. After the tightening of the monetary policy, investments decrease as in the normal set up. This has the usual effect of reducing the demand for capital and then its price. In the financial accelerator framework, the latter reduction leads to a decrease of the net worth which makes the entrepreneur riskier. He has then to pay a higher premium and this fact further depresses investments, generating the extra response displayed in Fig. 5.

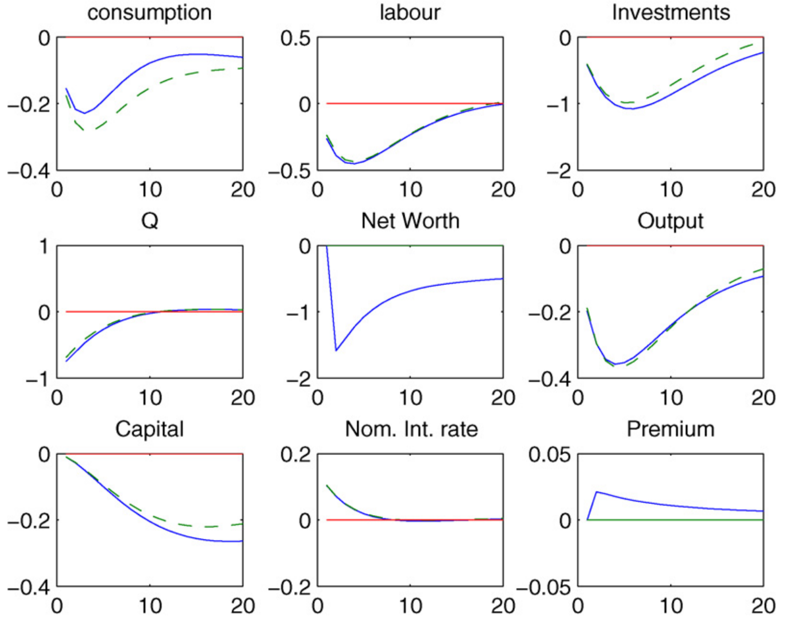

Fig. 5. Mean variables' responses to a one std. dev. orthogonalized monetary policy shock. Percentage deviation from the steady state. Dashed line: NOFA. Solid line: FA.

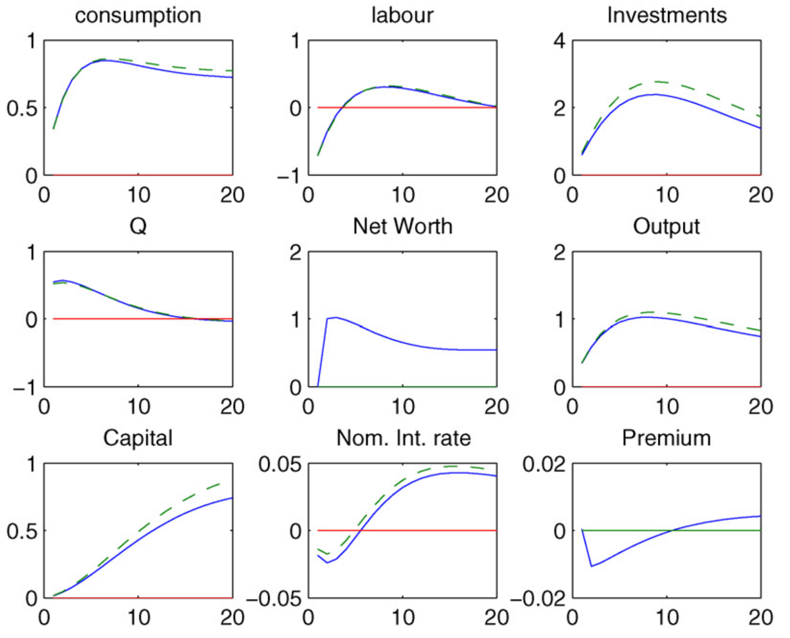

Fig. 6. Mean variables' responses to a one std. dev. orthogonalized technology shock. Percentage deviation from the steady state. Dashed line: NOFA. Solid line: FA.

