# The role of financial frictions during the crisis: an estimated DSGE model*

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**Abstract**

After the recent banking crisis in 2008, financial market conditions have turned out to be a relevant factor for economic fluctuations. This paper provides a quantitative assessment of the impact of financial frictions on the U.S. business cycle. The analysis compares the original Smets and Wouters model (2003, 2007) with an alternative version augmented with the financial accelerator mechanism *á la* Bernanke, Gertler and Gilchrist (1996, 1999). Both versions are estimated using Bayesian techniques over a sample extended to 2012. The analysis supports the role of financial channels, namely the financial accelerator mechanism, in transmitting dysfunctions from financial markets to the real economy.

The Smets and Wouters model, augmented with the financial accelerator mechanism, is suitable to capture much of the historical developments in U.S. financial markets that led to the financial crisis. The model can account for the output contraction in 2008, as well as the widening in corporate spreads and supports the argument that financial conditions have amplified the U.S. business cycle and the intensity of the recession.

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# 1 Introduction

The financial crisis that began in 2008 has called attention on the close interaction between financial and credit markets on the one side, and the real economy on the other side. If macro-financial linkages indeed increase the persistence and the amplitude of the macroeconomic fluctuations, a good understanding of the business cycle dynamics requires adding financial market frictions in macroeconomic models.

This paper investigates to what extent financial transmission channels, by amplifying the business cycle, have accounted for output collapse in the U.S. during the recent crisis. To this purpose, I extend the Smets and Wouters model (2003, 2007) (hereafter, SW) by adding financial frictions as modelled in Bernanke, Gertler and Gilchrist (1996, 1999) (hereafter, BGG). To estimate the parameters of the model and the stochastic processes governing the structural shocks in the U.S. economy, I use the same set of shocks and macroeconomic series used in the SW model (2003), together with an additional shock (*i.e.* the spread shock) and a financial variable (*i.e.* the corporate spread). I estimate the model on U.S. quarterly data from 1967 to 2012 using Bayesian methods.

The main contribution of this paper to the economic debate consists in providing an assessment of the implications of financial frictions for U.S. business cycles. The analysis highlights that modelling financial frictions is a fairly important feature in normal times, but it becomes crucial when crises occurs. In this respect the paper relates to De Graeve (2008) and Queijo von Heideken (2009), but it enriches the analysis in two directions. First, it extends the estimation sample up to 2012 to assess the implications of the recent crisis. Second, this paper incorporates corporate spreads in the Bayesian estimation together with a spread shock, which creates a wedge between the policy rate and the lending rate faced by enterprises and hence limits the borrowing capacity in the corporate sector. This is an important feature to model, given that very often cyclical downturns are preceded by wider spreads (see Faust, Gilchrist, Wright and Zakrajšek (2012)). Although this set-up does not explicitly model the banking system, the spread shock is suitable to capture the effect of financial tightening on firms' borrowing capacity.

Moreover, the paper also contributes to the literature by identifying the shocks that are responsible for the financial crisis and the key sources of economic fluctuations. In this respect, the model accounts well for the events that started with the subprime crisis in the summer of 2007 and subsequently triggered the financial crisis. The concomitance of a peak in the external finance premium and in the spread shock on the one side, and the deepening of the recession on the other side, supports the argument that financial conditions have played an important role in shaping the business cycle, especially during the financial crisis.

The modeling framework initially developed in BGG has been adopted in several other studies (see for instance, Levin, Natalucci and Zakrajšek (2004); Gertler, Gilchrist and Natalucci (2007); Christensen and Dib (2008); De Graeve (2008); Queijo von Heideken (2009)) and it is able to capture the role of financial frictions as a mechanism of amplification and transmission of macroeconomic shocks. This approach departs from a more recent strand of literature, which explicitly models the banking sector and emphasizes the role of financial sector as a source of shocks, rather than as a mechanism of propagation (*e.g.* Gerali, Neri, Sessa and Signoretti (2010); Martin and Ventura (2010); Kollmann, Enders and Müller (2011); Gertler and Kiyotaki (2010)). This latter strand of literature concludes that financial shocks (namely, shocks that either increase the cost of loans or decrease the demand of credit) explain a large share of contraction in the economic activity. Despite the ongoing research to incorporate the banking sector in DSGE models, the financial accelerator mechanism *à la* BGG remains a valid approach in a number of prominent central banks and institutions' models (see Gerke *et al.* (2012); Gilchrist and Zakrajšek (2011)). Moreover, results from this paper are also not at odds with those found in models with the banking sector. In fact, the spread shock in this paper, by affecting entrepreneur's borrowing costs, has similar effects to a financial shock that affects the demand of credit. Thus, even without explicitly modeling the banking sector, the model is able to capture macroeconomic dynamics as the expansion and collapse of the economic activity during the last decades, as well as the conduct of monetary policy. This is a remarkable result of the model, which highlights how the Smets and Wouters model with financial frictions yields results similar to those obtained in larger-scale models, having however the advantage of remaining more tractable[1]. This finding addresses a key issue that macroeconomists and analysts must resolve when using DSGE models for policy analysis: they must strike a balance between simplicity and transparency on the one hand, and reality and completeness on the

[1]Some similarities can be found in Jermann and Quadrini (2012), who introduce a shock originated in the financial sector of the economy, without explicitly modeling the banking sector. However, the structure of the shock in this paper is different.

other hand[2].

An analysis similar to the one presented in this paper has been proposed by Gilchrist, Ortiz and Zakrajšek (2009). However, this paper differs in several aspects. First, while Gilchrist, Ortiz and Zakrajšek (2009) estimate only the elasticity of the external finance premium, the estimation herein includes a broader set of parameters related to the financial accelerator mechanism. Second, this paper finds stronger evidence in favour of the presence of financial frictions, as proved by the higher estimate of the elasticity of the external finance premium. Third, their conclusions in favour of the model with financial frictions are not supported by accurate model comparison. This paper, instead, provides more robust results based on Bayesian factors.

The rest of the paper is structured as follows. Section 2 presents the model. Section 3 shortly discusses the estimation methodology. Section 4 presents estimation results. Section 5 discusses the contribution of each shock to the developments in the U.S. economy, as well as 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. Data are described in the Appendix.

# 2 Model presentation

To assess the role of financial factors, I extend the SW model so to include the financial accelerator mechanism *à la* BGG (1999). The model framework closely follows Smets and Wouters (2003, 2007)[3], except in the presence of financial frictions. Therefore, for an exhaustive description of the model, I refer the reader to the original papers. However, to make the paper self-contained, in this section I directly outline the log-linearized version of the model and I concentrate the discussion on the aspects related to my contribution to the SW model, *i.e.* the financial accelerator mechanism. All variables are log-linearized around their steady-state and variables not indexed by time denote steady-state values.

Output ($y_t$) is composed by:

$$y_t = \frac{c}{y}c_t + \frac{i}{y}i_t + \varepsilon_t^g + r^k\left(\frac{k}{y}\right)z_t^k + \left(\frac{k}{y}\right)f\left(1-\frac{r}{f}\right)\left(1-\frac{1}{lev}\right)\left(f_t + p_{t-1}^k + k_t\right) \tag{1}$$

[2]The Research task Force Transission Channel (RTF-TC) has point out that "some of the research conducted by RTF-TC introduced a banking sector in a complicated manner which makes it difficult to fully understand the forces driving the interaction between the real and financial sectors. In contrast, if the aim is to understand the transmission channels between the real and the financial sectors, then simpler models appear to be more desirable." See Bank of International Settlement (2012), p. 7.

