The role of financial frictions in the 2007-2008 crisis: an estimated DSGE model*

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Abstract

After the banking crises experienced by many countries in the 1990s and in 2008, financial market conditions have turned out to be a relevant factor for economic fluctuations. The purpose of this paper is to determine whether frictions in financial markets are important for business cycles, and whether the recent 2007-2008 crisis has enhanced (or reduced) the size of some shocks and the role played by financial factors in driving economic fluctuations.

The analysis is based on both versions of the Smets and Wouters DSGE model (2003, 2007), which are estimated using Bayesian techniques. Both versions are augmented to include an endogenous financial accelerator mechanism which arises from information asymmetries between lenders and borrowers that create inefficiencies in financial markets. The analysis is based on the same data-set as in the Smets and Wouters model, but extended to 2010.

One first set of results suggests that the recent crisis has amplified the relevance of financial factors. Overall, this paper proves that the Smets and Wouters model augmented with a financial accelerator mechanism is suitable to capture much of the historical developments in U.S. financial markets that led to the financial crisis in 2007-2008. In particular, the concomitance of a peak in leverage ratio and the deepening of the recession supports the argument that leverage and credit have an important role to play in shaping the business cycle, in particular the intensity of recessions.

JEL classification: C11, E22, E32, E44.

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1 Introduction

After the banking crises experienced by many countries in the 1990s and in 2008, financial market conditions have turned out to be a relevant factor for economic fluctuations. As a consequence, the financial accelerator approach has become wide-spread in the literature and many empirical studies have introduced this type of frictions in DSGE models.

A first strand of the empirical literature, following Bernanke, Gertler and Gilchrist (1999), states that financial market frictions are relevant for the U.S. and the euro area (Levin, Natalucci and Zakrajšek (2004); Christensen and Dib (2008); De Graeve (2008); Queijo (2009)). This strand of the literature disregards the potential role of financial factor as a source of shocks itself and assumes that financial frictions work as a mechanism of transmission of macroeconomic shocks. Based on this modelling framework, these studies conclude that financial frictions are important to understand the transmission of non-financial aggregate shocks.

More recently, after that the 2007-2008 crisis has featured a significant disruption of financial intermediation, a second strand of literature has emphasized the role of financial sector as a source of shocks and not only as a.mechanism of propagation. This more recent literature is unanimous in concluding that banking sector shocks and investors' sentiment explain the largest share of the contraction in the economic activity in the euro area during the 2007-2008 crisis (Gerali, Neri, Sessa and Signoretti (2010); Martin and Ventura (2010); Kollmann, Enders and Müller (2011)) and the quick and strong propagation of the crisis (Gertler and Kiyotaki (2009)).

However, results reached by the more recent strand of the literature are not at odds with those stated by the first strand of literature based on the original approach proposed by Bernanke, Gertler and Gilchrist (1999). The more recent strand of the literature developed after the crisis emphasizes the role of credit supply factors and concludes that financial shocks (namely, shocks that either push up the cost of loans or decrease the demand of credit) explain a large share of contraction in the euro area economic activity. The so-called net-worth shock in Bernanke, Gertler and Gilchrist (1999), by affecting entrepreneur's net worth, also affects borrowing needs and therefore might have similar effects as a financial shock that affects the demand of credit.

This paper follows the approach of the first strand of the literature and attempts to quantify the role of such frictions in business cycle fluctuations by estimating a DSGE model with the financial accelerator mechanism à la Bernanke, Gertler and Gilchrist (1996, 1999) using a Bayesian maximum Likelihood approach. To this purpose, I extend the Smets and Wouters model (henceforth, SW) by adding financial frictions. I consider two alternative versions of the Smets and Wouters model. The first version (denoted as SW 2007[1]) includes a kind of "exogenous financial accelerator mechanism" that works through an exogenous disturbance term, the risk premium shock. This shock represents a wedge between the interest rate controlled by the central bank and the return on assets held by the households. A positive shock to this wedge increases the required return on assets and hence reduces current consumption. At the same time, it also increases the cost of capital and hence reduces the value of capital and investment. This shock works as an exogenous financial accelerator mechanism, as it has similar effects as so-called net worth shock in Bernanke, Gertler and Gilchrist (1999) and Christiano, Motto and Rostagno (2010), which explicitly model the external finance premium. This exogenous financial accelerator effect is lacking in a previous version of the SW model (denoted as SW 2003[2]), where the risk premium shock is replaced by a discount factor shock, which affects only the intertemporal consumption Euler equation.

Starting from both versions of the SW model, I introduce an endogenous financial accelerator mechanism following the pioneer paper of Bernanke, Gertler and Gilchrist (1996, 1999) (henceforth, BGG). This endogenous mechanism is based on information asymmetries between lenders and entrepreneurs that create inefficiencies in financial markets, affect the supply of credit and amplify business cycles. Specifically, during booms (recessions), an increase (fall) in borrowers' net worth decreases (increases) their cost of obtaining external funds, further stimulating (reducing) investment and amplifying the effects of the initial shock[3].

[1] Smets and Wouters (2007), published in the *American Economic Review*, American Economic Association, Vol. 97, No. 3, pp. 586-606, June.

[2] Smets and Wouter (2003) published in *Journal of the European Economic Association,* MIT Press, Vol. 1, No. 5, pages 1123-1175.

[3] This approach has also been adopted by Carlstrom and Fuerst (1997) and Christiano, Motto and Rostagno (2010). Differently in Kiyotaki and Moore (1997) the financial accelerator mechanism arises from the reduction of asset price used as collateral. Therefore, borrowers that use these assets as collateral are limited in their ability to borrow, and hence to invest, as the market value of collateral has been

I introduce the full set of structural shocks as in the SW 2007 model: three shocks arising from technology and preferences (a productivity shock, a shock to the investment adjustment cost function, and a government consumption shock); two "cost-push" shocks (modelled as shocks to the mark-up in the goods and labour markets) and a monetary policy shock. To estimate the parameters of the model and the stochastic processes governing the structural shocks, I use the same seven key macroeconomic time series for the U.S. economy used in the SW model: real GDP, consumption, investment, the GDP deflator, the real wage, employment and the nominal short-term interest rate.

I estimate the model on U.S. data using Bayesian methods. One benefit of using Bayesian methods is that we can include prior information about the parameters, especially information about structural parameters from microeconomic studies. Data are available on quarterly basis from 1947 up to 2010.

Discussion on the source of business cycle has recently revamped, following the most severe and protracted recession. The paper contributes to this debate in three respects. First, I assess the influence of the great recession on estimates results. For this purpose, I re-estimate the standard Smets and Wouters models over the whole sample up to 2010, so to include the effects of crisis times. The comparison between these estimates with those based on the sample up to 2004 proves that the recent crisis has amplified the role of financial factors. Second, I check the relevance of the financial accelerator mechanism. For this purpose, once included the crisis times 2007-2010, I estimate an alternative specification of the model, which entails financial frictions as an endogenous mechanism. Estimation results conclude that financial factors have enhanced the relevance of financial-type shocks in driving economic fluctuations. Third, I identify the shocks that are responsible for the financial crisis and are accounted as the key sources of economic fluctuations. In this respect, I demonstrate that leverage and credit have played an important role in shaping the business cycle. Beside on this empirical evidence, the paper draws policy recommendations in favour of a more prudential regulation of financial markets. Moreover, results in this paper help interpreting movements in the premium in relation to shocks driving the business cycle and are in line with the events that started

reduced. A partial list of works in this strand of literature includes Christiano, Gust and Roldos (2002), Iacoviello (2005), Iacoviello and Neri (2009), Aoki, Benigno and Kiyotaki (2009) and Mendoza (2008).

with the subprime crisis in the summer 2007 and triggered the financial crisis.
A similar analysis has recently been proposed by Gilchrist, Ortiz and Zakrajšek (2009). However, their analysis presents two pitfalls. First, the conclusion in favour of the presence of a financial accelerator mechanism is at odds with the low estimate of the elasticity of the external premium. Second, no marginal likelihood is reported to support the conclusion in favour of the model with financial accelerator. This paper avoids these pitfalls and attempts to determine if frictions in credit markets have become more important for business cycles especially during the recent financial crisis, even if realistic frictions in goods and labour markets are added to a model with frictions in financial markets.
The rest of the paper is structured as follows. Section 2 presents the model. In Section 3, I shortly discuss the estimation methodology. Section 4 presents estimation results. In Section 5, I analyze the contribution of each shock to the developments in U.S. economy and I discuss the historical relevance of disturbances for macroeconomic performance, with a particular focus on the most recent financial crisis. Finally, Section 6 summarizes the main conclusions.

2 Model presentation

This model already entails a kind of financial accelerator mechanism that operates exogenously through a risk premium shock. However, to assess the role played by financial factors, both endogenous and exogenous, the analysis also takes into account an alternative version of the Smets and Wouters model that does not entail the exogenous financial accelerator mechanism (Smets and Wouters (2003))[4]. Both versions are augmented to include the endogenous financial accelerator mechanism à la Bernanke, Gertler and Gilchrist (1999). For reason of clarity, the description of the model focuses on the Smets and Wouters (2007)[5] version extended to allow the endogenous financial accelerator mech-

[4] The main difference between the two versions of the Smets and Wouters model is that in the Smets and Wouters (2007) the discount factor shocks is replaced by the risk premium shock. In contrast to a discount factor shock, the risk premium shock affects in the same direction both consumption and investment, while the discount factor shock affects only consumption. Therefore, the risk premium shock helps to explain the comovement of consumption and investment.

[5] For the general description, I refer mainly at Smets and Wouters (2007) published in the *American Economic Review*, American Economic Association, Vol. 97, No. 3, pages 586-606, June.

anism. The model closely follows Smets and Wouters (2007), except in the presence of financial frictions. Therefore, for an exhaustive description of the model, I refer the reader to the original paper (Smets and Wouters (2007)). However, to make the paper self-contained, in this section I shortly present directly the log-linearized version of the model and I concentrate the discussion on the aspects related to financial frictions.

Output (y_t) is composed by consumption (c_t), investment (i_t), capital-utilization costs that are a function of the capital utilization rate (z_t^k), and exogenous spending (g_t). I assume that exogenous spending follows an $AR(1)$ process with an IID-Normal error term and is also affected by the productivity shock[6] as follows: $g_t = \rho_g g_{t-1} + \eta_t^g + \rho_{ga}\eta_t^a$

$$y_t = \frac{c}{y}c_t + \frac{i}{y}i_t + g_t + [r - (1-\delta)] \begin{pmatrix} \frac{i}{y} \\ \frac{i}{k} \end{pmatrix} z_t^k \tag{1}$$

where $\frac{c}{y} = 1 - \frac{g}{y} - \frac{i}{y}, \frac{i}{y} = [\gamma - (1-\delta)]\frac{k}{y}$ and the terms $[r - (1-\delta)] \left(\frac{i}{y}/\frac{i}{k}\right) z_t^k$ measures the cost associated with variable capital utilization. In the model entailing financial frictions, this standard aggregate resource constraint is augmented with a term capturing the cost of bankruptcy

$$y_t = \frac{c}{y}c_t + \frac{i}{y}i_t + g_t + [f - (1-\delta)] \begin{pmatrix} \frac{i}{y} \\ \frac{i}{k} \end{pmatrix} z_t^k + \begin{pmatrix} \frac{i}{y} \\ \frac{i}{k} \end{pmatrix} f\left(1 - \frac{r}{f}\right)\left(1 - \frac{1}{lev}\right)\left(r_t + p_t^k + k_t\right) \tag{2}$$

where the cost associated with variable capital utilization is now $[r - (1-\delta)] \left(\frac{i}{y}/\frac{i}{k}\right) z_t^k$. The term $\begin{pmatrix} \frac{i}{y} \\ \frac{i}{k} \end{pmatrix} f\left(1 - \frac{r}{f}\right)\left(1 - \frac{1}{lev}\right)\left(r_t + p_t^k + k_t\right)$ measure the bankruptcy costs, where $lev = \frac{p^k k}{n}$ is the steady-state value of the leverage ratio, that is the ratio of capital to net worth. Households maximize a non-separable[7] utility function with two arguments

[6] The latter is empirically motivated by the fact that, in estimation, exogenous spending also includes net exports, which may be affected by domestic productivity developments.