It is worth noting that in this case, contrary to the BGG theoretical prescriptions, but also to the US empirical evidence, the accelerator effect is not transmitted to output. Rather, that variable seems to responde slightly more in the case of no financial frictions. This is due to the consumption reaction, which is much stronger when the accelerator is not working, more than counteracting the effect on investments.[25]

Confirming the theoretical prescriptions (BGG and Walentin, 2005) and the empirical findings the premium turns out to be counter-cyclical if a monetary policy shock hits the economy. I then analyze the investment specific shock and the technology shock, in Figs. 6 and 7, respectively, to highlight two important results holding for the Euro Area like for the US, namely the not necessarily counter-cyclicality of the premium and the not necessarily stronger response of investments when the accelerator is on (although the latter effect is less accentuated in the Euro Area).

In fact, in the case of the positive investment specific shock both those properties are there. Investments increase less in the case of the model without frictions and although the premium is increasing[26] output still augments (i.e. the premium is pro-cyclical).

The same is true in the case of the technology shock, where the premium is counter-cyclical for a short period of time, but still the response of investments is not amplified by the accelerator. This can be easily explained by the interaction of the financial frictions with the investments adjustments costs.[27]

[25] This response is explained by the fact that consumption's dynamics is described solely by the Euler equation, i.e. the real interest rate is its main determinant. Hence that response is not directly related to financial fictions which operate through the investment channel. This suggests that a different modellization of the households may be necessary. This is left for future research.

[26] The premium increases because the investment specific shock is a supply shock given the fact that it implies a reduction in the price of capital, despite the fact that investments increase, and this leads to a decrease of the net worth which gives less collateral to entrepreneurs who in turn has to face a higher premium.

[27] The interaction is clear if the peak of investments' response is analyzed. When the financial frictions are on, it is reached before than in the model without them. Entrepreneurs know that they are going to pay more in the future because of the higher premium, hence they tend to anticipate investments.

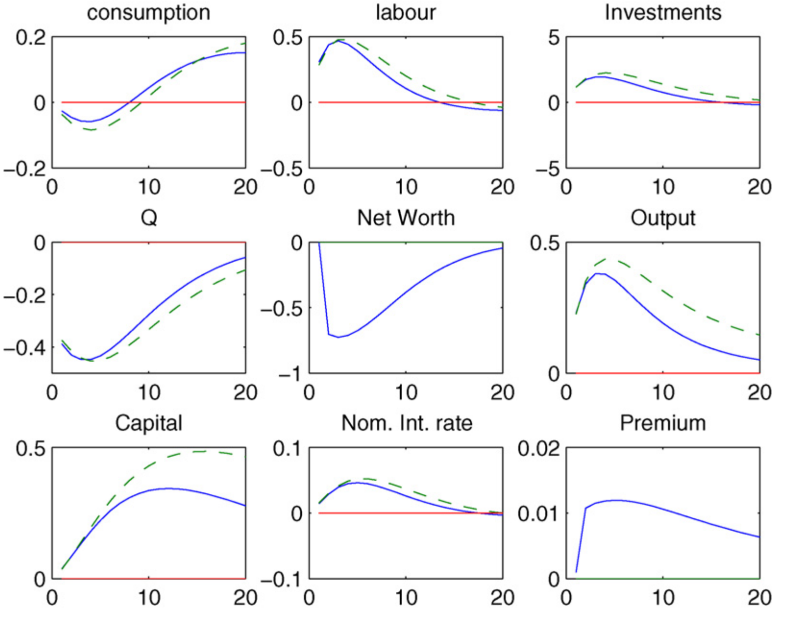

Fig. 7. Mean variables' responses to a one std. dev. orthogonalized investment specific shock. Percentage deviation from the steady state. Dashed line: NOFA. Solid line: FA.

Given that changing the investments flow is costly for entrepreneurs (notice the high persistence in investments due to those costs), when investments increase they tend to increase for a protracted period. This forces entrepreneurs to ask for more credit, putting pressure on the risk premium given their increasing leverage.