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

where $c_t$ stands for consumption, $i_t$ for investment and $g_t$ for exogenous public spending. The terms $\frac{c}{y}$ and $\frac{i}{y}$ represent respectively the steady-state of consumption-to-output ratio and investment-to-output ratio and they are defined as: $\frac{c}{y} = 1 - \frac{g}{y} - \frac{i}{y}$, $\frac{i}{y} = [\gamma - (1-\delta)] \frac{k}{y}$, where $\gamma$ is the steady-state growth rate, $\delta$ is the depreciation rate of capital, $\frac{g}{y}$ is the steady-state of public spending-to-output ratio and $\frac{k}{y}$ is the steady-state capital-output ratio. The term $r^k \left(\frac{k}{y}\right) z_t^k$ measures the cost associated with variable capital utilization, where $r^k$ is the steady-state rental rate of capital and $z_t^k$ is the capital utilization rate. The term $\left(\frac{k}{y}\right) f \left(1 - \frac{r}{f}\right)\left(1 - \frac{1}{lev}\right)\left(f_t + p_{t-1}^k + k_t\right)$ measures the bankruptcy costs, where $k_t$ stands for capital, $r$ is the steady-state of the risk-free interest rate, $p_{t-1}^k$ is the lagged value of capital stock, $f$ is the steady-state of the external funding cost and $lev$ is the steady-state value of the leverage ratio, that is the ratio of capital to net worth in the corporate sector. I assume that public spending follows an $AR(1)$ process with an IID-Normal error term and is also affected by the productivity shock[4] as follows:
$\varepsilon_t^g = \rho_g \varepsilon_{t-1}^g + \eta_t^g + \rho_{ga} \eta_t^a$
Households maximize a non-separable[5] utility function with two arguments (goods and labour effort) over an infinite life horizon. Aggregate consumption evolves according to:

$$c_t = c_1 c_{t-1} + c_2 E_t c_{t+1} + c_3 \left(l_t - E_t l_{t+1}\right) - c_4 \left(r_t - E_t \pi_{t+1} + \varepsilon_t^\beta\right) \tag{2}$$

$$c_1 = \left(\frac{\frac{h}{\gamma}}{1 + \frac{h}{\gamma}}\right); c_2 = \left(\frac{1}{1 + \frac{h}{\gamma}}\right); c_3 = \frac{\sigma - 1}{\sigma\left(1 + \frac{h}{\gamma}\right)} \frac{W^h L}{C}; c_4 = \left[\frac{1 - \frac{h}{\gamma}}{\sigma\left(1 + \frac{h}{\gamma}\right)}\right]$$

where the parameter $h$ introduces habit in consumption, $\sigma$ represents the inverse of elasticity of intertemporal substitution and $\frac{W^h L}{C}$ is the steady-state ratio of labour income to consumption. Equation (2) 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 preference shock $\varepsilon_t^\beta$ which is assumed to follow an $AR(1)$ process with an IID-Normal error term: $\varepsilon_t^\beta = \rho_\beta \varepsilon_{t-1}^\beta + \eta_t^\beta$.
Investment dynamics are:

$$i_t = \frac{1}{1 + \beta\gamma}\left[i_{t-1} + \beta\gamma E_t i_{t+1} + \frac{1}{\gamma^2 \varphi} p_t^k\right] + \varepsilon_t^i \tag{3}$$

[4]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.

[5]The non-separability of the utility function implies that consumption will also depend on expected employment growth. Therefore, when the elasticity of the intertemporal substitution is smaller than one ($\sigma > 1$), consumption and labour supply are complements.

where $\varphi$ is the steady-state elasticity of the capital adjustment cost function and $\beta$ is the discount factor applied by households. The disturbance to the investment-specific technology process is assumed to follow an $AR(1)$ 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:

$$p_t^k = -(f_t + \varepsilon_t^b) + \frac{r^k}{r^k + (1-\delta)} r_{t+1}^k + \frac{(1-\delta)}{r^k + (1-\delta)} p_{t+1}^k \tag{4}$$

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. The term $\varepsilon_t^b = \rho_b \varepsilon_{t-1}^b + \eta_t^b$ represents an exogenous disturbance to the external cost of funding. This shock amplifies the wedge between the policy rate set by the central bank and the cost of funding faced by the entrepreneurs, and hence it has similar effects as the so-called "net-worth" shock in BGG (1999) and Christiano, Motto and Rostagno (2010)[6].

Following BGG (1998), I extend the original Smets and Wouters model and I assume the existence of an agency problem that makes external finance more expensive than internal funds. The entrepreneurs costlessly observe their output which is subject to a random outcome. External lenders incur an auditing cost to observe an entrepreneur's output. After observing his project outcome, an entrepreneur decides whether to repay his debt or to default. If he 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:

$$E_t f_{t+1} = (r_t - E_t \pi_{t+1}) + \omega (p_t^k + k_{t+1} - n_{t+1}) \tag{5}$$

The gross external finance premium ($prem_t$) depends on the borrowers' leverage ratio ($p_t^k + k_{t+1} - n_{t+1}$) and the parameter $\omega$ capturing the elasticity of the external finance premium with

[6]The spread shock is close to the so-called "risk premium shock" in the SW (2007) model. However, while in the SW model, this shock introduces a wedge between the policy rate and the interest rate faced by both firms and consumers, here the spread shock affects only the cost of funding faced by entrepreneurs. The reason behind is that this model features financial frictions only in the corporate sector, which motivates the choice of focusing only on the corporate spread.

respect to the leverage ratio :

$$prem_t = E_t f_{t+1} - (r_t - E_t \pi_{t+1}) = \omega(p_t^k + k_{t+1} - n_{t+1}) \tag{6}$$

To ensure that entrepreneurs' net worth will never be sufficient to fully finance the new capital acquisition, I assume that entrepreneurs have a limited life span and the probability that entrepreneurs will survive until next period is $\nu$. The entrepreneur's net worth is defined as

$$\frac{1}{\nu f} n_{t+1} = (lev) f_t - \omega(lev-1)(p_{t-1}^k + k_t) - (lev-1)\left(r_{t-1} - \pi_t\right) + \left[\omega(lev-1)+1\right] n_t \tag{7}$$

The size of the external finance premium is positively related to leverage conditions of entrepreneurial balance sheets. The presence of an external finance premium magnifies the effect of adverse shocks, as it raises the cost of borrowing and further worsens balance sheet conditions. Output is produced using capital ($k_t$) and labour services ($l_t$):

$$y_t = \Phi_P \left[\alpha k_t + (1-\alpha) l_t + \varepsilon_t^a\right] \tag{8}$$

The parameter $\alpha$ captures the share of capital in production, and the parameter $\Phi_P$ reflects the presence of fixed costs in production. Disturbances in total factor productivity are captured by the term $\varepsilon_t^a = \rho_a \varepsilon_{t-1}^a + \eta_t^a$ which 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 ($z_t$):

$$k_t = k_{t-1}^p + z_t \tag{9}$$

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:

$$k_t^p = \frac{(1-\delta)}{\gamma} k_{t-1}^p + \frac{\delta}{\gamma} i_t + \delta \gamma^2 \varphi \varepsilon_t^i \tag{10}$$

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

$$z_t = \frac{1-z^k}{z^k} r_t^k \tag{11}$$

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

$$r_t^k = w_t + l_t - k_t \tag{12}$$

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 ($\mu_t^p$) is determined, under monopolistic competition, as the difference between the marginal product of labour ($mpl_t$) and the real wage ($w_t$):

$$\mu_t^p = mpl_t - w_t = \alpha r_t^k + (1-\alpha)w_t + \varepsilon_t^a \tag{13}$$

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

$$\mu_t^w = w_t - mrs_t = w_t - \left[ w_t \sigma_l l_t + \frac{1}{1-\frac{h}{\gamma}} c_t + \frac{\frac{h}{\gamma}}{1-\frac{h}{\gamma}} c_{t-1} \right] \tag{14}$$

where $\sigma_l$ is the elasticity of labour supply with respect to the real wage.

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

$$\pi_t = \frac{1}{1+\beta\gamma\iota_p} \left\{ \beta\gamma E_t \pi_{t+1} + \iota_p \pi_{t-1} - \pi_{mk} \mu_t^p \right\} + \varepsilon_t^p \tag{15}$$

Equation (15) states that 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 ($\varepsilon_t^p$). The price mark-up disturbance is assumed to follow an $ARMA(1,1)$ process with an IID-Normal error term: $\varepsilon_t^p = \rho_p \varepsilon_{t-1}^p + \eta_t^p - \mu_p \eta_{t-1}^p$, where the inclusion of the $MA$ term is designed to capture the high-frequency fluctuations in inflation. The term $\pi_{mk} = \frac{(1-\xi_p)(1-\beta\xi_p)}{\xi_p[(\Phi_P - 1)\varkappa_p + 1]}$ measures the speed of adjustment to the desired mark-up and it depends on the degree of price stickiness ($\xi_p$), the degree of indexation to past inflation ( $\iota_p$), 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 ($\Phi_P$) through a zero-profit condition.