[7] The non-separability of the utility function implies that consumption will also depend on expected

(goods and labour effort) over an infinite life horizon. Aggregate consumption evolves according to

$$c_t = c_1 c_{t-1} + c_2 E_t c_{t+1} + c_3 \left(l_t - E_t l_{t+1}\right) - c_4 \left(r_t - E_t \pi_{t+1} + \varepsilon_t^b\right) \tag{3}$$

$$c_1 = \left(\frac{\frac{h}{\gamma}}{1+\frac{h}{\gamma}}\right); c_2 = \left(\frac{1}{1+\frac{h}{\gamma}}\right);$$

$$c_3 = \frac{\sigma - 1}{\sigma\left(1+\frac{h}{\gamma}\right)\lambda_w} \frac{(1-\alpha)}{\alpha} \frac{r^k \frac{k}{y}}{\frac{c}{y}}; c_4 = \left[\frac{1-\frac{h}{\gamma}}{\sigma\left(1+\frac{h}{\gamma}\right)}\right]$$

where the parameter h introduces habit in consumption, γ is the steady state growth and σ represents the inverse of elasticity of intertemporal substitution. Equation (3) states that current consumption (c_t) depends on a weighted average of past and expected future consumption and on expected growth in hours worked ($l_t - E_t l_{t+1}$), the ex-ante real interest rate ($r_t - E_t \pi_{t+1}$), and a disturbance term ε_t^b. The disturbance is assumed to follow an $AR(1)$ process with an IID-Normal error term: $\varepsilon_t^b = \rho_b \varepsilon_{t-1}^b + \eta_t^b$ and represents a wedge between the interest rate controlled by the central bank and the return on assets held by the households. A positive shock to this wedge increases the required return on assets and reduces current consumption. At the same time, it also increases the cost of capital and reduces the value of capital and investment, as shown in equation (5). This shock has similar effects as so-called net-worth shocks in Bernanke, Gertler and Gilchrist (1999) and Christiano, Motto and Rostagno (2010), which explicitly model the external finance premium.

Investment dynamic is governed by

$$i_t = \frac{1}{1+\beta\gamma}\left[i_{t-1} + \beta\gamma E_t i_{t+1} + \frac{1}{\gamma^2 \varphi} p_t^k\right] + \varepsilon_t^i \tag{4}$$

where p_t^k is the current value of capital stock, φ is the steady-state elasticity of the capital adjustment cost function, and β is the discount factor applied by households. The disturbance to the investment-specific technology process is assumed to follow an

employment growth. Therefore, when the elasticity of the intertemporal substitution is smaller than one ($\sigma > 1$), consumption and labour supply are complements.

$AR(1)$ process with an IID-Normal error term: $\varepsilon_t^i = \rho_i \varepsilon_{t-1}^i + \eta_t^i$.

The corresponding arbitrage equation for the value of capital is given by

$$p_t^k = -(f_t + \varepsilon_t^b) + \frac{r^k}{r^k + (1-\delta)} r_{t+1}^k + \frac{(1-\delta)}{r^k + (1-\delta)} p_{t+1}^k \tag{5}$$

where f_t is the external cost of funding and r_t^k is the rental cost of capital. This equation states that the current value of the capital stock depends positively on its expected future value and the expected real rental rate on capital and negatively on the ex-ante cost of external funding and the risk premium disturbance. In the SW (2003) version of the Smets and Wouters model that does not entail the risk premium shock, equations (3) and (5) become:

$$c_t = c_1 c_{t-1} + c_2 E_t c_{t+1} + c_3 \left(l_t - E_t l_{t+1}\right) - c_4 \left(r_t - E_t \pi_{t+1} + \varepsilon_t^b\right) \tag{6}$$

Hereby, where ε_t^b has to be interpreted as a shock to preferences, that enter only in the consumption Euler equation and hence affects only consumption and does not affect the price of capital

$$p_t^k = -(r_t - \pi_{t+1}) + \frac{r^k}{r^k + (1-\delta)} r_{t+1}^k + \frac{(1-\delta)}{r^k + (1-\delta)} p_{t+1}^k \tag{7}$$

Following BGG (1998), I assume the existence of an agency problem that makes external finance more expensive than internal funds. The entrepreneurs costless observe their output which is subject to a random outcome. Foreign lenders incur an auditing cost to observe an entrepreneur's output. After observing her project outcome, an entrepreneur decides whether to repay her debt or to default. If she defaults, lenders audit the loan and recover the project outcome less monitoring costs. Accordingly, the marginal external financing cost is equal to a gross premium for external funds over the gross real opportunity costs equivalent to the riskless interest rate. Thus, the demand for capital should satisfy the following optimality condition which states that the real expected return on capital is equal to the real cost on external funds:

$$E_t f_{t+1} = (r_t - E_t \pi_{t+1}) + \omega(p_t^k + k_{t+1} - n_{t+1}) \tag{8}$$

The gross external finance premium ($prem$) depends on the borrowers leverage ratio ($p_t^k + k_t - n_t$) and the elasticity of the premium with respect to the leverage ratio (ω):

$$prem_t = E_t f_{t+1} - (r_t - E_t \pi_{t+1}) = \omega(p_t^k + k_{t+1} - n_{t+1}) \quad (9)$$

The entrepreneur's net worth is defined as

$$\frac{1}{\nu f} n_{t+1} = (lev) f_t - \omega(lev - 1)(p_{t-1}^k + k_t) - (lev - 1)(r_{t-1} - \pi_t) + [\omega(lev - 1) + 1] n_t \quad (10)$$

As the leverage ratio rises, the risk premium also rises. The higher risk premium will increase the cost of borrowing and, on the other hand, the lower price of capital will decrease the return on capital. Then, the entrepreneurial net worth will decrease at the end of the period and, other things being equal, the leverage ratio will be higher. This mechanism amplifies the recession.

Output is produced using capital (k_t) and labour services (l_t).

$$y_t = \Phi_P [\alpha k_t + (1 - \alpha) l_t + \varepsilon_t^a] \quad (11)$$

The parameter α captures the share of capital in production, and the parameter Φ_P is one plus the share of fixed costs in production, reflecting the presence of fixed costs in production. Disturbances in total factor productivity are captured by the term $\varepsilon_t^a = \rho_a \varepsilon_{t-1}^a + \eta_t^a$ that follows an $AR(1)$ process with an IID-Normal error term.

The current capital services depend on capital installed in the previous period (k_{t-1}^p) and the degree of capital utilization (z_t)

$$k_t = k_{t-1}^p + z_t \quad (12)$$

where the accumulation of installed capital (k_t^p) is a function of the flow of investment and of the relative efficiency of these investment expenditures as captured by the investment specific technology disturbance:

$$k_t^p = \frac{(1-\delta)}{\gamma} k_{t-1}^p + \frac{\delta}{\gamma} i_t + \delta\gamma^2 \varphi \varepsilon_t^i \tag{13}$$

and the degree of capital utilization is a positive function of the rental rate of capital:

$$z_t = \frac{1-z^k}{z^k} r_t^k \tag{14}$$

where z^k determines the elasticity of utilization costs with respect to capital inputs. The rental rate of capital is derived by cost minimization

$$r_t^k = w_t + l_t - k_t \tag{15}$$

Price and wage setting follow a Calvo-price adjustment mechanism with partial indexation. Due to price stickiness and partial indexation, prices and wages adjust sluggishly to their desired mark-up. Price mark-up (μ_t^p) is determined, under monopolistic competition, as the difference between the marginal product of labour (mpl_t) and the real wage (w_t):

$$\mu_t^p = mpl_t - w_t = \alpha r_t^k + (1-\alpha) w_t + \varepsilon_t^a \tag{16}$$

Similarly the wage mark-up is determined as the difference between the real wage and the marginal rate of substitution between working and consuming:

$$\mu_t^w = w_t - mrs_t = w_t - \left[w_t \sigma_l l_t + \frac{1}{1-\frac{h}{\gamma}} c_t + \frac{\frac{h}{\gamma}}{1-\frac{h}{\gamma}} c_{t-1} \right] \tag{17}$$

where σ_l is the elasticity of labour supply with respect to the real wage and h is the habit parameter in consumption.

Profit maximization by price-setting firms gives rise to the following New-Keynesian Phillips curve:

$$\pi_t = \frac{1}{1+\beta\gamma\iota_p} \left\{ \beta\gamma E_t \pi_{t+1} + \iota_p \pi_{t-1} + \pi_{mk} \mu_t^p \right\} + \varepsilon_t^p \tag{18}$$

where $\pi_{mk} = \dfrac{(1-\xi_p)(1-\beta\xi_p)}{\xi_p[(\Phi_P - 1)\varkappa_p + 1]}$. Inflation ($\pi_t$) depends positively on past and expected future inflation, negatively on the current price mark-up, and positively on a price mark-up disturbance (ε_t^p). The price mark-up disturbance is assumed to follow an $ARMA(1,1)$ process with an IID-Normal error term: $\varepsilon_t^p = \rho_p \varepsilon_{t-1}^p + \eta_t^p - \mu_p \eta_{t-1}^p$. The inclusion of the MA term is designed to capture the high-frequency fluctuations in inflation. The speed of adjustment to the desired mark-up depends, among others, on the degree of price stickiness (ξ_p), the degree of indexation to past inflation (ι_p), the curvature of the Kimball goods market aggregator ($\varkappa_p$), and the steady-state mark-up, which in equilibrium is itself related to the share of fixed costs in production (Φ_P) through a zero-profit condition. Similarly, Calvo-style wage setting implies

$$w_t = \frac{1}{1+\beta\gamma}\left\{\beta\gamma E_t\pi_{t+1} + w_{t-1} + \iota_w\pi_{t-1} - (1+\beta\gamma\iota_w)\pi_t + \beta\gamma E_t\pi_{t+1} + w_{mk}\mu_t^w\right\} + \varepsilon_t^w \tag{19}$$

where $w_{mk} = \dfrac{(1-\xi_w)(1-\beta\gamma\xi_w)}{\xi_w[(\Phi_w - 1)\varkappa_w + 1]}$. The real wage is a function of expected and past real wages, expected, current, and past inflation, the wage mark-up, and a wage mark-up disturbance (ε_t^w). The wage mark-up disturbance is assumed to follow an $ARMA(1,1)$ process with an IID-Normal error term: $\varepsilon_t^w = \rho_w \varepsilon_{t-1}^w + \eta_t^w - \mu_w \eta_{t-1}^w$. As in the case of the price mark-up shock, the inclusion of a MA term allows us to pick up some of the high-frequency fluctuations in wages. The speed of adjustment to the desired wage mark-up depends on the degree of wage stickiness (ξ_w), the degree of wage indexation (ι_w) and the demand elasticity for labour, which itself is a function of the steady-state labour market mark-up ($\Phi_w - 1$) and the curvature of the Kimball labour market aggregator ($\varkappa_w$). Finally, the monetary authority follows a generalized Taylor rule in setting the short-term interest rate (r_t) in response to the lagged interest rate, current inflation, the current level and the current change in the output gap and an exogenous disturbance term $\varepsilon_t^r = \rho_r \varepsilon_{t-1}^r + \eta_t^r$ that is assumed to follow an $AR(1)$ process with an IID-Normal error term

$$r_t = \rho r_{t-1} + \rho_\pi(1-\rho)\pi_t + \rho_y(1-\rho)(y_t - y_t^P) + \rho_{dy}\left[(y_t - y_{t-1}) - (y_t^P - y_{t-1}^P)\right] + \varepsilon_t^r \tag{20}$$

3 Methodology for estimation and model evaluation

The model presented in the previous section is estimated with Bayesian estimation techniques[8] using seven key macroeconomic quarterly U.S. time series as observable variables: the log difference of real GDP, real consumption, real investment the log difference of the GDP deflator, the real wage, log hours worked, and the federal funds rate.[9] The data sample is 1966-2010, at quarterly frequency.[10] The corresponding measurement equation is:

$$Y_t = \begin{bmatrix} d\log GDP_t \\ d\log CONS_t \\ d\log INV_t \\ d\log W_t \\ \log HOURS_t \\ d\log P_t \\ FEDFUNDS_t \end{bmatrix} = \begin{bmatrix} \bar{\gamma} \\ \bar{\gamma} \\ \bar{\gamma} \\ \bar{\gamma} \\ \bar{l} \\ \bar{\pi} \\ \bar{r} \end{bmatrix} + \begin{bmatrix} y_t - y_{t-1} \\ c_t - c_{t-1} \\ i_t - i_{t-1} \\ w_t - w_{t-1} \\ l_t \\ \pi_t \\ r_t \end{bmatrix} \tag{21}$$

where $\bar{\gamma} = 100(\gamma - 1)$ is the common quarterly trend growth rate to real GDP, consumption, investment and wages; $\bar{\pi} = 100\pi$ is the quarterly steady-state inflation rate and $\bar{r} = 100(\beta^{-1}\gamma^{\sigma}\bar{\pi})$ is the steady-state nominal interest rate; $\bar{l}$ is steady-state hours worked, which is normalized to be equal to zero.