Since the assumption on investments adjustment costs is crucial, I tried to estimate the model with capital adjustment cost, to check the validity of the argument behind the interaction with the financial frictions. In particular, under capital adjustments costs Eq. (2) reduces to

$$\hat{q}_t = \chi(\hat{\imath}_t - \hat{k}_t) \tag{5}$$

where χ is a parameter whose estimated posterior mode is 2.12 in the model with financial frictions and 1.86 without them. Under this set up investments over-react when financial frictions are on, giving rise to the financial accelerator. Premium is entirely counter-cyclical. In addition, the log data density is −298.97 in the FA model and −301.88 in the other case, giving an empirical argument in favour of the investment adjustment costs.

In the end, the labour supply shock in Fig. 8. The mechanism is by now clear, so I will not describe it. What it is important to stress is that this shock leads to a counter-cyclical premium.

Which is the lesson learned from this section? The most relevant shocks driving the premium push it in different directions. Either they make it move in the same direction of output or to the opposite direction. At any point in time they may occur contemporaneously, but with different intensity. The behaviour of the premium highlighted in Fig. 3 during recessions is then determined by the combination of those forces, and its sign is determined by the shock(s) which dominate upon the other(s).

5.5. *Robustness checks*

The robustness check is conducted on two levels. On the one hand it is related to the choice of the prior distributions (their mean and variance, rather than their shape) and on the other hand it touches the steady state values assumed prior the estimation.

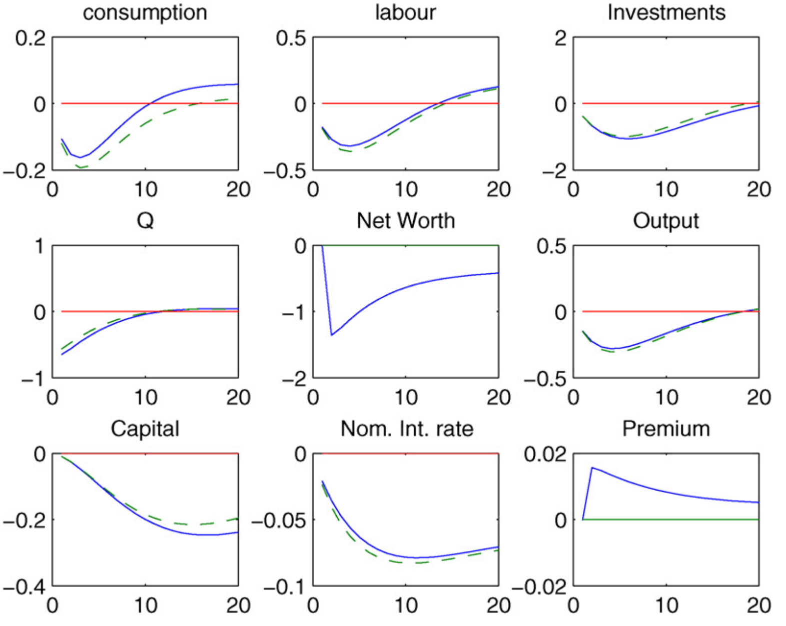

Fig. 8. Mean variables' responses to a one std. dev. orthogonalized labour supply shock. Percentage deviation from the steady state. Dashed line: NOFA. Solid line: FA.

In what concerns the former, most of the priors are taken from Smets and Wouters (2003), hence they do not need a robustness check here. On the contrary I would spend some words on the two estimated parameters governing the financial frictions, i.e. $\varkappa$ and ϑ^e. The latter is not really relevant. Changing it in a reasonable range does not affect results.

What is more relevant is the elasticity of the risk premium. The choice of the prior mean is clearly dictated by the BGG calibrated value and supported by the previous empirical findings. I tried up to a value twice higher (0.1) and four times higher (0.2) and results still hold (posterior means are 0.048 and 0.1061 and probability intervals are 0.021–0.073 and 0.041–0.184, respectively). A slightly more delicate issue is related to the variance of the prior. Canova and Sala (2009) argue that the posterior of parameters presenting identification problems becomes more diffuse once a more diffuse prior is used. Hence, they suggest using a sequence of prior distributions with larger variances to detect potential identification problems. I used an infinite variance for $\varkappa$. Hence I estimated the model first imposing a variance of 0.01, obtaining a posterior standard deviation of 0.0065. Assuming a variance of 0.05 leads to a posterior standard deviation of 0.0074.