Similarly, Calvo-style wage setting implies

$$w_t = \frac{1}{1+\beta\gamma} \left\{ w_{t-1} + \iota_w \pi_{t-1} - (1+\beta\gamma\iota_w)\pi_t + \beta\gamma E_t \pi_{t+1} - w_{mk} \mu_t^w \right\} + \varepsilon_t^w \tag{16}$$

Equation (16) states that 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 ($\varepsilon_t^w$). 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 term $w_{mk} = \frac{(1-\xi_w)(1-\beta\gamma\xi_w)}{\xi_w[(\Phi_w-1)\varkappa_w+1]}$ measures the speed of adjustment to the desired wage mark-up, and it depends on the degree of wage stickiness ($\xi_w$), the degree of wage indexation ($\iota_w$) 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 that is assumed to follow an $AR(1)$ process with an IID-Normal error term $\varepsilon_t^r = \rho_r \varepsilon_{t-1}^r + \eta_t^r$ :

$$r_t = \rho r_{t-1} + \rho_\pi(1-\rho)\pi_t + \rho_y(1-\rho)(y_t - y_t^P) + \rho_{dy}\left[(y_t - y_{t-1}) - (y_t^P - y_{t-1}^P)\right] + \varepsilon_t^r \qquad (17)$$

To obtain the original model without financial frictions, it is sufficient to set the elasticity of the external finance premium to the leverage ratio $\omega = 0$ and the steady-state of the leverage ratio $lev = 1$. Moreover, the model without financial frictions does not entail the spread shock.

# 3 Methodology for estimation and model evaluation

The model with financial frictions presented in the previous section is estimated with Bayesian estimation techniques using eight key macroeconomic quarterly U.S. time series as observable variables: the log difference of real GDP, the log difference of real consumption, the log difference of real investment, the log difference of the GDP deflator, the log difference of real wage, log hours worked, the federal funds rate and the corporate spread[7]. The data sample is 1967-2012, at a quarterly frequency[8]. The corresponding measurement equations are:

[7] 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. The interest rate is provided by the Board of Governors of the Federal Reserve System. The corporate spread is defined as the difference between the corporate BAA yield and the corporate AAA yield, both provided by the Board of Governors of the Federal Reserve System. De Graeve (2008) and Gertler and Lown (2000) show that the high yield spread (<BBB) is the best indicator of the external finance premium. However, here the BAA-AAA spread is preferred because it is available over a longer time span. A more detailed description of data is given in the Appendix A.

[8] The dataset starts in 1947. As in the original Smets and Wouters (2003), I decided to shorten the sample to 1957:Q1-2012:Q4 by dropping the first 10 years, as they results to be not 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.

$$Y_t = \begin{bmatrix} d\log GDP_t \\ d\log CONS_t \\ d\log INV_t \\ d\log W_t \\ \log HOURS_t \\ d\log P_t \\ FEDFUNDS_t \\ CORPORATE\ SPREAD_t \end{bmatrix} = \begin{bmatrix} \bar{\gamma} \\ \bar{\gamma} \\ \bar{\gamma} \\ \bar{\gamma} \\ \bar{l} \\ \bar{\pi} \\ \bar{r} \\ \end{bmatrix} + \begin{bmatrix} y_t - y_{t-1} \\ c_t - c_{t-1} \\ i_t - i_{t-1} \\ w_t - w_{t-1} \\ l_t \\ \pi_t \\ r_t \\ prem_t \end{bmatrix} \tag{18}$$

where $\bar{\gamma} = 100(\gamma - 1)$ is the common quarterly trend growth rate for real GDP, consumption, investment and wages; $\bar{l}$ is steady-state hours worked, which is normalized to be equal to zero; $\bar{\pi} = 100\pi$ is the quarterly steady-state inflation rate; $\bar{r} = 100(\beta^{-1}\gamma^{\sigma}\bar{\pi})$ is the steady-state nominal interest rate. In the specification of the model without financial frictions, the corporate spread is not included in the list of observable variables.

Bayesian methods combine prior information on parameters from existing evidence with sample information as captured by the likelihood of data[9].

The specification of prior distributions for the majority of parameters closely follows the SW model. Therefore, for an exhaustive discussion of prior elicitation and estimation methodology, I refer the reader to Smets and Wouters (2007). Here, I discuss only the priors of parameters describing the corporate sector and related to the financial accelerator mechanism (hereafter, FA), which is absent in the original setting. I assume that the elasticity of leverage with respect to premium is normally distributed with a mean 0.05 and a standard error 0.02, as in Carlstrom, Fuerst, Ortiz and Paustian (2012). The steady-state of the leverage ratio is also normally distributed in the range $[1, 4]$ with a mean 1.7 and a standard deviation 0.25. This latter choice is consistent with data reported by Gilchrist, Ortiz and Zakrajšek (2009) which show that the leverage ratio over the period 1973-2009 was 1.7 on average, having a value of 4 as a ceiling.

[9]Bayesian estimation methods of DSGE models have been initially proposed by Smets and Wouters (2003), An and Schorfheide (2005) and Del Negro *et al.* (2007). 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.

# 4 Estimation results

In this section, I present the estimation results[10] for the two alternative specifications of the SW models, with and without financial frictions. To assess to what extent the recent global crisis has affected the main forces driving economic fluctuations, each of the two specifications is estimated both on the sample including the global crisis (1967:Q1-2012:Q4) and on a shorter "pre-crisis" sample (up to 2007:Q2). The estimation results might help to understand whether the recent financial crisis has emphasized the role of financial factors. To this purpose, I start by comparing the alternative model specifications, with and without financial frictions, in term of their performance. Then, I move to the discussion on parameter estimates.

Table 1 reports the log-marginal likelihood for the model with and without financial frictions over the two estimation samples. Bayesian model comparison is conducted pairwise by computing the log of the Bayes factor $BF$, which is the difference between the log of marginal likelihood functions of two alternative models:

$$log(BF_{ij}) = log(p(Y \mid M_i)) - log(p(Y \mid M_j)) \tag{19}$$

where $p(Y \mid M_i)$ and $p(Y \mid M_j)$ are the marginal likelihood functions of respectively model $i$ and model $j$[11]. Kass and Raftery (1995) suggest that values of $2log(BF_{ij})$ above 10 provide very strong evidence in favor of model $i$; values between 6 and 10 represent strong evidence; values between 2 and 6 positive evidence, while values between 0 and 2 are "not worth more than a bare mention". I refer to this statistic as the KR criterion. For the sake of comparability, the two models specifications, with and without the financial accelerator, should feature the same number of shocks and should be estimated using the same observable variables. For this reason, only for the comparison exercise, in the model with the financial accelerator the spread shock is absent and the series for the corporate spread is not included in the observables. In such a way, to allow the model comparison, both specifications of the model are estimated using 7 observable variables and 7 shocks[12]. By shutting out the effect of exogenous disturbances to the corporate

[10] All estimations are done using Dynare Version 4 (http://www.dynare.org). See Adjemian *et al.* (2011).

[11] The most commonly used method to calculate the marginal likelihood is the modified harmonic mean because it works for all sampling methods and is not sensitive to the step size. Here, I use the Laplace approximation which assumes that the posterior distribution is close to a normal distribution. The advantage of using the Laplace approximation is that it can generate an approximation of the marginal likelihood very quickly, given the normality assumption and the estimated mode. The Laplace approximation works very well in practice and it is often very close to the modified harmonic mean.

[12] This version of the SW model with financial frictions, based on 7 variables and 7 shocks, is very close to the specification in De Graeve (2008).

spread, this choice allows me to ascribe differences in the performance of the two models only to the presence of the endogenous financial accelerator mechanism. The model comparison, based on the maximum likelihood and Bayes factors, outlines some important results. First, the performance improves when the FA mechanism is included, especially when the estimation is carried out over the sample up to 2012. The marginal likelihood improves by 8 log-points when the estimation is carried out on the pre-crisis sample, and 11 log-points if the estimation sample is extended up to 2012:Q4. The KR criterion provides strong evidence in favour of the model with financial frictions under both estimation samples. The KR criterion also suggests that when the global crisis is included in the estimation sample, the over-performance of the model with financial frictions is more noticeable. Therefore, the model comparison provides evidence that financial frictions are a fairly important feature in normal times, but they become crucial during crises.

From now on, in the rest of the paper, for the model with financial frictions I refer to the model with a set of 8 shocks, which includes the spread shock, and estimated using the corporate spread in the set of the 8 observable variables, as described in Section 3.

Results derived from the model comparison are corroborated by the estimation results reported in Table 2 and Table 3, which prove that during the recent global crisis financial factors have played a major role in transmitting disturbances. The higher estimate of the elasticity of the external finance premium to the leverage ratio, in the 1967-2012 sample, suggests that during the crisis lenders have become more sensitive to deterioration of corporate balance sheets, and have reacted by raising the external finance premium for high-risk corporate firms. Compared to other works (*e.g.* Gilchrist, Ortiz and Zakrajšek (2009)), the estimate of the elasticity of the external finance premium is higher and hence it provides a stronger support in favour of the role of financial frictions as a mechanism of amplification of shocks[13]. The estimate of the leverage ratio over the sample 1967-2012 is 1.67 and in line with the historical data reported in Gilchrist, Ortiz and Zakrajšek (2009). The lower estimate of the leverage ratio compared to the pre-crisis period captures the ongoing process of deleveraging in the corporate sector.