I start by solving the model for an initial set of parameters. Then, after specifying the prior distributions for the parameters, I use the Kalman filter to calculate the likelihood function of the data (for given parameters). Combining prior distributions with the likelihood of the data, I obtain the posterior kernel which is proportional to the pos-

[8] Bayesian estimation methods of DSGE models have been initially proposed by Smets and Wouters (2003), Schorfheide and An (2005) and Del Negro et al. (2005). Smets and Wouters (2003) have applied full-information Bayesian methods to estimate a micro-founded macroeconometric model with rigidities and found that the model is competitive with an unrestricted Bayesian VAR, both in terms of goodness-of-fit and in terms of out-of-sample forecasting performance.

[9] The first four variables are provided by the U.S. Department of Commerce of the Bureau of Economic Analysis; wage and hours worked are provided by the U.S. Department of Labor, Bureau of Labor Statistics, interest rate is provided by the Board of Governors of the Federal Reserve System.

[10] The dataset starts in 1947. As in the original Smets and Wouters (2003), I decided to shorten the sample to 1957:Q1-2010:Q1 by dropping the first 10 years, as they results not to be representative of the rest of the sample. In addition the first 10 years are used as a training sample for calculate the marginal likelihood of unconstrained VARs. Finally, the first 4 observation are skipped in order to evaluate the likelihood, so that the sample starts in 1967:Q1.

terior density. The estimated posterior mode of the parameters is obtained by directly maximizing the log of the posterior distribution with respect to the parameters and an approximate standard error based on the corresponding Hessian.

In specifying most of the prior distributions of parameters, I follow SW 2007. Therefore, for an exhaustive discussion of prior elicitation and estimation methodology, I refer the reader to Smets and Wouters (2003, 2007). Hereby, I discuss only the priors of parameters describing the entrepreneurial sector and related to the endogenous financial accelerator mechanism (hereafter, FA), which is lacking in the original setting. The steady-state of the external cost of financing is calibrated to $1/\beta$ =1.01; the elasticity of leverage with respect to premium is normally distributed with a mean 0.05 and a standard error 0.02. The steady-state of the leverage ratio is also normally distributed in the range $[1, 3.5]$ with a mean 2 and a standard deviation 0.25. Finally, the probability of default is described by a beta distribution with mean 0.97 and standard deviation 0.02.

Bayesian model comparison is done pairwise, comparing the models through the posterior odds ratio defined as $PO_{ij} = \dfrac{p(M_i \mid Y)}{p(M_j \mid Y)} = \dfrac{p(Y \mid M_i)p(M_i)}{p(Y \mid M_j)p(M_j)}$, where $p(M_i \mid Y)$ and $p(M_j \mid Y)$ are the posterior probability respectively of model i and model j. The posterior odds ratio updates prior odds $p(M_i)$ and $p(M_j)$with the Bayes factor defined as

$$B_{ij} = \frac{p(Y \mid M_i)}{p(Y \mid M_j)} \tag{22}$$

Geweke (1999) proposes different methods to calculate the marginal likelihood $p(Y \mid M_i)$ and $p(Y \mid M_j)$ necessary for model comparison. Generally, the most popular is the modified harmonic mean because it works for all sampling methods and it is not sensitive to the step size. As an alternative, it is possible to use the Laplace approximation that assumes that the posterior distribution is close to a normal distribution. The advantage is that it can generate an approximation of the marginal likelihood very quickly, given the normality assumption and the estimated mode. It turns out that this approximation works very well in practice and it is often very close to the modified harmonic mean. Applying a more intuitive logarithmic scale, one can defined the log Bayes factor as the difference between the log likelihood of alternative model, namely $2\log(B_{ij}) = ML(M_i) - ML(M_j)$. Values of the log Bayes factor smaller than -2 suggest preference for model M_j, while values larger than 2 suggest preference for model M_i.

4 Estimation results

In this section, I start presenting estimation results[11] for four alternative specifications of the SW models, summarized in Chart 1. As a first step, I consider two alternative version of the Smets and Wouters model. The first version, defined as SW (2007), does not include explicitly an endogenous FA mechanism, but it entails a risk premium shock that simulates the FA mechanism. This shock has similar effects as the so called net-worth shock in Bernanke, Gertler and Gilchrist (1999), which explicitly models the endogenous FA mechanism and the external finance premium. On the contrary, in the second version of the Smets and Wouters model, defined as SW (2003), any kind of FA mechanism is lacking. Each of these two models is considered both in the original set-up and in an alternative set-up entailing an endogenous FA mechanism à la BGG (1999). Thereby, the number of model specifications rises to four. Finally, each of the four specifications is estimated both on the sample 1966:Q1-2010:Q1 and on a shorter sample up to 2004:Q4, in order to assess whether the recent global crisis has affected the main forces driving economic fluctuations.

The basic idea is to assess whether the introduction of an endogenous FA mechanism (partially) invalidates the exogenous FA mechanism (introduced through the risk premium shock). Moreover, the estimation results might help interpreting the recent economic developments and understanding whether or not the recent financial crisis has emphasized the role of financial factors. To this purpose, I first start comparing the eight specifications in term of their performance, and then I proceed to estimate parameters.

Table 1 reports the log likelihood for each of the four specifications of the model over the two samples. The model comparison based on the maximum likelihood and Bayes factors outlines some important results. First, the risk premium shock plays a key role, especially during the recent crisis, as proved by the better performance of the SW (2007) model compared to the SW (2003) model. The intuition is that the SW (2007) model introduces – even if through an exogenous mechanism – financial frictions that are completely

[11] All estimations are done with Dynare, version 4.3 (www.dynare.org).

neglected in the SW (2003) model. Second, the performance of both the SW (2003) and SW (2007) model improves when the endogenous FA mechanism à la BGG is included. However, the relative improvement of the endogenous FA mechanism is slightly lower if the estimation is carried over the sample up to 2010. This confirms what already stated, that is the recent crisis has revaluated the role of the risk premium shock as a source of exogenous financial frictions. Third, when the last crisis is included in the estimation sample, the advantages of the SW (2007) model, compared to the SW (2003) model, are amplified, as provided by the log Bayes factor becoming larger than 10. To summarize, results suggest that financial factors turn to have played a key role, both if they arise from an exogenous risk premium to the rate at which private sector accesses financial market, and if they arise from the deterioration of firms' balance sheets that widens the wedge between internal and external financing. In addition, the role of the exogenous risk premium shock results to be amplified during the recent crisis.

The results outlined from the model comparison are corroborated by the estimation results reported in Table 2. The endogenous FA mechanism substantially increases the persistence of the risk premium shock, while the volatility results to be slightly lower. Overall, the endogenous FA mechanism emphasizes the negative effect of the risk premium shock on investment decisions and hence on output, as showed in Figure 1. This result seems to prove that the introduction of endogenously driven financial frictions has emphasized – and not replaced – the role played by the risk premium shock, especially during the last recession. Opposite conclusions held for the investment shock: the endogenous FA mechanism increases the volatility of the investment shock, but reduces the persistence. Overall, the endogenous FA mechanism reduces the impact of the investment shock, as showed in Figure 2.

The estimates of the parameters linked to the financial accelerator mechanism – namely the leverage ratio and the elasticity of the finance premium – prove that firms' balance sheets have slightly deteriorated during the recession. Surprisingly, the estimate of the elasticity of the external finance risk premium over the longer sample including the crisis period is lower than that one estimated on the pre-crisis sample. However, the elasticity in this work results to be relatively high compared to other papers. For instance, Gilchrist, Ortiz and Zakrajšek (2009) estimate the elasticity of the external finance risk premium equal to 0.01, while in this work the estimate is equal to 0.025. Moreover, the leverage ratio results to be very volatile in the more recent period, especially from 2006Q1 onwards[12]. Therefore, the relatively high value of the estimate of the elasticity of the external finance risk premium combined with the high volatility of the leverage ratio in the more recent period gives a high external finance risk premium, even though the elasticity results to be lower than that one estimated over the sample excluding the crisis period. More generally, the recent recession has increased the volatility of the U.S. economy. This is reflected in the higher variance of the variables, once recent data are included (Table 3). Concerning the U.S. corporate leverage ratio, in this paper the estimate is higher than the value estimated in Queijo (2009) over the sample up to 2007:Q4. This result confirm that during 2008-2009 corporate sector has been more leveraged.

Turning to structural parameters, once the endogenous FA mechanism operates and the crisis period is included into the estimation sample, monetary policy results to be less reactive to inflation. This result is in line with the view sometimes expressed by policy-makers aiming to avoid a worsening of market sentiment (*e.g.*, Bini Smaghi, 2008). The prospect of hitting the ZLB calls central banks to cut interest rates by less than reaction function estimated on pre-crisis data would predict. An aggressive interest rate cut may be taken as a sign that policy-makers have a more pessimistic view of the economic outlook than market participants[13]. As a counterfactual, I have performed a conditional forecast of the interest rate starting in 2008Q2. The conditional forecast assumes that *(i)* the central bank faces exactly the same shocks as in the crisis period, that is the conditional path for the shock over the horizon 2008Q2-2010Q1 imposes that shocks are exactly those produced by the model over the whole estimation sample; *(ii)* the conditional path for the monetary policy shock imposes that the monetary shock is zero. The latter assumption

[12] The series of the leverage ratio is not shown in this paper. However, data and figure are available up to request.

[13] An opposite recommendation is prescribed by a strand of literature on monetary policy in the vicinity of the zero bound. Among these authors, Adam and Billi (2006) argue that at low interest rates, forward looking agents anticipate the possibility that future shocks might push the interest rate down to the ZLB. As a result, output and inflation are lowered today. To counteract this amplification mechanism, the central bank must therefore cut rates pre-emptively in order to raise expectations of future inflation and output. Furthermore, using dynamic programming techniques, Orphanides and Wieland (2000) find that the policy rate becomes increasingly sensitive to inflation as it falls and the likelihood that the ZLB will be reached rises.

for the conditional forecast implies that the monetary authority exactly implements its regular Taylor rule and the ZLB constraint is not binding; *(iii)* the FED implements either the pre-crisis Taylor rule or the Taylor rule estimated over the whole sample. The conditional forecast shown in Figure 3 suggests some important results. First, if the FED were not responding to the monetary shock, it should have cut the interest rate more aggressively than what it has effectively done. Of course, the FED cut the interest rate (mainly in 2008Q2 and 2008Q4, as proved by the observed series), but it was not allowed to further decrease the effective interest rate below the ZLB. Second, if the ZLB were not binding – as stated in the assumption *(ii)* – the Taylor rule estimated over the whole sample would respond more aggressively than the pre-crisis Taylor rule. The interest rate is negative in both cases. However, in the case of the Taylor rule estimated over the whole sample, the interest rate decreases more than in the case of the pre-crisis Taylor rule. Finally, in 2008Q2, the effective interest rate is lower than the interest rate implied by Taylor rules that do not respond to the monetary shock. This implies that in 2008Q2, the monetary shock to the Taylor rule was negative. This result points out that the FED has decreased interest rate pre-emptively, before the ZLB was hit. This result is in line with Gerlach and Lewis (2010) who find evidence that after the autumn 2008, the ECB, in response to worsening economic conditions, has cut interest rates more rapidly than the regular reaction function would have predicted.

An argument that might be raised to this analysis is that this work attempts to estimate this financial-type shock without including any financial variable (*e.g.* interest rate spreads) among observables. In this respect, I refer to Gilchrist, Ortiz and Zakrajšek (2009) as a counterfactual. They also estimate the Smets and Wouters (2007) model, augmented with a financial accelerator mechanism and extended to 2009:Q1. Their analysis differs in the number of shocks and selected variables: they include two financial shocks (namely, an external finance premium shock and a net-worth shock) and then they add to the set of observables two financial series, the logarithm of the leverage ratio and the credit spread. I point out that, even without adding additional financial shocks and financial series, the estimates obtained in this work are very close to those in Gilchrist, Ortiz and Zakrajšek (2009). Moreover, they calibrate the steady-state leverage ratio at

$lev = 1.7$, the value that corresponds to the average leverage ratio in the U.S. non-financial corporate sector over the sample period. Then, they estimate only the elasticity of the external finance premium and they conclude in favour of the presence of a financial accelerator mechanism even though they obtained a low estimate of the elasticity of the external premium. Hereby, compared to Gilchrist, Ortiz and Zakrajšek (2009), the estimate of the elasticity of the external premium results to be higher and the estimate of the leverage ratio is extremely close to their calibrated value. These findings provide a stronger support in favour of the presence of an operative financial accelerator mechanism in the U.S. economy.