Turning to the steady state values, the check still refers to the financial sector values. They are two: the steady state risk premium and the steady state capital-net worth ratio. As showed in the BGG appendix they are highly non linearly correlated. Hence once controlled for one of them the other is controlled as a consequence. The check I did focuses on the premium steady state. I pushed it first to an annual 4% and then to a 6%. The corresponding implied capital-net worth steady state values are 2.25 and 2.44, respectively. Changing the premium affects also $\varkappa$ and hence the mean of the prior distribution. It becomes 0.09 and 0.17, respectively. Results hold in the sense that the estimation has still nice properties, but of course $\varkappa$ is different, i.e. closer to the new prior mean. Nevertheless, I think that 2% is a reasonable value for the steady state premium for the Euro Area. An argument in favor of that value, among others, is that for instance in the forth quarter of 2008, the worst quarter ever of the crisis in terms of spreads, the BBB graded corporate bonds spread was about 4.85% while the AA graded corporate bonds spread was about 1.4%.[28] In addition, Queijo (2008) estimates the

[28] See the ECB Monthly Bulletin 03/2009.

steady state risk premium at 3.6, but she highlights that the value is higher than the one reported in De Fiore and Uhlig (2005) for the Euro Area: they report a risk premium on loans between 1.6 and 2.7%.

6. Concluding remarks

In this paper I estimated a New Keynesian Dynamic Stochastic General Equilibrium model à la Smets and Wouters (2003, 2005, 2007) featured with financial frictions à la BGG, i.e. featured with the financial accelerator mechanism, for the Euro Area for the period 1980q1 to 2008q3.

The main aim is to estimate a time series for the unobserved risk premium entrepreneurs have to pay on their loans given the risky nature of their projects and the asymmetric information existing between them and the banks providing the funds.

Before moving to the dynamic analysis of the estimated series, I first proceeded to its graphical analysis to capture salient features. From this quick look no relevant regularities in the premium's behaviour emerged. In fact, in the recession periods it turned out to be either pro or counter-cyclical. This suggested me that a deeper investigation on the causes of those not systematic movements would have been interesting, because they are the main difference of the premium in the Euro Area with respect for instance to the US one.

Second, I searched for what can be called an external validation of the estimated series. To do that I relied on its comparison with some available proxies for the Euro Area for it, represented by the spreads of the risk return over the risk free interest rate (the ten years government bonds interest rate in my case). The comparison is for the period 2000q1 to 2008q3 (because of the shortness of the available proxies).

That validation shows that the model with financial frictions can generate a series for the premium, without using any financial macroeconomic aggregates, highly correlated (about 65%) with the A grade corporate bonds spread. This allows me to rely on the goodness of the series with a certain degree of confidence.

As for the dynamic properties of the premium, two exercises have been done: the variance decomposition and the IRFs analysis. The former with the aim of understanding the stochastic sources behind the premium's movements. The latter to evaluate the impact that those sources have on the premium itself.

The exercises highlight first that the premium is driven mainly by four shocks: investment specific, technology and labour supply shocks from the supply side, and the monetary policy shock from the demand side. Second, those four shocks have different impacts on the premium. Monetary policy and labour supply shocks lead to a counter-cyclical premium, while the other two generate a cyclical response.

The main conclusion is that, different from the US evidence, in the Euro Area the premium does not display any relevant regularity, because it is driven by several stochastic forces with opposite implications for its behaviour.