[13] With a similar approach, Gilchrist, Ortiz and Zakrajšek (2009) estimate the SW model, augmented with a financial accelerator mechanism and extended to 2009:Q1. 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. They calibrate the leverage ratio to 1.7, which corresponds to the average leverage ratio in the U.S. non-financial corporate sector over the period 1973-2009.

Similarly to this paper, they conclude in favour of a financial accelerator mechanism. However, their conclusion is not supported by a high value of the elasticity of the external finance premium. They estimate this parameter to be equal to 0.01, while in this work the estimate is equal to 0.03.

The estimates of the parameters describing the FA mechanism are able to replicate the observed series. Figure 1 reports the estimated external finance premium generated by the model with financial frictions over the sample 1967-2012, together with the BAA-AAA spread and the BAA-10 year Treasury Bill spread. The estimated external finance premium is positively correlated with the observed series of the corporate spreads and is able to reproduce the tightening of credit conditions witnessed in late-2008 and early-2009.

Turning to exogenous shocks, estimation results point out that, when the FA mechanism is operative, the investment shock and, to a lesser extent, the preference shock become less relevant albeit more persistent. The intuition is that during the crisis demand shocks (*i.e.* the preference shock and the investment shock) have been partially replaced by exogenous disturbances introduced by movements in the spread. The analysis of the impulse response functions (hereafter, IRFs) based on the estimated parameters reaches the same conclusions. Figure 2 depicts the IRFs of output and its components to the investment shock. The line marked by circles is from the original model without the FA mechanism, while the line marked by triangles is from the model augmented with financial frictions. The IRFs show that the FA mechanism reduces the impact of the investment shock.

The IRFs analysis highlights another important result related to the effectiveness of the fiscal stimulus in the presence of financial frictions. Figure 3 reports the response of output and its components to a government spending shock. The IRFs show that in the model with financial frictions the fiscal stimulus, by reducing the external finance premium, encourages investment and the crowing-out effect is hence negligible. The underlying reason is that the higher inflation resulting from the fiscal stimulus reduces the real interest rate and hence the external finance risk premium. This channel supports investment and output growth (see Merola (2012) and Carillo and Poilly (2013) for a more detailed discussion)[14].

Turning to structural parameters, the comparison of the estimates of the model with financial frictions over the two alternative samples (last column of Table 2 and last column of Table 3) shows that, during the crisis, monetary policy has become less reactive to inflation. According to this estimate, the prospect of hitting the ZLB in 2008-2009 called for the FED to cut interest rates less aggressively compared to the pre-crisis period. This result is in line with the concern sometimes expressed by policy-makers to avoid a worsening of market sentiment (*e.g.* Bini

[14]Fernández-Villaverde (2010) also states that in the presence of financial frictions the fiscal stimulus becomes more effective. However, in Fernández-Villaverde (2010) this conclusion hinges on the assumption of nominal liabilities and works through the debt-deflation effect, while here the mechanism is more simple and general.

Smaghi (2008)). 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[15]. As a counterfactual, I have performed a conditional forecast of the interest rate starting in 2008:Q2. Figure 4 depicts the conditional forecast, which is based on the following assumptions: *(i)* the conditional path for the shocks over the horizon 2008:Q2-2012:Q4 imposes that all shocks, except the monetary shock, are exactly those produced by the model over the whole estimation sample (1967-2012); *(ii)* the conditional path for the monetary policy shock imposes that the monetary shock is zero from 2008 onwards. The latter assumption allows simulating a hypothetical situation in which the monetary authority can decrease the interest rate below zero, as if the ZLB did not represent a constraint. The conditional forecast in Figure 4 suggests some important results[16]. First, if the FED would be allowed to cut the interest rate below zero, it would have reacted more aggressively than what it has effectively done. Of course, the FED did in fact cut the interest rate (mainly in 2008:Q2 and 2008:Q4, as proved by the observed series), but it was not allowed to further decrease the effective interest rate below zero. If the interest rate could fall below the ZLB, it would have been negative during the crisis from 2008:Q3 to 2010:Q4, and then it would have turned positive again as a result of rebounding economic activity. Second, if the conditional forecast is carried on assuming that monetary shocks are zero from 2008:Q2 onwards, the model recommends the FED to decrease the interest rate in 2008:Q2 less aggressively than what it has actually done. This result points out that the FED decreased the interest rate preemptively, before the economy hit the ZLB. This finding is in line with the evidence for the euro area found in Gerlach and Lewis (2010) who argue that in early-2008, the ECB, in response to worsening economic conditions, cut interest rates more rapidly than the regular reaction function would have predicted.

Finally, the estimation results help in the interpretation of movements in the external finance premium in relation to shocks driving the business cycle. Figure 5 plots the impulse response functions for the external finance premium, based on the parameters estimated over the whole sample 1967-2012. The analysis shows that the external finance premium is not necessarily countercyclical. In this respect, the analysis confirms the results stated in De Graeve (2008)

[15] A contrasting recommendation is prescribed by a strand of literature on monetary policy in the vicinity of the zero bound. Among these authors, 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.

[16] Unfortunately this model is not suitable to comparing unconventional monetary policy measures and traditional interest rate policy. The reason is that unconventional monetary policy shocks are characterized by a significant shift in the monetary base or in the balance sheet size of the central bank. The SW model does not consider this aspect, which would represent an insightful step forward.

and Gelain (2010), who find that the countercyclicality of the external finance premium depends on the type of shock. In this paper, the IRFs in Figure 5 show that the the productivity shock leads to a procyclical external finance premium after three periods[17]. The external finance premium reacts countercyclically to the spread shock. The spread shock introduces a wedge between the interest rate set by the central bank and the interest rate faced by enterprises. It thereby increases the external finance premium and discourages investments and economic activity. The investment shock also leads to a procyclical external finance premium, by implying a reduction in the price of capital and hence a decrease in net worth. As entrepreneurial borrowing needs increase, the external finance premium becomes procyclical. The external finance premium generally reacts countercyclically to a government spending shock, as far as the higher aggregate demand increases the price of capital and hence borrowing needs. However, financial frictions imply that borrowers' collateral improves, due to the increase in the price of capital. As a consequence, the external finance premium may become slightly procyclical. This result confirms the intuition behind the IRFs reported in Figure 3. The analysis shows that the positive effect on output of the productivity shock, the investment specific shock and the government spending shock are not overturned by the increase in the external finance premium. Therefore, the IRFs analysis shows that 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 finance 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 BGG (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, leading to an increase in firms' borrowing needs and in the external finance premium.

[17]This finding is consistent with De Graeve (2008), while it contrasts with those of BGG (1999) and Queijo von Heideken (2009), in which favourable productivity shocks reduce the external finance 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 BGG (1999) assumes 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.

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

## 5.1 Variance decomposition

Table 3 and Table 4 report the contribution of each shock to the variance of the observed macroeconomic variables, for both the model with and without financial frictions. This decomposition provides insights into the main forces driving economic fluctuations. The contribution of each of the structural shocks to the variance of the observed variables is reported on impact, as well as at various horizons (2.5 years and 10 years).

The dominant forces behind short-term developments in output are the productivity shock, the government shock and, to a lesser extent, the preference shock. In the long-run, the spread shock gains relevance and partially replaces the productivity and the preference shock. When the FA mechanism is operative, the relevance of the investment shock is largely reduced, as also proved by the IRFs displayed in Figure 2.

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

In the model without financial frictions, the investment shock explains the largest part of investment at any horizon. As with output, the role of the investment shock in driving economic fluctuation is reduced when the FA mechanism becomes operative and the main force behind investment fluctuations becomes the spread shock.

The model can be used to understand where aggregate fluctuations in the external finance premium originate. Not surprisingly, fluctuations in the external finance premium are mainly driven by the spread shock and the investment shock. The spread shock becomes more prominent during the crisis.