Finally, the estimation results help interpreting movements in the premium in relation to shocks driving the business cycle. Figure 4 plots impulse response functions (IRFs) for the external risk premium, based on estimated parameters. The analysis proves that the premium is not necessarily countercyclical. The external risk premium becomes procyclical after three periods, conditional on a productivity shock. This finding is consistent with De Graeve (2008), while it contrasts with Bernanke, Gertler and Gilchrist (1999) and Queijo (2009), in which favourable productivity shocks reduce the premium and therefore boost investment. As explained in De Graeve (2008), the primary reason for the different responses lies in the form of adjustment costs. This paper features investment adjustment costs, while Bernanke, Gertler and Gilchrist (1999) features capital adjustment costs. In the case of investment 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. This implies that, in case of the productivity shock, the capital stock outgrows net worth, thereby increasing borrowing needs and the external finance premium. The same conclusion holds for the risk premium shock: a positive[14] risk premium shock increases the cost of capital and hence reduces investment. As the capital stock is much lower than net worth, borrowing needs and hence the external finance risk premium decrease, as well as investment and total output. The investment shock also leads to a procyclical external premium, by implying a reduction in the price of capital and hence a decrease in net

[14] Here positive refers to the fact that the risk premium is increasing, and not to the effects of the risk premium shock on output. A positive risk premium shock increases both the require return on assets and the cost of capital, and thereby it reduces both output components, that is consumption and investment.

worth. As entrepreneurial borrowing needs increase, the external premium results to be procyclical. The government consumptions shock, by crowding out private investments, reduces the price of capital and hence net worth. Borrowing needs increases and hence the external premium results countercyclical. The analysis proves that the positive effect on output of the productivity shock, the risk premium shock, the investment specific shock and the government spending shock are not overturned by the increase in the external risk premium. Therefore, the IRFs analysis proves how economic expansions may occur in the wake of increasing external finance premium. A price mark-up shock is associated with lower production and lower external premium: with higher market power, firms have an incentive to reduce production to maximize profits and are less limited in borrowing. Finally, the external finance premium is countercyclical conditional on a monetary policy shock. This finding is in line with those of Bernanke, Gertler and Gilchrist (1999) and De Graeve (2008): 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 – and hence the external finance risk premium – increase.

5 What were the main driving forces during the financial recession in 2007-2008?

5.1 Variance decomposition

Table 4 reports the contribution of each shock to the variance of the observed macroeconomic variables of both the model with financial frictions and the model without financial frictions. This decomposition provides insight into the main forces driving economic fluctuations. The contribution of each of the structural shocks to variance of the observed variables is reported on impact and at various horizons (2.5 years and 10 years). For a question of simplicity, I focus the analysis only on the SW (2007) with endogenous financial frictions, given that it yields the best performance in terms of likelihood, as proved in section 4.

The dominant forces behind short-term developments in the output are the productivity shock, the risk premium shock and the government shock. If the recession is introduced in conjunction with endogenous financial frictions, the risk premium becomes the dominant source of output fluctuations in the model entailing the recession. Confirming the large identified VAR literature on the role of monetary policy shocks (*e.g.* Christiano, Eichenbaum and Evans (2000)), monetary policy shocks contribute only a small fraction of the variance of output at all horizons.

Looking at the determinant of consumption, regardless of the presence of endogenous financial frictions, a big part of the variations is explained by the risk premium shock, at any horizon and especially before the occurrence of the crisis.

Not surprisingly, the investment shock explains the largest part of investment at any horizon. In the presence of endogenous financial frictions, the monetary policy shock causes a great deal of movements in the premium and partially replaces the investment shock in explaining variations in investment, especially during the occurrence of the crisis when financial frictions have played a determinant role. Therefore, the relevance of the investment shock is muted. Although the risk premium shock affects both components of output, it has a larger impact on consumption than investment, and the main source behind fluctuations in investment remains the investment shock.

By affecting output, the risk premium also affects hours worked and therefore proves to be the main source of short-run fluctuations also in hours worked. Similarly to output and consumption, the concomitance of the recession and the presence of endogenous financial frictions strengthens the role played by the risk premium shock. However, in the long-run, the wage mark-up shock becomes the dominant factor behind movements in hours worked.

Turning to the determinants of inflation, variations in the short-term inflation are mainly driven by the price mark-up shock. In the model without financial frictions, in the long-run, the wage mark-up shock dominates the price mark-up shock. This outcome remains valid also in the model entailing financial frictions but abstracting from the recession. However, once the sample is extended up to 2010, the recession emphasizes the role played by the price mark-up shock, which remains the dominant source of inflation variations both in the short-run and in the long-run. Monetary policy shock accounts only for a small fraction of inflation volatility. At the short and medium-term horizon, most of variations in the nominal interest rate are due to the various demand and productivity shocks. Once the estimation sample is extended to include the recession, the monetary policy is less aggressive due to the binding zero lower bound constraint. In this case, the price mark-up shock accounts for an even smaller fraction of inflation volatility.

Finally, wage developments are mostly explained by wage mark-up shock at any horizon. To some extent, this finding is not very surprising as wages are estimate to be highly sticky. It is therefore not very surprising that one needs quantitatively important shocks to account for the behaviour of wages.

To summarize, the introduction of an endogenous FA mechanism emphasizes the role played by the risk premium shock, especially during the recession in 2007-2008, while it reduces the relevance of the investment shock, especially in the long-run.

5.2 Historical decomposition

Figures 6-8 summarize the historical contribution of the various structural shocks to output developments and credit conditions in the U.S. from 2000 onwards, with a particular focus on the recent crisis. This decomposition is based on the best estimates of the various shocks in the SW (2007) model with endogenous FA mechanism. While obviously such decomposition must be treated with caution, it helps in understanding how the estimated model interprets specific movements in the observed data and therefore can shed some light on its plausibility.

Focusing on the decomposition of output, the risk premium shock and the investment shock mostly account for a significant portion of drop in output from 2007 onwards (Figure 6). This result accords well with the considerable damage that the recent financial crisis and recession have inflicted on the economy between the middle of 2007 and early 2009, most notably a significant tightening of credit. Moreover, the financial crisis has raised the cost of capital and hence discouraged investment. On the opposite side, fiscal policy has contributed quite significantly to the surge in output during the crisis. The stimulus package passed in early 2009 has successfully supported employment and output. However, in some quarters, much of the fiscal stimulus has been offset by consolidation measures at state and local level. Furthermore, accordingly to OECD data[15], productivity has increased strongly in the U.S. during the recession, and hence the fall in output has been moderate compared to other countries. Going backward, monetary policy and price mark-up shock also account for a portion of output variation between 2001 and 2006. In January 2001, as the economy weakened rapidly following the collapse of the dotcom bubble, the FED started to loosen monetary policy. The Federal Open Market Committee (FOMC) reduced the Federal Funds rate from 6.25 percent to 1.75 percent by the end of the year. Policy rates kept going down in 2002 and 2003, although at a markedly slower rate, reaching 1 percent on 25 June 2003. The Federal Funds rate was set to stay at this unusually low level for a full year, until 24 June 2004. The loose monetary policy contributed to the surge in output between 2001 and 2004. Two considerations motivated the decision to maintain low nominal interest rates over that period. First, employment was recovering more slowly than expected from the 2001 recession (the "jobless recovery"). Second, the FOMC was seriously concerned about the risks of a Japanese-style deflation, following the collapse of the U.S. equity markets. The perceived danger was that the FED would be forced to lower its policy rate to zero. In order to avoid this undesirable outcome, the FOMC started to provide "forward guidance", namely to announce that monetary policy would remain accommodative for an extended period of time, so as to anchor expectations of moderate price inflation. As deflationary risks started to fade and the economy's recovery took hold, the FOMC shifted towards tightening its monetary stance. Starting in June 2004, the FOMC increased interest rates gradually and measurably until June 2006, when they reached a plateau of 5.25 percent. The unexpected hike in interest rates accounts for a portion of drop in output between 2005 and 2007. Then, when the crisis was acute, the transmission mechanism of the monetary policy stimulus through its traditional instrument – the nominal interest rate – was less effective. With policy rates near to the lower bound, the FED was forced to use unconventional monetary policy measures to support activity in capital markets and the impaired banking system.

Similar conclusions are drawn for the decomposition of output components, that is consumption and investment[16]. Accordingly to national data, credit conditions tightened

[15] OECD (2010), *Economic Survey of the United States*, OECD, Paris.

[16] Figures with historical decomposition of consumption and investment are available upon request.

significantly and consumer and business expenditures fell 6% between the second quarter of 2008 and the second quarter of 2009. Concerning consumption, the risk premium shock, as a proxy of tightening credit conditions, explains the sharp increase during the crisis in the desire of households to save – for precautionary reasons – rather than spend. Concerning investments, the risk premium shock has limited lending opportunities to business and hence has depressed investments.

The analysis points out that financial factors play an important role in business cycle, both in the form of the exogenous risk premium shock and in the form of an endogenous financial accelerator mechanism. On the one hand, the direction of the risk premium shock has reversed course sharply in 2007—that is, from having a significantly expansionary effect on output (as well as on its components, consumption and investment) during the period 2004-2006 to having a negative influence on investment spending by the middle of 2007. This result supports the idea that financial crisis recessions tend to go hand to hand with slowdown in credit growth. One possible interpretation of the risk premium shock is that it behaves as a proxy of the health condition of the financial system. To corroborate this intuition, Figure 5 proves the existence of a correlation of the smoothed risk premium shock and the OECD Financial Condition index[17]. This index proves a tightening of financial conditions in the U.S. starting from the second half of 2008. As already discussed, hereby the risk premium shock plays a similar role as the net-worth shock in Bernanke, Gertler and Gilchrist (1999)[18]. The important difference is the risk premium shock is just an exogenous disturbance, while net worth is a key endogenous variable in the agency cost model.

Figure 7 depicts historical fluctuations of the leverage ratio based on the estimation results. The historical decomposition shows that the leverage ratio has peaked in the third quarter of 2008. More precisely, following the period of relatively low external financing

[17] A increase (decline) in the index implies an easing (tightening) of financial conditions, while a positive (negative) risk premium shock implies a contraction (expansion) in both consumption and investment and hence in output..

[18] Similarly, Justiniano, Primiceri and Tambarlotti (2011) demonstrate that a marginal-efficiency investment shock, that is a shock that affects the transformation of investment goods into productive capital, results to be the most important source of macro fluctuations. This specific investment shock plays a similar economic role to that of net worth in Carlstrom and Fuerst (1997). As a counterfactual, they re-estimate the model including the spread among the observables, but the interpretation of the marginal-efficiency investment shock as a proxy for the efficiency of the financial system remains valid.

costs, the leverage ratio has experienced a rise peaking in the third quarter of 2008. Then after 2008, leverage ratio has started to decrease, because households and companies seek to reduce leverage, so that spending and investment are primarily constrained by balance-sheet repair, not by the availability of credit[19]. The gradual decline in the leverage ratio reflects both demand and supply-side factors affecting credit to the corporate sector. As regards the demand side, lower levels of economic activity and weaker capital formation have contributed to reduce firms' need for external financing. On the supply side, even though this framework does not feature credit-supply factors as in Gerali, Sessa, Neri and Signoretti (2010), results point are consistent with the argument that the tighter credit standards applied by banks have contributed to firms' deleveraging by curtailing the growth of bank loans to the non-financial corporate sector[20]. The concomitance of a peak in leverage ratio and the deepening of the recession supports the argument that leverage and credit play a relevant role in shaping the business cycle, in particular the intensity of recessions. The underlying idea is that financial accelerator effects are also likely to be stronger when balance sheets are larger and thus more vulnerable to weakening.