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Appendix A. Steady state values

The steady state value of the return on capital R^k is

$$R^k = SR^n$$
$$R^k = Re^k + 1 - \delta$$

where $S = 1.005$ is the steady state level of the finance premium. Remembering that $R^n = (1+i) = (1+r) = \frac{1}{\beta}$ (because of the zero inflation steady state), I can write Re^k as

$$Re^k + 1 - \delta = SR^n$$
$$Re^k = S\frac{1}{\beta} - 1 + \delta$$

The real marginal cost is the inverse of the mark-up

$$MC = \left(\frac{\theta - 1}{\theta}\right)$$

I also know that marginal costs are

$$MC = \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}(Re^k)^{\alpha}(W)^{1-\alpha}$$

Solving for W

$$W = \left[\frac{MC(1-\alpha)^{1-\alpha}(\alpha)^{\alpha}}{(Re^k)^{\alpha}}\right]^{1/(1-\alpha)}$$

From the entrepreneurs's cost minimization problem I have

$$Re^k = \alpha MC\frac{Y}{K}$$
$$W = (1-\alpha)MC\frac{Y}{L}$$

Combining the two

$$W = (1-\alpha)Re^k\frac{1}{\alpha}\frac{Y}{L}\frac{K}{Y}$$

Re-arranging and solving for L/K

$$\frac{L}{K} = \frac{(1-\alpha)}{\alpha}\frac{Re^k}{W}$$

Profits are

$$\Pi = \lambda_d Y - Re^k K - WL - F$$

where λ_d is the price mark up. I know that in equilibrium $Y = Re^k K + WL$, and that thanks to the fixed cost profits are zero in steady state. Hence.

$$\Pi = \lambda_d Y - Y - F = 0$$

Solving for F

$$F = (\lambda_d - 1)Y$$

which implies that

$$\lambda_d = 1 + \frac{F}{Y} \tag{A.1}$$

But Y still includes F. Hence an alternative way to write it is

$$F = (\lambda_d - 1)\left[\left(\frac{K}{L}\right)^{\alpha} L - F\right]$$

Solving again for F

$$F = \frac{\lambda_d - 1}{\lambda_d}\left(\frac{K}{L}\right)^{\alpha} L \tag{A.2}$$

Combining Eq. (A.2) with Eq. (A.1) the steady state value of Y is

$$Y = \frac{1}{(1 + F/Y)}\left(\frac{K}{L}\right)^{\alpha} L$$

Solving for K/Y

$$\frac{K}{Y} = \left(\frac{L}{K}\right)^{\alpha-1}\left(1 + \frac{F}{Y}\right)$$

Using this expression I get I/Y

$$\frac{I}{Y} = \delta\frac{K}{Y}$$

From the resource constraint I can derive an expression for C

$$Y = C + I + G$$

Then

$$C = Y - I - gY$$

where $g \equiv G/Y$. Hence

$$g = 1 - \left(\frac{C}{Y} + \frac{I}{Y}\right)$$

Using the production function

$$C = (1 - g)\left[\left(\frac{K}{L}\right)^{\alpha} L - F\right] - I$$

Substitute out F using Eq. (A.2) and I with its steady state expression δK

$$C = (1 - g)\left[\left(\frac{K}{L}\right)^{\alpha} L - \frac{\lambda_d - 1}{\lambda_d}\left(\frac{K}{L}\right)^{\alpha} L\right] - \delta K$$
$$C = (1 - g)\frac{1}{(1 + F/Y)}\left(\frac{K}{L}\right)^{\alpha} L - \delta K$$

Or equivalently

$$C = \left[(1 - g)\frac{1}{(1 + F/Y)}\left(\frac{K}{L}\right)^{\alpha} - \delta\frac{K}{L}\right] L$$

Solving for C/K

$$\frac{C}{K} = (1 - g)\frac{1}{(1 + F/Y)}\left(\frac{L}{K}\right)^{1-\alpha} - \delta$$

The steady state value of capital is given by

$$K = \frac{W(\theta^w - 1)}{\theta^w}\left\{\left[(1 - h)\frac{C}{K}\right]^{-\sigma_c}\left(\frac{L}{K}\right)^{-\sigma_L}\right\}^{1/(\sigma_c + \sigma_L)}$$

As a consequence

$$C = \frac{C}{K}K; \qquad I = \delta K; \qquad Y = \frac{C+I}{1-g}; \qquad L = \frac{L}{K}K; \qquad NW = \frac{NW}{K}K$$

where NW/K is obtained from the entrepreneur-bank optimal contract's first order conditions.

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