By affecting output, the productivity shock and the government spending shock also affect hours worked and represent the main source of short-run fluctuation in hours worked. To a lesser extent, the preference shock and the spread shock are another important source of economic fluctuations in hours worked in the short-run. 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 long-run, the wage mark-up shock dominates the price mark-

up shock, if the crisis is excluded from the estimation sample. However, once the sample is extended up to 2012, 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. The monetary policy shock accounts only for a small fraction of inflation volatility.
Finally, wage developments are mostly explained by the wage mark-up shock at any horizon. To some extent, this finding is not very surprising as wages are estimated to be highly sticky and therefore one needs quantitatively important shocks to account for the behaviour of wages.
To summarize, the variance decomposition confirms that, during the recession started in 2007-2008, disturbances originated in the corporate spread have gained relevance and have partially replaced the role of traditional demand shocks in driving macroeconomic fluctuations.

## 5.2 Historical decomposition

Figure 6 depicts the historical contribution of the various structural shocks to output developments in the U.S. from 2000 onwards. This decomposition is based on the estimates of the various shocks in the SW model with the FA mechanism over the sample 1967-2012. While obviously such decomposition must be treated with caution, it helps to understand how the estimated model interprets specific movements in the observed data, especially the contraction in 2007-2008.
The spread shock accounts for a significant portion of drop in output from 2008 onwards. 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, notably a significant tightening of credit which dramatically impeded economic activity. The preference shock also contributed to the slowdown of the economic activity in 2007-2008, reflecting the sharp increase in the desire of households to save, for precautionary reasons, rather than spend.
On the opposite side, fiscal policy has in part contributed to the surge in output during the crisis[18]. This finding captures the effect of the fiscal stimulus package passed in early-2009, which has successfully supported employment and output. Accordingly to OECD data[19], productivity has increased strongly in the U.S. during the recession, and hence the fall in output has been moderate compared to other countries.
Concerning the role of the monetary policy shock, the historical decomposition of output growth

[18] However, in some quarters, much of the fiscal stimulus has been offset by consolidation measures at state and local level.
[19] OECD (2010), *Economic Survey of the United States*, OECD, Paris.

shows that monetary policy, along with the price mark-up shock, accounts for a portion of output growth variation between 2001 and 2006. Figure 6 shows that output fluctuations between 2001 and 2004 are largely explained by the monetary policy shock. This is in line with the loose monetary policy adopted by the FED in 2001-2004 in the aftermath of the dotcom bubble. The loose monetary policy contributed to the surge in output between 2001 and 2004. Then, starting in June 2004, the FOMC increased interest rates gradually until June 2006. The unexpected hike in interest rates accounts for a portion of drop in output between 2005 and 2007, as captured in the historical decomposition of output growth. When the crisis was acute, 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. Therefore, the transmission mechanism of the monetary policy stimulus through its traditional instrument, the nominal interest rate, was less effective. The monetary shock did contribute to the surge in output from 2009 onwards, but it became a less relevant source of output fluctuations during the crisis, as shown in Figure 6.

The analysis points out that the spread shock plays an important role in the business cycle. The direction of the spread shock has sharply reversed its course in 2007, from having a significantly expansionary effect on output and investment during the period 2004-2006 to having a negative influence, especially on investment spending, by the middle of 2007. The results point out that the link between the spread shock and the real economy operates via investment. The historical decomposition of investments reported in Figure 7 shows that the rise of investments in 2006-2007 and then the sharp contraction in 2008 have been largely caused by the spread shock. The spread shock, although not a purely financial shock, is suitable to account for the macroeconomic dynamics before and during the crisis. Similar conclusions are reached by Gerali, Neri, Sessa and Signoretti (2010) in a larger-scale model with the banking sector. Results highlight a remarkable aspect of this model: although the Smets and Wouters model augmented with financial frictions remains a medium-scale model and does not explicitly include the banking sector, it is able to yield results similar to those obtained in large-scale models.

Results also support the idea that financial crisis recessions tend to go hand in hand with credit tightening. One possible interpretation of the spread shock is that it behaves as a proxy of the health conditions of the financial system. To corroborate this intuition, Figure 8 shows the existence of a correlation between the spread shock and the OECD Financial Condition index. This index shows a tightening of financial conditions in the U.S. starting from the second half of

2008[20]. The peak in the spread shock is associated with the break-out of the financial crisis and deterioration of financial conditions. The correlation between the spread shock and financial conditions provides further support to the intuition that the spread shock, by raising up the cost of loan, constraints firms' demand for investment and behaves similarly to financial-type shocks in models with the banking system.

# 6 Conclusions

This paper provides an insight into the role of financial factors for cyclical economic fluctuations in the U.S. economy. Based on the Bayesian estimation of a model with financial frictions, a first set of results suggests that the recent crisis has enhanced the financial accelerator as a mechanism of propagation and amplification of business cycles. A second set of results provides evidence that, during the crisis, the role of disturbances in the corporate spread has become more relevant. The direction of the spread shock has reversed course sharply in 2007, having a significantly expansionary effect on output during the period 2004-2006 and then accounting for the economic slowdown in 2008. The spread shock generated by the model shows a high correlation with financial condition measures, supporting the intuition that the spread shock, by raising up the cost of loan, constraints firms' demand for investment and behaves similarly to financial-type shocks in models with an explicit modelling of the banking sector.

Overall, the model with financial frictions is suitable to capture much of the historical developments in financial markets that led to episodes of economic expansion in 2006 and the slowdown in 2008. In particular, the concomitance of the peak in the external finance premium and the deepening of the recession supports the argument that enterprises' balance sheets and financial factors have an important role to play in shaping the business cycle, in particular the intensity of recessions.

These results are obtained in a comparatively small and tractable model which does not explicitly model the banking sector.

[20]An 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.

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# Appendix A: data description

**Source of the original data**

- GDP: Real Gross Domestic Product - Billions of Chained 2005 Dollars, Seasonally Adjusted Annual Rate.

  *Source:* U.S. Department of Commerce, Bureau of Economic Analysis.

- GDPDEF: Gross Domestic Product - Implicit Price Deflator - 2005=100, Seasonally Adjusted.

  *Source:* U.S. Department of Commerce, Bureau of Economic Analysis.

- CONS: Personal Consumption Expenditures - Billions of Dollars, Seasonally Adjusted Annual Rate.

  *Source:* U.S. Department of Commerce, Bureau of Economic Analysis.

- FPI: Fixed Private Investment - Billions of Dollars, Seasonally Adjusted Annual Rate.

  *Source:* U.S. Department of Commerce, Bureau of Economic Analysis.

- CE16OV: Civilian Employment: Sixteen Years & Over, Thousands, Seasonally Adjusted.

  *Source:* U.S. Department of Labor: Bureau of Labor Statistics.

- CE16OV index: CE16OV (1992:3)=1.

- Federal Funds Rate: Averages of Daily Figures - Percent.

  *Source:* Board of Governors of the Federal Reserve System.

- LNS11000000: Civilian Labor Force Status : Civilian no-institutional population - Age: 16 years and over -Seasonally Adjusted - Number in thousands.

  *Source:* U.S. Bureau of Labor Statistics.

- LNSindex: LNS10000000(1992:3)=1.

- PRS85006023 - Non-farm Business, All Persons, Average Weekly Hours Duration: index, 1992 =100, Seasonally Adjusted.

  *Source*: U.S. Department of Labor.

- PRS85006103 - Non-farm Business, All Persons, Hourly Compensation Duration: index, 1992 =100, Seasonally Adjusted.

  *Source:* U.S. Department of Labor.

- BAA and AAA Moody's Seasoned Corporate Bonds, Not Seasonally Adjusted, Average of Daily Data, Percent.

  *Source:* Bond of Governors of the Federal Reserve System.

- DGS10: 10 Year Treasury Constant Maturity Rate, Not Seasonally Adjusted, Percent.

  *Source:* Bond of Governors of the Federal Reserve System.

**Definition of data variables used in the estimation**

- consumption = $log_n$( ( CONS / GDPDEF ) / LNSindex ) * 100
- investment = $log_n$( ( FPI / GDPDEF ) / LNSindex ) * 100
- output = $log_n$( GDP / LNSindex ) * 100
- hours = $log_n$( (PRS85006023 * CE16OV / 100 ) / LNSindex ) * 100
- inflation = $log_n$( GDPDEF / GDPDEF(-1) ) * 100
- real wage = $log_n$( PRS85006103 / GDPDEF ) * 100
- interest rate = Federal Funds Rate / 4
- external finance premium = BAA-AAA corporate spread / 4.