Similar conclusions hold for the historical decomposition of the external finance risk premium, reported in Figure 8. In Section 4, I have showed the cyclical behaviour of the external finance risk premium conditional on the investment shock and the risk premium shock. These two shocks result to be the main drivers of the increase in the external risk premium during both the 2001 dotcom crisis and the 2007-2008 crisis. High inflation for most of the 2008 has been responsible of the increase in the external risk premium. However, these upward pressures have been mitigated by wage moderation and accommodative monetary policy during the same period. Developments in the external finance

[19] For instance, Mian and Sufi (2011) study economic developments in individual U.S. counties during the Great Recession. They find that higher income leverage going into the crisis is associated with much weaker spending growth after crisis.

[20] The model framework adopted in this paper differs from that one of Gerali, Sessa, Neri and Signoretti (2010). Here, I focus on the demand side of credit, while Gerali *et al.* (2010) emphasize the role of credit supply factors. However, results are not at odds. Gerali *et al.* (2010) find that financial shocks (namely, shocks that either push up the cost of loans or decrease the demand of credit) explain a large share of contraction in the euro area economic activity. In this paper, it is the risk premium shock that plays a key role in explaining macroeconomic fluctuations in the output. Now, even though this paper does not explicitly model the banking sector, the risk premium shock, as it is modelled in Smets and Wouters (2007), has similar effect as a shock that pushes up the cost of loan, as it increases the cost of capital and hence results in a firms' demand for investment.

premium are consistent with the primary credit rate, depicted in Figure 9. The primary credit rate is the rate at which corporate institutions in a good shape have access to credit. Therefore it gives a good description of credit conditions. Figure 9 shows that a first peak in the credit rate arises in 2006-early 2007, and a second increase arises in the third quarter of 2008.

6 Conclusions and policy implications

This paper provides evidence in support of the notion that financial frictions play an important role in the U.S. cyclical fluctuations. Based on the likelihood of alternative models, one first set of results suggests that the recent crisis has amplified the relevance of financial factors. Moreover, both estimates and the variance decomposition prove that the introduction of an endogenous FA mechanism has increased the role played by the risk premium shock, especially during the recession in 2007-2008, while it has decreases the relevance of the investment shock, especially in the long-run. The historical decomposition shows that the model entailing financial frictions is suitable to capture much of the historical developments in financial markets that led to episodes of financial crisis in 2007-2008. In addition, the concomitance of a peak in the leverage ratio and the deepening of the recession supports the argument that leverage and credit have an important role to play in shaping the business cycle, in particular the intensity of recessions.

The model also explains the gradual decline in the leverage ratio starting in the second quarter of 2009. On the demand side, lower levels of economic activity and weaker capital formation have contributed to reduce firms' need for external financing. On the supply side, the tighter credit standards applied by banks have contributed to firms' deleveraging by curtailing the growth of bank loans to the non-financial corporate sector. This set of results supports the argument that financial market frictions arising from asymmetric information and moral hazard play an important macroeconomic role as an amplification mechanism for disturbances in the economy. Therefore, some prescriptions can be drawn, as financial vulnerabilities have increased in a globalized economy. Prudential regulation and supervision policies should counter the accumulation of risks to financial system stability.

References

[1] Adam, K., and R. Billi (2006), "Optimal Monetary Policy under Commitment with a Zero Bound on Nominal Interest Rates", Journal of Money, Credit and Banking, Vol. 38, No. 7, pp. 1877-1905.

[2] Aoki, K. , Benigno, G. and N. Kiyotaki (2009), "Capital Flows and Asset Prices," CEPR Discussion Papers No. 921, Centre for Economic Performance, LSE.

[3] Bernanke, B., and M. Gertler (1989), "Agency Costs, Net Worth and Business Fluctuations." American Economic Review 79, pp.14-31.

[4] Bernanke, B. , Gertler, M. and S. Gilchrist (1996), "The Financial Accelerator and the Flight to Quality," The Review of Economics and Statistics, MIT Press, Vol. 78, No. 1, pp. 1-15, February.

[5] Bernanke, B. , Gertler, M. and S. Gilchrist (1999), "The Financial Accelerator in a Quantitative Business Cycle Framework," Handbook of Macroeconomics, in: J. B. Taylor & M. Woodford (ed.), Handbook of Macroeconomics, edition 1, Vol. 1, Chapter 21, pages 1341-1393 Elsevier.

[6] Bini Smaghi, L. (2008), ""Carefully with the d words!", speech given in the European Colloquia Series, Venice, 25 November 2008.

[7] Carlstrom, C. T and T. Fuerst (1997), "Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis," American Economic Review, American Economic Association, Vol. 87, No. 5, pp. 893-910, December.

[8] Christensen, I and A. Dib (2008), "The Financial Accelerator in an Estimated New Keynesian Model", Review of Economic Dynamics, Vol. 11, No. 1, pp. 155.-178.

[9] Christiano, L., Gust, C. and J. Roldos (2002), "Monetary Policy in a Financial Crisis", NBER Working Paper No. 9005.

[10] Christiano, L., Motto, R. and M. Rostagno (2010), "Financial Factors in Economic Fluctuations," Working Paper Series 1192, European Central Bank.

[11] De Graeve, F. (2008), "The External Finance Premium and The Macroeconomy: U.S. Post-WWII Evidence", Journal of Economic Dynamic and Control, Vol. 32, No. 11, pp. 3415-3440, November.

[12] Del Negro, M., Schorfheide, F., Smets, F. and R. Wouters (2007), "On the Fit of New Keynesian Models," Journal of Business & Economic Statistics, American Statistical Association, Vol. 25, pp. 123-143, April.

[13] Gerali, A., Neri, S. , Sessa, L. and F. Signoretti (2010), "Credit and Banking in a DSGE Model of the Euro Area," Journal of Money, Credit and Banking, Vol. 42. No.s1107-141, 09.

[14] Gerlach, S. and J. Lewis (2010), "The Zero Lower Bound, ECB Interest Rate Policy and the Financial Crisis", mimeo.

[15] Gertler, M., Gilchrist, S. and F. Natalucci (2003), " External Constraints on Monetary Policy and the Financial Accelerator", NBER Working Paper No.10128., pp. 107-141.

[16] Gertler, M. and N. Kiyotaki (2009), "Financial Intermediation and Credit Policy in Business Cycle Analysis", mimeo (in preparation for the Handbook of Monetary Economics), October 2009.

[17] Geweke, J. (1999), "Using Simulation Methods for Bayesian Econometric Models: Inference, Development and Communication," Econometric Reviews, Taylor and Francis Journals, Vol. 18, No.1, pp 1-73.

[18] Gilchrist, S. , Sim, J. and E. Zakrajšek (2010), "Uncertainty, Financial Frictions, and Investment Dynamics", mimeo.

[19] Iacoviello, M. (2005), "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle", American Economic Review, Vol. 95, No. 3, pp. 739-764.

[20] Iacoviello, M. and S. Neri (2010), "Housing Market Spillovers: Evidence from an Estimated DSGE Model," American Economic Journal: Macroeconomics, American Economic Association, Vol. 2, No. 2, pp. 125-64, April.

[21] Justiniano, A. , Primiceri, G. E. and A. Tambarlotti (2011), "Investment Shocks and the Relative Price of Investment", Review of Economic Dynamics, Vol. 14, No. 1, pp.101-121, January.

[22] Kiyotaki, N. and J. Moore (1997), "Credit Cycles", Journal of Political Economy, University of Chicago Press, Vol. 105, No. 2, pp. 211-48, April.

[23] Kollmann, R. , Enders, A. and G. Müller (2011), "Global Banking and International Business Cycles", European Economic Review, Vol. 55, pp. 407-426.

[24] Levin, A., Natalucci, F. and E. Zakrajšek (2004), "The Magnitude and Cyclical Behavior of Financial Market Frictions", Staff Working Paper 2004-70, Board of Governors of the Federal Reserve System.

[25] Martin, A. and J. Ventura (2010), "Theoretical Notes on Bubbles and the Current Crisis", IMF Economic Review, Palgrave Macmillan, Vol. 59, No.1, pp. 6-40.

[26] Meier, A. and G. Müller (2006), "Fleshing out the Monetary Transition Mechanism: Output Composition and the Role of Financial Frictions", Journal of Money, Credit, and Banking Vol. 38, No. 8, pp. 2099-2134, December.

[27] Mendoza, E.G. (2008), "Sudden Stops, Financial Crises and Leverage: A Fisherian Deflation of Tobin's Q" NBER Working Papers No. 14444, National Bureau of Economic Research.

[28] Mian, A. and A. Sufi (2011), "Consumers and the Economy, Part II: Household Debt and the Weak U.S. Recovery", Economic Letter, Federal Reserve Bank of San Francisco.

[29] OECD (2010), "Economic Survey of the United States", OECD, Paris.

[30] OECD (2011), "Economic Outlook, No. 90", OECD, Paris.

[31] Orphanides, A. and V. Wieland (2000), "Efficient Monetary Policy Design Near Price Stability", Journal of the Japanese and International Economies, Vol. 14, pp. 327-365.

[32] Queijo, V. (2009), "How Important are Financial Frictions in the U.S. and the Euro Area?", Scandinavian Journal of Economics, Blackwell Publishing, Vol. 111, No. 3, pp. 567-596.

[33] Schorfheide, F. and S. An (2005), "Bayesian Analysis of DSGE models ", CEPR Working Paper No. 5207.

[34] Smets, F. and Wouters, R. (2003), "An Estimated Stochastic Dynamic General Equilibrium Model of Euro Area", Journal of the European Economic Association, MIT Press, Vol. 1, No. 5, pages 1123-1175, 09.

[35] Smets, F. and R. Wouters (2007), "Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach," American Economic Review, American Economic Association, Vol. 97, No. 3, pp. 586-606, June.

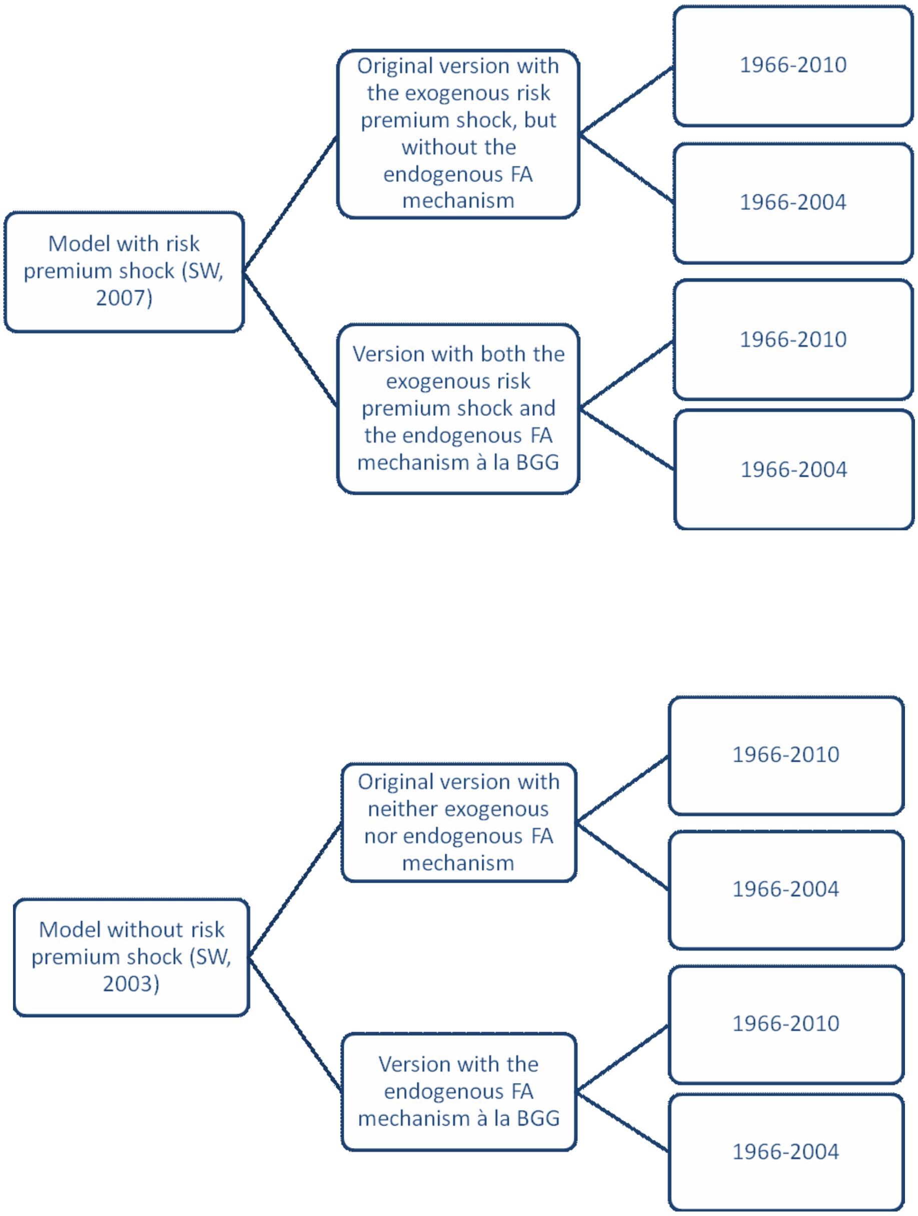

Chart 1

	Without financial accelerator		With financial accelerator	
Estimation sample	SW (2007)	SW (2003)	SW (2007)	SW (2003)
1966-2004	-930	-939	-915	-924
1966-2010	-1074	-1086	-1060	-1072