# Appendix B: the OECD Financial Condition Index

The OECD financial conditions index (hereafter, FCI) for the United States includes real short-term interest rates, real long-term interest rates, the real effective exchange rate, bond spreads, household wealth and credit standards. The weight of each variable in the FCI is based on the estimated relative effect of a one-unit change in that variable on US GDP after four to six quarters. Estimation was undertaken using two methods: a reduced-form equation for the output gap and an unrestricted vector auto-regression (VAR) to explain GDP growth. For more details on the construction of the OECD FCI, see Guichard, Haugh and Turner (2009). A tightening in financial condition is indicated by a fall in the FCI.
*Source:*OECD, Economic Outlook N.90.

Table 1: **Comparison of marginal likelihood, computed via Laplace approximation, of alternative specifications of the model, for alternative samples**

*The table reports the log-marginal likelihood computed via Laplace approximation and the Kass and Raftery criterion based on the log of the Bayes factors (see Section 4). Both model specifications, with and without the financial accelerator, are estimated using 7 observable variables and 7 shocks. For the sake of comparability, in the model with the financial accelerator, the spread shock is absent and the series for the corporate spread is not included in the observables.*

| Estimation sample | log(ML) Model without financial accelerator | log(ML) Model with financial accelerator | KR criterion 2log(BF) |
|---|---|---|---|
| 1967Q1-2007Q2 | -992 | -984 | 16 |
| 1966Q1-2012Q4 | -1142 | -1131 | 22 |

Table 2: **Estimation results: sample 1967:Q1-2012:Q4**
*Entries under the headline Prior specify the mean and the standard deviation of the prior distribution (see Section 3). Entries under the headline Posterior specify the estimates of the mode and the standard deviation as discussed in Section 4.*

| Estimation sample 1967Q1-2012Q4 | | | | | Without financial accelerator | | With financial accelerator | |
|---|---|---|---|---|---|---|---|---|
| parameters | | Prior | | | Posterior | | Posterior | |
| | | shape | mean | s.d. | mode | s.d. | mode | s.d. |
| *ρa* | AR term in productivity shock | beta | 0.5 | 0.2 | 0.97 | 0.007 | 0.96 | 0.010 |
| *ρb* | AR term in spread shock | beta | 0.5 | 0.2 | - | - | 0.75 | 0.055 |
| *ρβ* | AR term in preference shock | beta | 0.5 | 0.2 | 0.38 | 0.089 | 0.50 | 0.156 |
| *ρg* | AR term in gov. spending shock | beta | 0.5 | 0.2 | 0.98 | 0.007 | 0.98 | 0.007 |
| *ρi* | AR term in investment shock | beta | 0.5 | 0.2 | 0.78 | 0.041 | 0.98 | 0.017 |
| *ρr* | AR term in interest rate shock | beta | 0.5 | 0.2 | 0.23 | 0.072 | 0.19 | 0.072 |
| *ρp* | AR term in inflation shock | beta | 0.5 | 0.2 | 0.93 | 0.033 | 0.94 | 0.032 |
| *ρw* | AR term in wage shock | beta | 0.5 | 0.2 | 0.96 | 0.018 | 0.92 | 0.041 |
| *μp* | MA term in price shock | beta | 0.5 | 0.2 | 0.82 | 0.057 | 0.81 | 0.062 |
| *μw* | MA term in wage shock | beta | 0.5 | 0.2 | 0.94 | 0.026 | 0.89 | 0.045 |
| *φ* | investment adjustment costs | normal | 4 | 1.5 | 5.78 | 1.138 | 5.02 | 1.125 |
| *σ* | σ consumption | normal | 1.5 | 0.375 | 1.30 | 0.131 | 1.43 | 0.225 |
| *h* | habit in consumption | beta | 0.7 | 0.1 | 0.69 | 0.055 | 0.62 | 0.109 |
| *ξw* | wage Calvo adjustment | beta | 0.5 | 0.1 | 0.85 | 0.041 | 0.87 | 0.062 |
| *σL* | σ labour supply | normal | 2 | 0.75 | 1.94 | 0.596 | 1.92 | 0.587 |
| *ξp* | price Calvo adjustment | beta | 0.5 | 0.1 | 0.73 | 0.044 | 0.70 | 0.052 |
| *ιw* | wage indexation | beta | 0.5 | 0.15 | 0.59 | 0.128 | 0.64 | 0.127 |
| *ιp* | price indexation | beta | 0.5 | 0.15 | 0.23 | 0.083 | 0.25 | 0.091 |
| *zk* | steady-state capital utilization rate | beta | 0.5 | 0.15 | 0.78 | 0.086 | 0.89 | 0.048 |
| *Φp* | Fixed cost in production | normal | 1.25 | 0.125 | 1.59 | 0.075 | 1.61 | 0.073 |
| *ρπ* | T.R. coefficient on inflation | normal | 1.5 | 0.25 | 1.53 | 0.144 | 1.63 | 0.155 |
| ρ | T.R. interest rate smoothing | beta | 0.75 | 0.1 | 0.76 | 0.032 | 0.77 | 0.030 |
| *ρy* | T.R. coefficient on output | normal | 0.125 | 0.05 | 0.02 | 0.012 | 0.03 | 0.012 |
| *ρdy* | T.R. coefficient on d(output) | normal | 0.125 | 0.05 | 0.23 | 0.028 | 0.23 | 0.027 |
| *π* | steady-state inflation rate | gamma | 0.625 | 0.2 | 1.00 | 0.151 | 1.01 | 0.128 |
| $100[\beta^{-1}-1]$ | steady-state nominal interest rate | gamma | 0.25 | 0.1 | 0.13 | 0.051 | 0.12 | 0.052 |
| *l* | steady-state hours worked | normal | 0 | 2 | 4.10 | 1.409 | 4.93 | 1.216 |
| *trend* | trend growth rate | normal | 0.4 | 0.1 | 0.39 | 0.015 | 0.38 | 0.014 |
| *ηga* | response of gov.spending to prod. | normal | 0.5 | 0.25 | 0.53 | 0.077 | 0.51 | 0.078 |
| *α* | capital share in production | normal | 0.3 | 0.05 | 0.17 | 0.015 | 0.17 | 0.014 |
| *lev* | leverage ratio | normal | 1.7 | 0.2 | - | - | 1.67 | 0.151 |
| *ω* | elasticity external risk premium | normal | 0.05 | 0.02 | - | - | 0.03 | 0.007 |
| *σa* | σ productivity shock | Igamma | 0.1 | 2 | 0.46 | 0.026 | 0.46 | 0.025 |
| *σb* | σ spread shock | Igamma | 0.1 | 2 | - | - | 0.21 | 0.080 |
| *σβ* | σ preference shock | Igamma | 0.1 | 2 | 0.20 | 0.026 | 0.17 | 0.044 |
| *σg* | σ government spending shock | Igamma | 0.1 | 2 | 0.50 | 0.026 | 0.50 | 0.026 |
| *σi* | σ investment shock | Igamma | 0.1 | 2 | 0.40 | 0.041 | 0.32 | 0.054 |
| *σr* | σ interest rate shock | Igamma | 0.1 | 2 | 0.23 | 0.014 | 0.23 | 0.014 |
| *σp* | σ inflation shock | Igamma | 0.1 | 2 | 0.14 | 0.014 | 0.14 | 0.014 |
| *σw* | σ wage shock | Igamma | 0.1 | 2 | 0.28 | 0.020 | 0.28 | 0.021 |

Table 3: **Estimation results: sample 1967:Q1-2007:Q2**
*Entries under the headline Prior specify the mean and the standard deviation of the prior distribution (see Section 3). Entries under the headline Posterior specify the estimates of the mode and the standard deviation as discussed in Section 4.*

| Estimation sample 1967Q1-2007Q2 | | | | | Without financial accelerator | | With financial accelerator | |
|---|---|---|---|---|---|---|---|---|
| parameters | | Prior | | | Posterior | | Posterior | |
| | | shape | mean | s.d. | mode | s.d. | mode | s.d. |
| *ρa* | AR term in productivity shock | beta | 0.5 | 0.2 | 0.95 | 0.011 | 0.94 | 0.010 |
| *ρb* | AR term in spread shock | beta | 0.5 | 0.2 | - | - | 0.71 | 0.053 |
| *ρβ* | AR term in preference shock | beta | 0.5 | 0.2 | 0.16 | 0.076 | 0.24 | 0.102 |
| *ρg* | AR term in gov. spending shock | beta | 0.5 | 0.2 | 0.98 | 0.007 | 0.98 | 0.007 |
| *ρi* | AR term in investment shock | beta | 0.5 | 0.2 | 0.66 | 0.054 | 0.99 | 0.007 |
| *ρr* | AR term in interest rate shock | beta | 0.5 | 0.2 | 0.13 | 0.064 | 0.11 | 0.060 |
| *ρp* | AR term in inflation shock | beta | 0.5 | 0.2 | 0.90 | 0.045 | 0.88 | 0.046 |
| *ρw* | AR term in wage shock | beta | 0.5 | 0.2 | 0.98 | 0.010 | 0.93 | 0.032 |
| *μp* | MA term in price shock | beta | 0.5 | 0.2 | 0.76 | 0.080 | 0.71 | 0.091 |
| *μw* | MA term in wage shock | beta | 0.5 | 0.2 | 0.92 | 0.040 | 0.89 | 0.042 |
| *φ* | investment adjustment costs | normal | 4 | 1.5 | 6.40 | 1.139 | 4.15 | 0.789 |
| *σ* | σ consumption | normal | 1.5 | 0.375 | 1.40 | 0.129 | 1.36 | 0.193 |
| *h* | habit in consumption | beta | 0.7 | 0.1 | 0.70 | 0.040 | 0.68 | 0.070 |
| *ξw* | wage Calvo adjustment | beta | 0.5 | 0.1 | 0.77 | 0.062 | 0.85 | 0.055 |
| *σL* | σ labour supply | normal | 2 | 0.75 | 2.08 | 0.602 | 2.23 | 0.585 |
| *ξp* | price Calvo adjustment | beta | 0.5 | 0.1 | 0.69 | 0.052 | 0.66 | 0.046 |
| *ιw* | wage indexation | beta | 0.5 | 0.15 | 0.60 | 0.134 | 0.64 | 0.127 |
| *ιp* | price indexation | beta | 0.5 | 0.15 | 0.27 | 0.101 | 0.25 | 0.099 |
| *zk* | steady-state capital utilization rate | beta | 0.5 | 0.15 | 0.63 | 0.107 | 0.86 | 0.055 |
| *Φp* | Fixed cost in production | normal | 1.25 | 0.125 | 1.64 | 0.077 | 1.71 | 0.078 |
| *ρπ* | T.R. coefficient on inflation | normal | 1.5 | 0.25 | 1.96 | 0.180 | 1.79 | 0.205 |
| ρ | T.R. interest rate smoothing | beta | 0.75 | 0.1 | 0.81 | 0.025 | 0.78 | 0.029 |
| *ρy* | T.R. coefficient on output | normal | 0.125 | 0.05 | 0.06 | 0.020 | 0.04 | 0.020 |
| *ρdy* | T.R. coefficient on d(output) | normal | 0.125 | 0.05 | 0.23 | 0.027 | 0.23 | 0.026 |
| *π* | steady-state inflation rate | gamma | 0.625 | 0.1 | 1.25 | 0.154 | 1.00 | 0.108 |
| $100[\beta^{-1}-1]$ | steady-state nominal interest rate | gamma | 0.25 | 0.1 | 0.14 | 0.053 | 0.15 | 0.062 |
| *l* | steady-state hours worked | normal | 0 | 2 | 5.13 | 1.491 | 6.55 | 1.100 |
| *trend* | trend growth rate | normal | 0.4 | 0.1 | 0.40 | 0.015 | 0.39 | 0.015 |
| *ηga* | response of gov.spending to prod. | normal | 0.5 | 0.25 | 0.53 | 0.086 | 0.50 | 0.088 |
| *α* | capital share in production | normal | 0.3 | 0.05 | 0.19 | 0.016 | 0.18 | 0.017 |
| *lev* | leverage ratio | normal | 1.7 | 0.2 | - | - | 1.73 | 0.149 |
| *ω* | elasticity external risk premium | normal | 0.05 | 0.02 | - | - | 0.02 | 0.005 |
| *σa* | σ productivity shock | Igamma | 0.1 | 2 | 0.45 | 0.026 | 0.44 | 0.026 |
| *σb* | σ spread shock | Igamma | 0.1 | 2 | - | - | 0.18 | 0.055 |
| *σβ* | σ preference shock | Igamma | 0.1 | 2 | 0.24 | 0.022 | 0.23 | 0.028 |
| *σg* | σ government spending shock | Igamma | 0.1 | 2 | 0.51 | 0.028 | 0.51 | 0.028 |
| *σi* | σ investment shock | Igamma | 0.1 | 2 | 0.49 | 0.050 | 0.37 | 0.048 |
| *σr* | σ interest rate shock | Igamma | 0.1 | 2 | 0.23 | 0.014 | 0.23 | 0.014 |
| *σp* | σ inflation shock | Igamma | 0.1 | 2 | 0.14 | 0.015 | 0.14 | 0.016 |
| *σw* | σ wage shock | Igamma | 0.1 | 2 | 0.27 | 0.023 | 0.26 | 0.022 |

Table 4: **Variance decomposition: model with the FA mechanism**

*The contribution of each structural shock (rows) to variance of observed variables (columns) is reported on impact (t=1) and at various horizons (2.5 years and 10 years)*

| Var. \ Shocks | | Model with FA: 1967Q1-2012Q4 | | | | | | | | Model with FA: 1967Q1-2007Q2 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | productivity | spread | preference | gov. spending | investment | interest rate | inflation | wage | productivity | spread | preference | gov. spending | investment | interest rate | inflation | wage |
| t=1 | output | 20.69 | 12.99 | 19.22 | 30.82 | 2.24 | 9.88 | 3.04 | 1.12 | 18.90 | 14.78 | 17.15 | 36.41 | 1.96 | 7.39 | 2.61 | 0.80 |
| | cons. | 3.75 | 0.47 | 67.37 | 2.46 | 0.17 | 16.39 | 4.02 | 5.37 | 2.28 | 0.13 | 74.64 | 2.92 | 0.68 | 11.61 | 2.72 | 5.02 |
| | invest. | 1.79 | 70.23 | 0.28 | 0.02 | 20.23 | 5.24 | 2.11 | 0.10 | 2.91 | 71.30 | 0.34 | 0.07 | 17.64 | 5.17 | 2.53 | 0.04 |
| | int. rate | 8.70 | 2.80 | 22.63 | 1.46 | 1.03 | 54.73 | 7.81 | 0.86 | 9.05 | 2.58 | 18.79 | 1.38 | 0.63 | 57.97 | 8.10 | 1.50 |
| | inflation | 4.19 | 0.18 | 0.11 | 0.23 | 2.61 | 0.96 | 77.63 | 14.09 | 3.68 | 0.29 | 0.01 | 0.18 | 2.44 | 0.97 | 75.80 | 16.65 |
| | wage | 1.25 | 0.06 | 0.02 | 0.01 | 0.00 | 0.01 | 23.17 | 75.47 | 1.19 | 0.09 | 0.05 | 0.01 | 0.00 | 0.03 | 24.41 | 74.22 |
| | labour | 23.79 | 12.44 | 18.44 | 29.63 | 2.16 | 9.48 | 2.58 | 1.49 | 28.61 | 12.95 | 15.05 | 32.10 | 1.73 | 6.49 | 1.88 | 1.19 |
| | premium | 0.11 | 42.18 | 0.71 | 0.01 | 50.05 | 4.64 | 0.58 | 1.72 | 0.32 | 35.20 | 0.65 | 0.04 | 57.27 | 4.50 | 0.37 | 1.65 |
| t=10 | output | 17.13 | 15.51 | 15.96 | 22.86 | 5.77 | 9.97 | 7.21 | 5.59 | 16.32 | 16.52 | 14.48 | 27.92 | 4.66 | 7.86 | 5.76 | 6.48 |
| | cons. | 5.47 | 3.94 | 50.33 | 2.89 | 1.22 | 14.17 | 8.65 | 13.32 | 4.11 | 2.66 | 54.87 | 4.03 | 1.26 | 10.52 | 6.49 | 16.05 |
| | invest. | 2.67 | 59.78 | 0.22 | 0.02 | 27.38 | 4.77 | 4.24 | 0.93 | 3.94 | 61.07 | 0.25 | 0.08 | 24.91 | 4.59 | 3.93 | 1.24 |
| | int. rate | 11.66 | 13.17 | 10.78 | 1.96 | 27.00 | 16.97 | 7.96 | 10.51 | 12.67 | 13.30 | 6.57 | 1.91 | 24.07 | 18.05 | 7.99 | 15.43 |
| | inflation | 7.71 | 0.31 | 0.20 | 0.81 | 11.40 | 3.21 | 41.99 | 34.37 | 5.79 | 0.53 | 0.04 | 0.55 | 11.09 | 3.15 | 37.27 | 41.57 |
| | wage | 2.20 | 0.49 | 0.04 | 0.01 | 1.24 | 0.26 | 23.76 | 72.00 | 2.06 | 0.62 | 0.06 | 0.01 | 1.26 | 0.33 | 23.88 | 71.78 |
| | labour | 2.61 | 20.32 | 5.38 | 8.40 | 10.32 | 12.54 | 20.23 | 20.20 | 4.15 | 18.71 | 3.15 | 11.41 | 8.06 | 11.06 | 16.08 | 27.39 |
| | premium | 0.25 | 31.68 | 0.38 | 0.04 | 60.06 | 3.09 | 1.58 | 2.94 | 0.23 | 26.42 | 0.37 | 0.03 | 65.28 | 3.26 | 1.16 | 3.26 |
| t=40 | output | 16.74 | 17.12 | 14.81 | 21.16 | 5.81 | 9.68 | 8.10 | 6.59 | 16.24 | 17.26 | 13.54 | 26.13 | 4.61 | 7.72 | 6.76 | 7.74 |
| | cons. | 5.57 | 5.35 | 46.58 | 2.72 | 2.94 | 13.43 | 9.18 | 14.23 | 4.26 | 3.48 | 50.33 | 3.76 | 3.95 | 9.95 | 7.12 | 17.14 |
| | invest. | 3.00 | 58.94 | 0.19 | 0.03 | 26.70 | 4.62 | 5.02 | 1.51 | 4.47 | 60.27 | 0.23 | 0.09 | 23.68 | 4.50 | 4.81 | 1.95 |
| | int. rate | 10.55 | 15.96 | 6.93 | 3.04 | 35.18 | 10.98 | 5.47 | 11.90 | 9.42 | 13.21 | 4.55 | 2.42 | 38.19 | 11.71 | 5.31 | 15.19 |
| | inflation | 7.73 | 2.04 | 0.25 | 1.69 | 15.14 | 3.30 | 36.96 | 32.89 | 5.19 | 1.64 | 0.54 | 0.96 | 16.13 | 3.07 | 33.25 | 39.22 |
| | wage | 2.32 | 0.87 | 0.05 | 0.01 | 1.86 | 0.27 | 23.91 | 70.70 | 2.20 | 0.96 | 0.06 | 0.01 | 2.13 | 0.34 | 23.91 | 70.38 |
| | labour | 1.80 | 12.40 | 2.61 | 7.92 | 11.95 | 7.14 | 19.14 | 37.03 | 2.49 | 10.86 | 1.55 | 10.76 | 7.67 | 6.06 | 11.04 | 49.56 |
| | premium | 1.43 | 32.35 | 0.13 | 0.29 | 57.56 | 0.97 | 1.97 | 5.31 | 1.14 | 27.29 | 0.13 | 0.32 | 62.10 | 1.48 | 0.94 | 6.60 |