Table 1: Model comparison, log data density (Laplace approximation)

		Estimation sample 1966-2010							
		Without financial accelerator				With financial accelerator			
Prior		SW (2007)		SW (2003)		SW (2007)		SW (2003)	
Mean	s.d.	post. mode	post s.d.	post. mode	post s.d.	post. mode	post s.d.	post. mode	post s.d.
0.5	0.2	0.965	0.009	0.965	0.008	0.963	0.013	0.960	0.009
0.5	0.2	0.408	0.109	0.314	0.089	0.736	0.069	0.370	0.114
0.5	0.2	0.965	0.008	0.965	0.008	0.970	0.010	0.977	0.008
0.5	0.2	0.808	0.047	0.749	0.047	0.668	0.071	0.730	0.056
0.5	0.2	0.191	0.070	0.207	0.073	0.160	0.067	0.263	0.078
0.5	0.2	0.910	0.041	0.915	0.038	0.893	0.042	0.908	0.039
0.5	0.2	0.971	0.013	0.968	0.015	0.933	0.026	0.905	0.038
0.5	0.2	0.785	0.073	0.792	0.070	0.775	0.076	0.787	0.074
0.5	0.2	0.944	0.024	0.944	0.024	0.895	0.038	0.862	0.052
4	1.5	4.310	1.001	5.468	1.182	3.197	0.769	5.471	1.112
1.5	0.375	1.483	0.181	1.496	0.197	1.165	0.241	1.399	0.176
0.7	0.1	0.628	0.065	0.641	0.063	0.587	0.081	0.626	0.064
0.5	0.1	0.828	0.046	0.838	0.046	0.829	0.040	0.854	0.034
2	0.75	1.544	0.617	1.414	0.641	1.934	0.539	2.080	0.555
0.5	0.1	0.741	0.046	0.737	0.045	0.772	0.040	0.753	0.038
0.5	0.15	0.594	0.129	0.585	0.129	0.578	0.132	0.590	0.129
0.5	0.15	0.218	0.086	0.225	0.088	0.235	0.091	0.224	0.089
0.5	0.15	0.757	0.103	0.752	0.102	0.634	0.130	0.692	0.103
1.25	0.125	1.666	0.075	1.714	0.077	1.482	0.084	1.584	0.075
1.5	0.25	1.746	0.166	1.590	0.165	1.629	0.161	1.387	0.116
0.75	0.1	0.798	0.028	0.774	0.034	0.793	0.029	0.716	0.044
0.125	0.05	0.051	0.018	0.038	0.017	0.065	0.022	0.027	0.016
0.125	0.05	0.220	0.026	0.214	0.028	0.229	0.025	0.220	0.027
0.625	0.1	0.679	0.066	0.669	0.063	0.796	0.086	0.765	0.109
0.25	0.1	0.210	0.091	0.210	0.091	0.171	0.074	0.119	0.050
0	2	-0.623	1.106	-0.758	1.186	-0.854	0.829	-1.295	0.981
0.4	0.1	0.434	0.017	0.437	0.017	0.409	0.016	0.411	0.012
0.5	0.25	0.614	0.085	0.618	0.086	0.542	0.076	0.542	0.079
0.3	0.05	0.205	0.039	0.226	0.040	0.163	0.018	0.178	0.015
2	0.5	-	-	-	-	1.692	0.295	1.871	0.328
0.97	0.02	-	-	-	-	0.992	0.005	0.975	0.010
0.05	0.02	-	-	-	-	0.025	0.009	0.033	0.013
0.1	2	0.457	0.026	0.452	0.026	0.488	0.029	0.474	0.027
0.1	2	0.198	0.029	0.219	0.027	0.124	0.019	0.199	0.031
0.1	2	0.530	0.028	0.531	0.028	0.501	0.027	0.509	0.027
0.1	2	0.435	0.041	0.465	0.049	0.529	0.050	0.507	0.053
0.1	2	0.234	0.014	0.234	0.014	0.233	0.014	0.240	0.015
0.1	2	0.134	0.015	0.132	0.015	0.137	0.015	0.132	0.015
0.1	2	0.284	0.021	0.282	0.021	0.275	0.021	0.270	0.021

Table 2-panel A: Estimation results (whole sample)

			Estimation sample 1966-2004							
			Without financial accelerator				With financial accelerator			
	Prior		SW (2007)		SW (2003)		SW (2007)		SW (2003)	
	Mean	s.d.	post. mode	post s.d.	post. mode	post s.d.	post. mode	post s.d.	post. mode	post s.d.
ρa	0.5	0.2	0.957	0.012	0.959	0.010	0.940	0.017	0.942	0.015
ρb	0.5	0.2	0.197	0.085	0.162	0.077	0.293	0.121	0.217	0.092
ρg	0.5	0.2	0.964	0.009	0.963	0.009	0.974	0.010	0.976	0.009
ρi	0.5	0.2	0.744	0.068	0.661	0.061	0.602	0.068	0.580	0.063
ρr	0.5	0.2	0.127	0.066	0.126	0.065	0.116	0.063	0.119	0.065
ρp	0.5	0.2	0.922	0.046	0.923	0.046	0.890	0.051	0.887	0.051
ρw	0.5	0.2	0.973	0.014	0.976	0.012	0.918	0.029	0.913	0.032
μp	0.5	0.2	0.773	0.093	0.777	0.093	0.732	0.105	0.726	0.107
μw	0.5	0.2	0.916	0.050	0.927	0.043	0.836	0.057	0.834	0.060
φ	4	1.5	5.167	1.070	6.114	1.165	4.840	1.005	5.956	1.104
σ	1.5	0.375	1.463	0.149	1.528	0.148	1.326	0.156	1.485	0.147
h	0.7	0.1	0.688	0.047	0.677	0.045	0.688	0.054	0.658	0.047
ξw	0.5	0.1	0.768	0.068	0.776	0.063	0.797	0.053	0.808	0.051
σL	2	0.75	1.753	0.636	1.699	0.637	2.326	0.555	2.332	0.551
ξp	0.5	0.1	0.665	0.063	0.668	0.068	0.703	0.050	0.698	0.050
ιw	0.5	0.15	0.551	0.145	0.541	0.146	0.544	0.143	0.543	0.142
ιp	0.5	0.15	0.295	0.113	0.302	0.117	0.287	0.109	0.294	0.112
zk	0.5	0.15	0.537	0.122	0.562	0.121	0.456	0.119	0.516	0.133
Φp	1.25	0.125	1.713	0.076	1.729	0.078	1.576	0.078	1.592	0.078
$\rho\pi$	1.5	0.25	2.022	0.178	1.975	0.179	1.885	0.184	1.869	0.189
ρ	0.75	0.1	0.822	0.024	0.821	0.024	0.802	0.025	0.799	0.026
ρy	0.125	0.05	0.085	0.025	0.087	0.025	0.089	0.023	0.086	0.022
ρdy	0.125	0.05	0.221	0.027	0.224	0.028	0.222	0.025	0.225	0.026
π	0.625	0.1	0.658	0.077	0.638	0.074	0.791	0.099	0.786	0.126
$100[(1/\beta)-1]$	0.25	0.1	0.210	0.091	0.210	0.091	0.149	0.059	0.131	0.053
l	0	2	0.526	0.989	0.690	0.957	-0.107	0.813	-0.012	0.854
trend	0.4	0.1	0.443	0.017	0.446	0.016	0.422	0.013	0.420	0.014
ηga	0.5	0.25	0.640	0.097	0.633	0.097	0.573	0.089	0.559	0.090
α	0.3	0.05	0.266	0.045	0.269	0.045	0.193	0.018	0.194	0.017
lev	2	0.5	-	-	-	-	1.607	0.263	1.701	0.280
v	0.97	0.02	-	-	-	-	0.986	0.009	0.985	0.015
ω	0.05	0.02	-	-	-	-	0.031	0.015	0.030	0.017
σa	0.1	2	0.431	0.027	0.429	0.027	0.460	0.028	0.457	0.028
σb	0.1	2	0.242	0.024	0.251	0.024	0.227	0.030	0.240	0.026
σg	0.1	2	0.540	0.031	0.542	0.031	0.527	0.030	0.531	0.031
σi	0.1	2	0.449	0.048	0.515	0.055	0.554	0.054	0.598	0.057
σr	0.1	2	0.237	0.014	0.236	0.014	0.233	0.014	0.233	0.014
σp	0.1	2	0.124	0.017	0.123	0.017	0.123	0.017	0.124	0.017
σw	0.1	2	0.266	0.026	0.267	0.027	0.247	0.025	0.246	0.025

Table 2-panel B: Estimation results (sample up to 2004)

Variable	1966-2010	1966-2004
Output	0.97	0.88
Consumption	0.63	0.49
Investment	6.05	4.68
Labour	6.47	5.00
External risk premium	0.04	0.02

Table 3: Variance of selected variables (model with endogenous FA mechanism)

		Model with FA													
		SW (2007) 1966-2010							SW (2007) 1966-2004						
		σa	σb	σg	σi	σr	σp	σw	σa	σb	σg	σi	σr	σp	σw
t=1	output	23.67	29.90	24.63	8.72	11.38	1.65	0.05	18.62	24.80	34.37	14.66	5.77	1.72	0.06
	cons.	7.97	66.78	3.12	0.01	17.70	2.01	2.41	2.69	80.40	2.26	0.01	9.81	1.91	2.93
	invest.	1.99	8.64	0.21	77.63	9.88	0.97	0.68	3.11	2.27	0.63	88.70	4.61	0.67	0.00
	int. rate	5.98	35.35	1.37	1.43	48.24	6.35	1.27	9.48	22.66	1.71	2.18	54.82	6.85	2.29
	inflation	2.00	0.35	0.11	0.03	0.74	85.87	10.90	2.57	0.02	0.10	0.19	0.88	79.21	17.03
	wage	0.93	0.46	0.00	0.11	0.20	20.64	77.66	0.91	0.32	0.01	0.24	0.22	22.20	76.10
	labour	14.41	33.40	27.94	9.76	12.70	1.16	0.63	20.75	23.86	33.81	14.06	5.45	0.62	1.45
t=10	output	21.23	30.30	21.04	9.84	12.15	3.65	1.79	17.11	23.54	29.39	15.52	6.72	3.82	3.90
	cons.	9.31	59.18	3.48	0.96	16.51	4.41	6.15	4.41	64.32	3.44	0.98	9.94	5.44	11.48
	invest.	3.30	9.20	0.28	72.77	10.67	2.67	1.11	4.87	3.27	0.98	83.32	5.03	1.60	0.93
	int. rate	7.01	45.55	1.73	5.87	18.04	8.97	12.82	14.16	12.27	2.54	11.03	22.52	14.03	23.45
	inflation	4.33	0.90	0.51	0.05	2.88	54.05	37.28	3.72	0.50	0.31	0.40	3.00	44.29	47.78
	wage	2.34	1.11	0.00	0.42	0.78	20.72	74.63	2.14	0.40	0.02	0.76	0.66	22.78	73.23
	labour	2.26	28.89	10.61	11.77	20.17	13.64	12.66	4.44	7.57	15.28	15.99	12.40	12.49	31.83
t=40	output	21.13	29.91	20.17	10.09	12.12	4.37	2.21	17.43	22.63	28.26	15.47	6.74	4.61	4.86
	cons.	9.35	58.22	3.45	1.24	16.17	4.89	6.68	4.65	61.65	3.36	1.15	9.79	6.30	13.10
	invest.	3.73	9.71	0.33	70.22	10.77	3.71	1.53	5.53	3.14	1.08	81.55	5.01	2.12	1.57
	int. rate	7.55	40.44	2.81	6.97	15.22	7.73	19.28	12.42	13.11	3.34	11.54	19.25	11.96	28.38
	inflation	4.22	1.92	0.98	0.46	3.01	49.18	40.24	3.46	2.55	0.55	0.97	3.05	41.11	48.31
	wage	2.51	1.44	0.00	0.56	0.86	21.21	73.42	2.33	0.43	0.03	0.91	0.71	23.52	72.07
	labour	1.95	19.55	11.22	8.98	14.29	13.24	30.76	3.13	4.68	14.07	10.55	7.64	9.80	50.12

Figure 3-panel A: Variance decomposition (model with FA)

		Model without FA													
		SW (2007) 1966-2010							SW (2007) 1966-2004						
		σa	σb	σg	σi	σr	σp	σw	σa	σb	σg	σi	σr	σp	σw
t=1	output	17.99	25.89	29.38	17.13	7.94	1.61	0.06	17.20	22.84	33.84	19.03	5.43	1.63	0.03
	cons.	2.91	75.96	0.61	0.32	16.51	1.01	2.68	2.40	81.05	0.55	0.21	12.29	0.81	2.69
	invest.	1.81	7.64	0.31	83.32	4.87	1.95	0.09	2.62	4.23	0.66	87.94	3.00	1.54	0.00
	int. rate	6.23	25.52	1.96	3.35	54.35	7.07	1.51	7.63	20.99	2.03	3.38	57.26	6.25	2.46
	inflation	2.09	0.32	0.26	1.65	1.13	82.74	11.81	2.63	0.25	0.24	1.79	1.49	76.69	16.91
	wage	0.85	0.16	0.00	0.27	0.14	21.69	76.89	1.27	0.36	0.01	0.46	0.33	22.91	74.66
	labour	17.17	26.15	29.93	17.21	7.97	1.07	0.50	18.07	22.28	33.97	18.43	5.13	0.43	1.68
t=10	output	15.38	21.83	23.33	23.49	8.89	4.55	2.53	15.48	19.53	27.63	22.49	6.31	4.21	4.33
	cons.	4.93	59.95	0.98	4.66	16.42	4.53	8.51	4.94	62.22	1.22	2.02	12.56	4.35	12.68
	invest.	2.98	5.07	0.47	81.71	4.66	4.21	0.89	4.27	2.93	1.09	84.08	2.91	3.34	1.39
	int. rate	6.48	14.02	2.84	41.55	16.84	6.68	11.58	8.61	8.97	3.05	34.69	17.42	8.99	18.27
	inflation	4.04	0.89	0.96	5.47	3.97	47.74	36.94	3.47	0.49	0.63	4.76	4.40	40.19	46.07
	wage	2.13	0.32	0.01	2.70	0.77	22.06	72.02	3.23	0.41	0.04	2.40	0.94	23.79	69.19
	labour	2.19	9.36	9.37	41.50	13.05	13.69	10.85	3.03	5.95	12.31	31.71	9.16	11.46	26.38
t=40	output	15.07	20.78	22.19	24.90	8.98	5.26	2.82	15.58	18.81	26.69	23.02	6.42	4.85	4.64
	cons.	4.94	58.29	0.98	5.37	16.58	5.06	8.78	5.02	60.76	1.22	2.16	12.80	4.84	13.20
	invest.	2.99	4.64	0.46	81.28	4.65	4.81	1.17	4.39	2.75	1.09	83.59	2.92	3.74	1.53
	int. rate	6.30	11.28	3.73	40.62	13.74	5.64	18.68	7.50	7.30	3.30	32.07	14.34	7.48	28.00
	inflation	3.95	0.83	1.54	5.70	3.87	40.04	44.08	3.01	0.42	0.77	4.50	3.96	33.65	53.68
	wage	2.25	0.35	0.02	3.11	0.87	22.57	70.83	3.34	0.42	0.08	2.55	1.06	24.58	67.97
	labour	1.44	4.97	7.01	26.37	7.71	13.53	38.97	1.68	2.71	7.68	16.04	4.38	8.56	58.95

Table 3-panel B: Variance decomposition (model without FA)

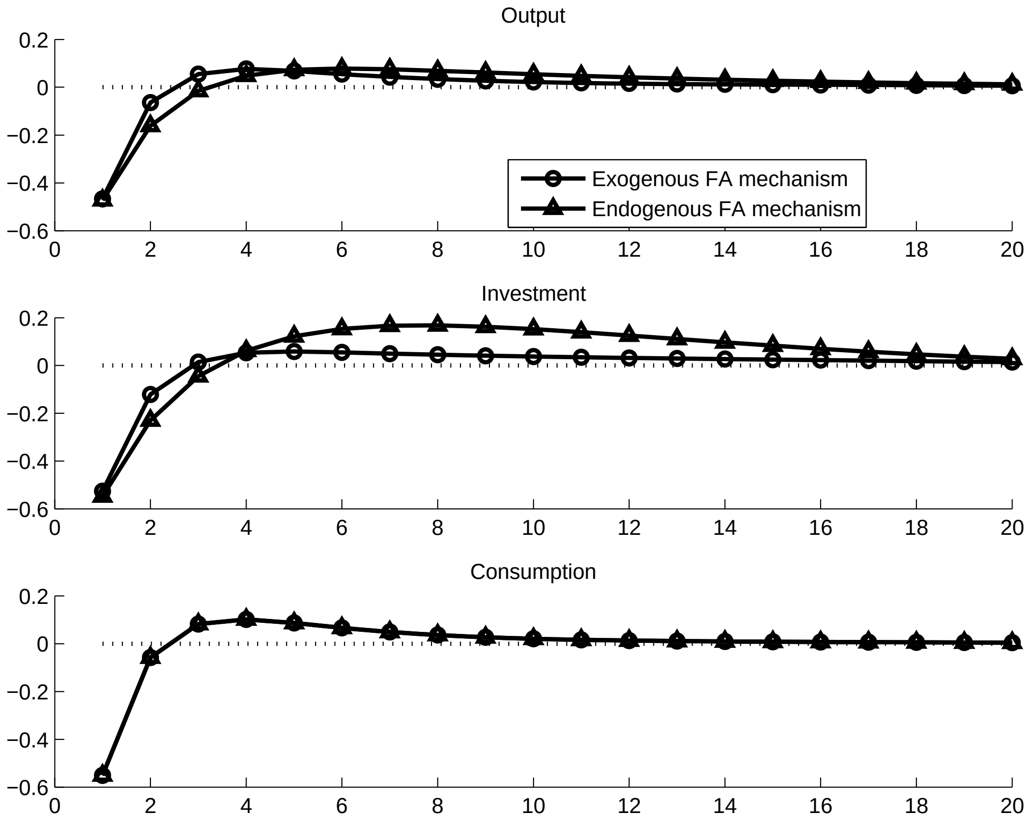

Figure 1: IRFs to the risk premium shock

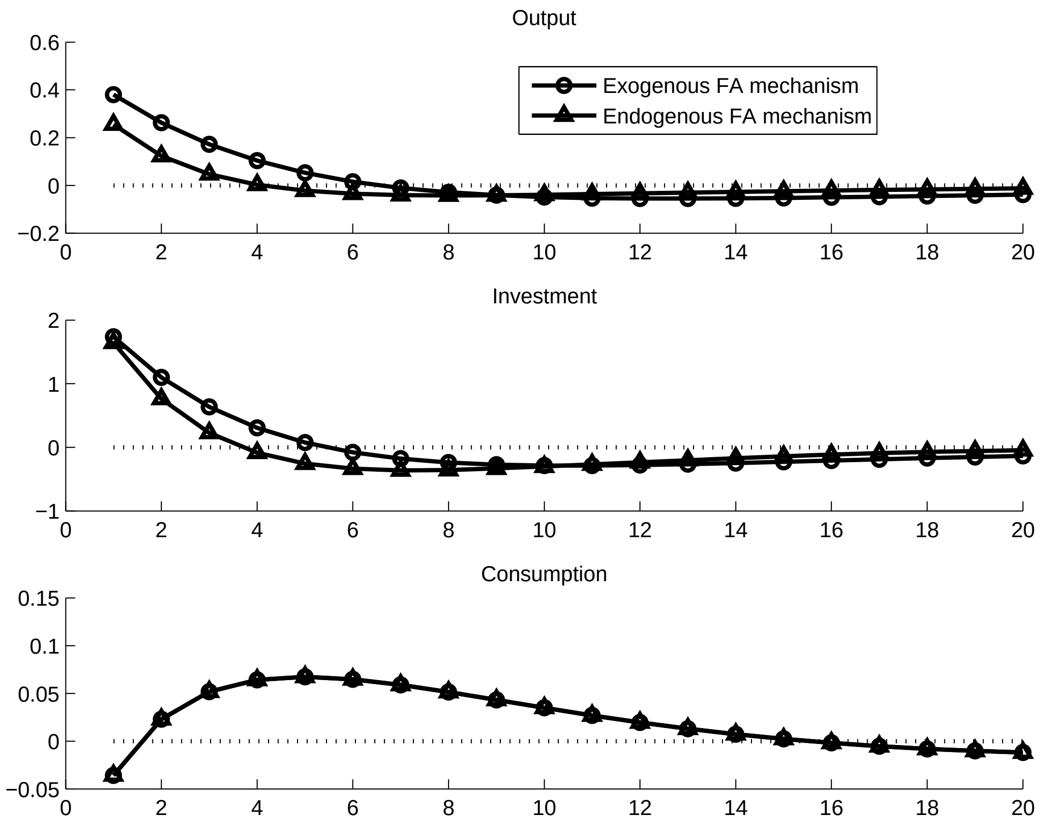

Figure 2: IRFs to the investment shock

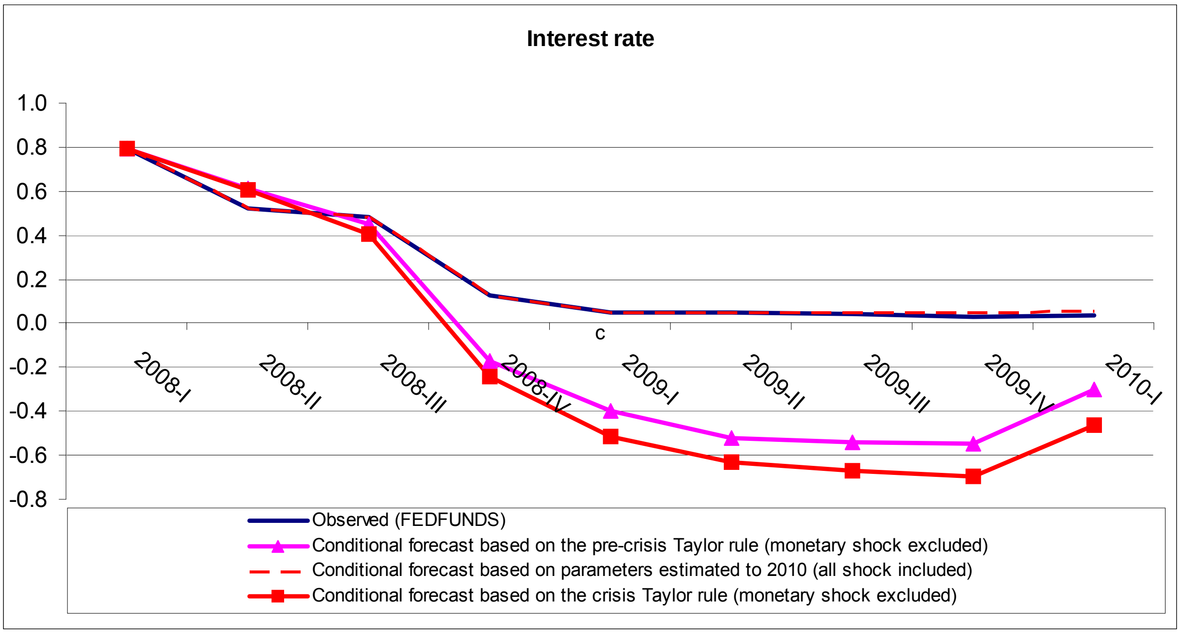

Figure 3: Conditional forecast for the interest rate

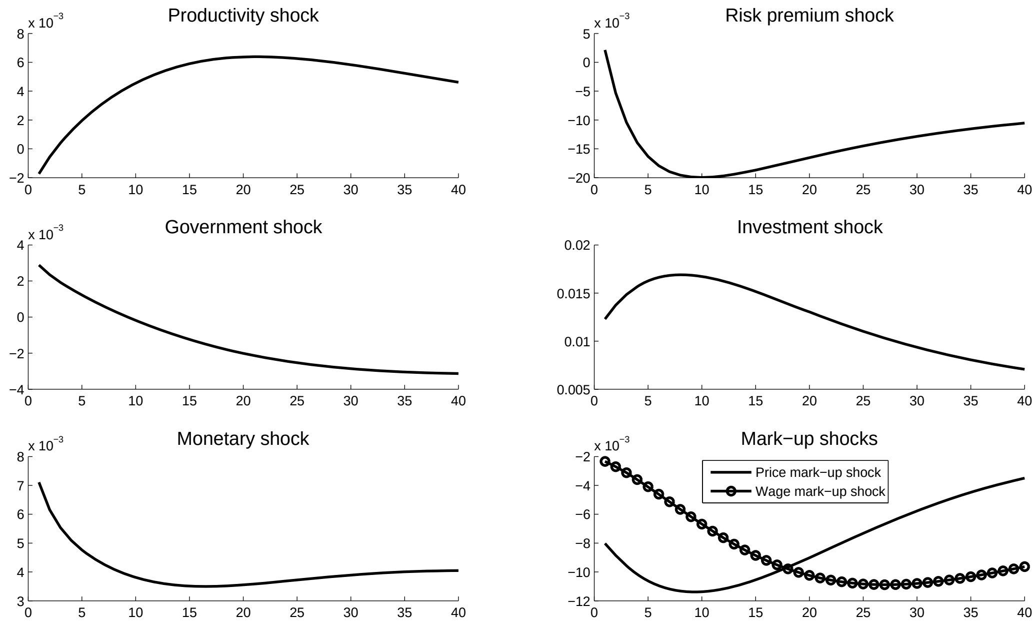

Figure 4: External finance risk premium (IRFs)

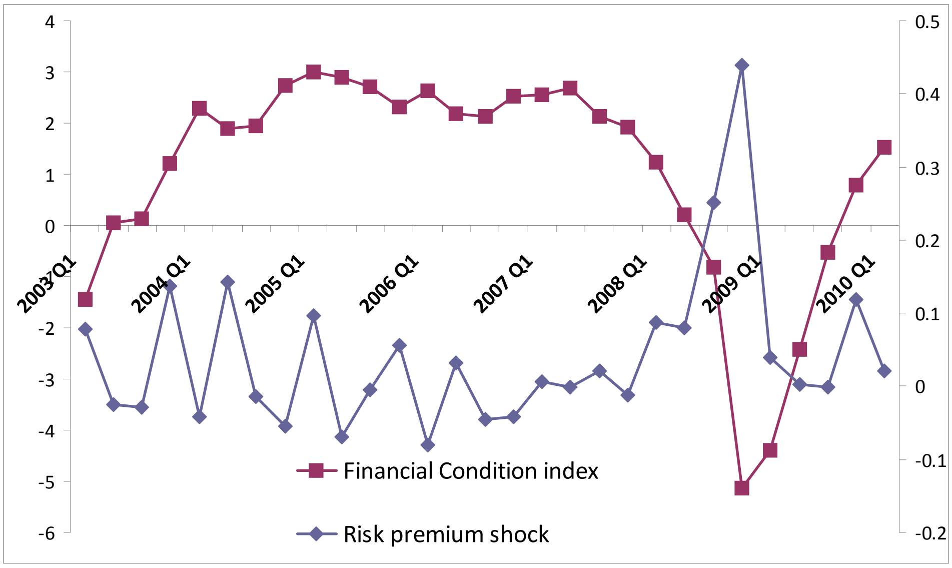

Figure 5: Financial Condition Index (source: OECD, Economic Outlook N.90) and risk premium shock

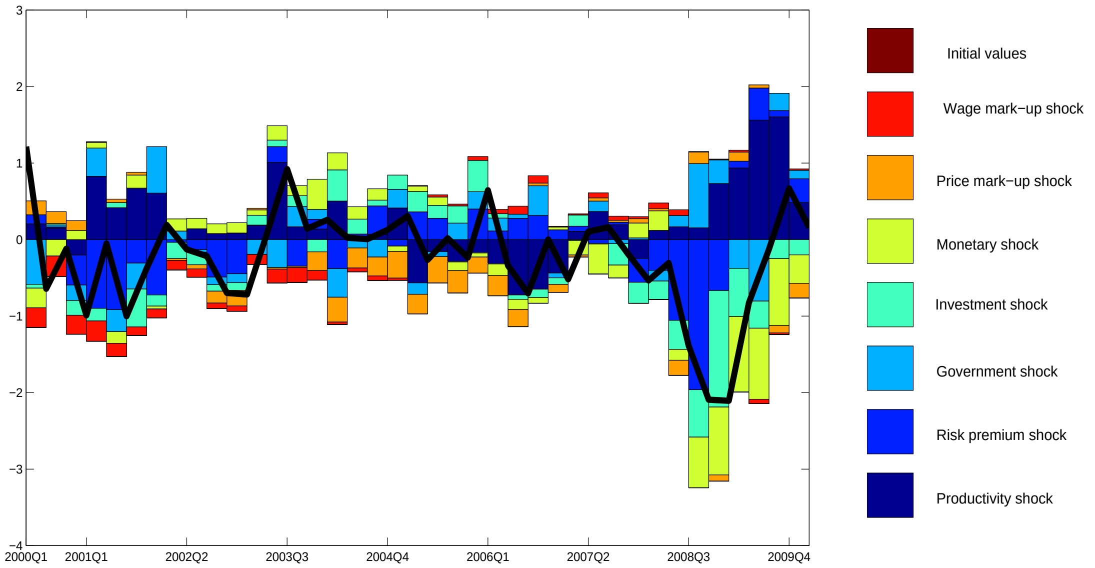

Figure 6: Historical decomposition of output growth

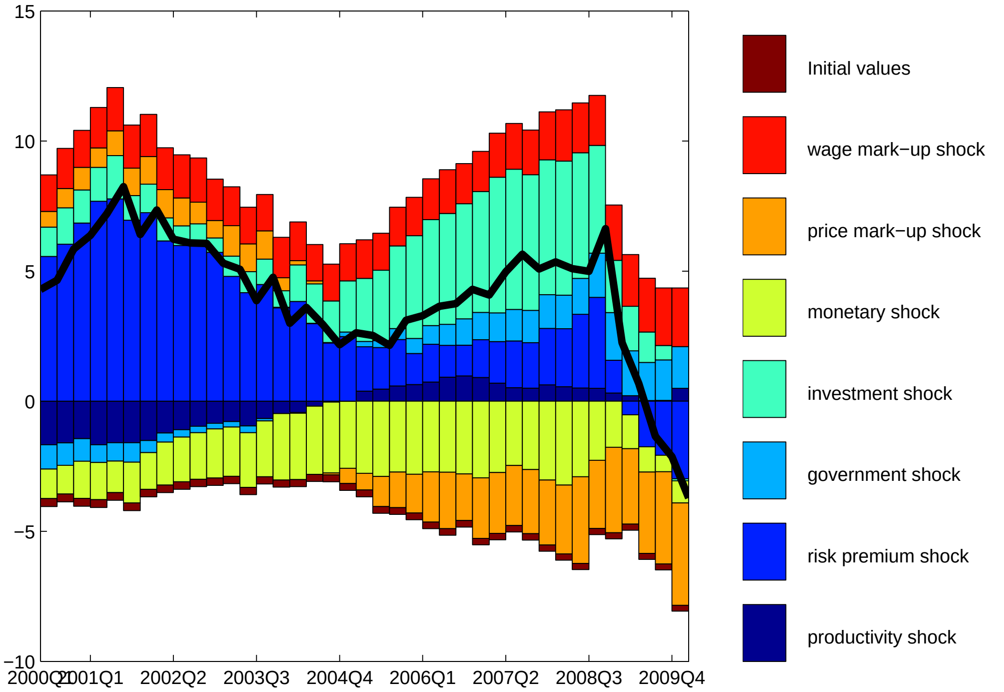

Figure 7: Historical decomposition of leverage ratio

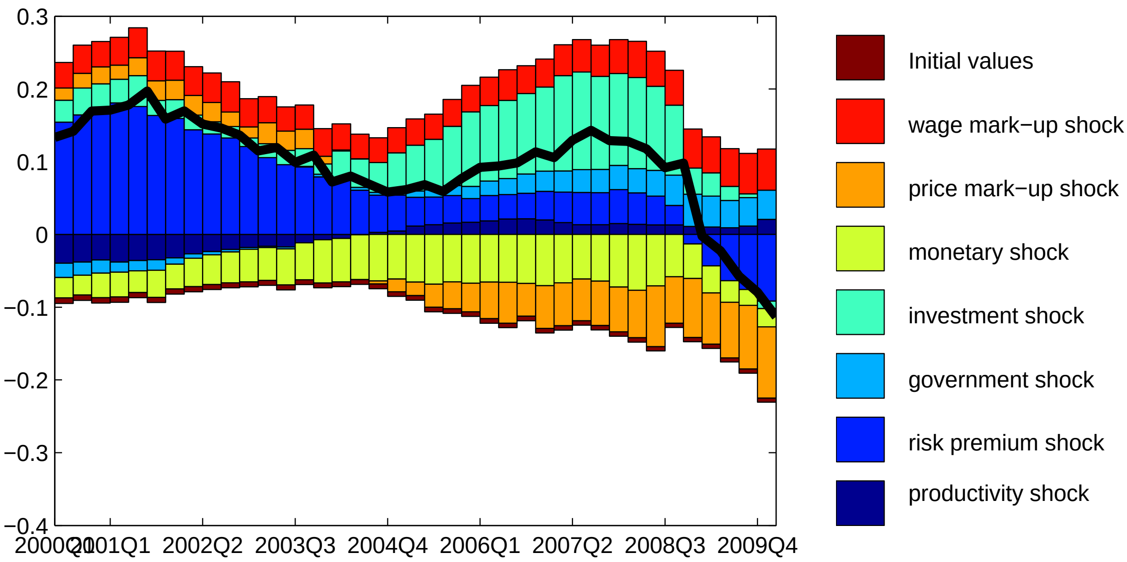

Figure 8: Historical decomposition of external finance premium

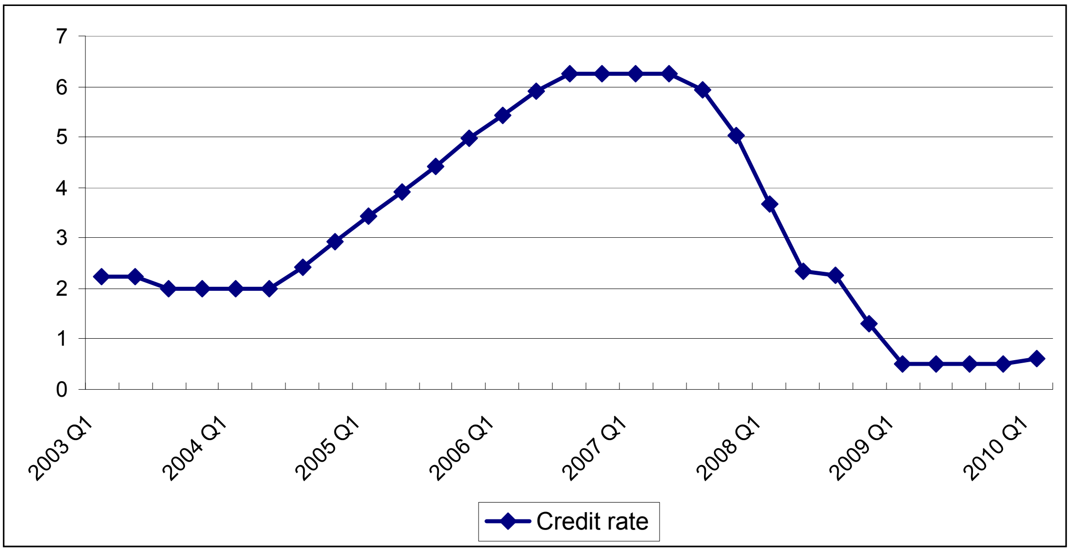

Figure 9: Prime loan rate on short-term business loans, percent (source: Federal Reserve Bank of St. Louis)