Table 5: **Variance decomposition: model without the FA mechanism**

*The contribution of each structural shock (rows) to variance of observed variables (columns) is reported on impact (t=1) and at various horizons (2.5 years and 10 years)*

| Var. \ Shocks | | Model without FA: 1967Q1-2012Q4 | | | | | | | | Model without FA: 1967Q1-2007Q2 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | productivity | spread | preference | gov. spending | investment | interest rate | inflation | wage | productivity | spread | preference | gov. spending | investment | interest rate | inflation | wage |
| | output | 18.44 | - | 21.73 | 33.46 | 15.16 | 8.52 | 2.25 | 0.44 | 16.94 | - | 18.64 | 38.55 | 17.69 | 5.63 | 2.22 | 0.32 |
| | cons. | 2.18 | - | 76.27 | 1.33 | 0.00 | 15.67 | 1.79 | 2.76 | 1.59 | - | 79.93 | 1.64 | 0.01 | 11.96 | 1.59 | 3.27 |
| | invest. | 1.63 | - | 0.02 | 0.05 | 92.02 | 3.71 | 2.58 | 0.00 | 2.60 | - | 0.08 | 0.21 | 92.98 | 2.13 | 1.96 | 0.05 |
| t=1 | int. rate | 7.06 | - | 21.41 | 1.41 | 3.08 | 57.77 | 8.09 | 1.19 | 8.68 | - | 17.58 | 1.42 | 2.60 | 59.61 | 8.24 | 1.87 |
| | inflation | 3.72 | - | 0.37 | 0.32 | 1.59 | 1.26 | 79.93 | 12.82 | 3.13 | - | 0.18 | 0.20 | 0.99 | 1.34 | 78.42 | 15.74 |
| | wage | 1.00 | - | 0.07 | 0.00 | 0.16 | 0.06 | 22.87 | 75.85 | 0.95 | - | 0.26 | 0.01 | 0.34 | 0.27 | 26.02 | 72.16 |
| | labour | 24.23 | - | 20.14 | 31.19 | 13.99 | 7.88 | 1.55 | 1.01 | 27.16 | - | 16.19 | 34.08 | 15.31 | 4.81 | 0.99 | 1.47 |
| | output | 15.72 | - | 17.87 | 25.76 | 20.39 | 9.43 | 5.87 | 4.97 | 15.49 | - | 16.16 | 31.08 | 19.27 | 6.54 | 4.93 | 6.53 |
| | cons. | 3.94 | - | 59.11 | 1.99 | 3.39 | 15.61 | 5.38 | 10.58 | 3.44 | - | 60.70 | 2.78 | 1.14 | 11.98 | 4.90 | 15.07 |
| | invest. | 2.89 | - | 0.07 | 0.09 | 86.82 | 3.49 | 5.24 | 1.38 | 4.68 | - | 0.07 | 0.39 | 87.15 | 2.21 | 3.73 | 1.77 |
| t=10 | int. rate | 11.74 | - | 11.22 | 2.72 | 32.47 | 22.64 | 8.02 | 11.18 | 14.93 | - | 7.45 | 2.67 | 22.42 | 22.31 | 10.62 | 19.60 |
| | inflation | 7.78 | - | 1.17 | 1.24 | 5.55 | 4.64 | 43.15 | 36.48 | 5.27 | - | 0.43 | 0.64 | 2.99 | 4.57 | 39.52 | 46.57 |
| | wage | 2.06 | - | 0.14 | 0.00 | 1.97 | 0.47 | 23.73 | 71.62 | 2.24 | - | 0.29 | 0.03 | 1.68 | 0.90 | 26.14 | 68.73 |
| | labour | 3.14 | - | 6.78 | 10.11 | 32.97 | 12.75 | 16.06 | 18.19 | 4.92 | - | 4.06 | 14.31 | 20.85 | 8.98 | 13.93 | 32.96 |
| | output | 15.37 | - | 16.94 | 24.37 | 21.74 | 9.48 | 6.59 | 5.51 | 15.64 | - | 15.54 | 29.94 | 19.49 | 6.66 | 5.77 | 6.96 |
| | cons. | 3.99 | - | 57.14 | 1.94 | 4.39 | 15.66 | 5.80 | 11.07 | 3.59 | - | 59.06 | 2.73 | 1.25 | 12.17 | 5.59 | 15.61 |
| | invest. | 2.98 | - | 0.08 | 0.09 | 85.64 | 3.48 | 5.88 | 1.85 | 5.08 | - | 0.07 | 0.39 | 85.81 | 2.26 | 4.36 | 2.03 |
| t=40 | int. rate | 12.22 | - | 9.19 | 4.36 | 33.31 | 18.73 | 6.96 | 15.25 | 13.33 | - | 6.06 | 3.38 | 20.51 | 18.36 | 8.91 | 29.45 |
| | inflation | 8.12 | - | 1.22 | 2.31 | 6.34 | 4.90 | 38.68 | 38.44 | 4.71 | - | 0.39 | 0.91 | 2.92 | 4.28 | 34.27 | 52.51 |
| | wage | 2.17 | - | 0.15 | 0.01 | 2.35 | 0.54 | 24.10 | 70.67 | 2.39 | - | 0.30 | 0.05 | 1.85 | 1.03 | 26.89 | 67.49 |
| | labour | 1.64 | - | 2.98 | 7.36 | 18.13 | 6.30 | 14.54 | 49.05 | 2.09 | - | 1.48 | 9.03 | 8.35 | 3.49 | 7.62 | 67.94 |

Figure 1: **Correlation between the external finance premium and the U.S. corporate spread**

*The solid line represents the smoothed external finance premium estimated by the model with FA over the sample 1967-2012. The other two lines represent the BAA-AAA spread and the BAA-10 years Treasury Bill spread (Source: Moody's and Board of Governors of the Federal Reserve System*

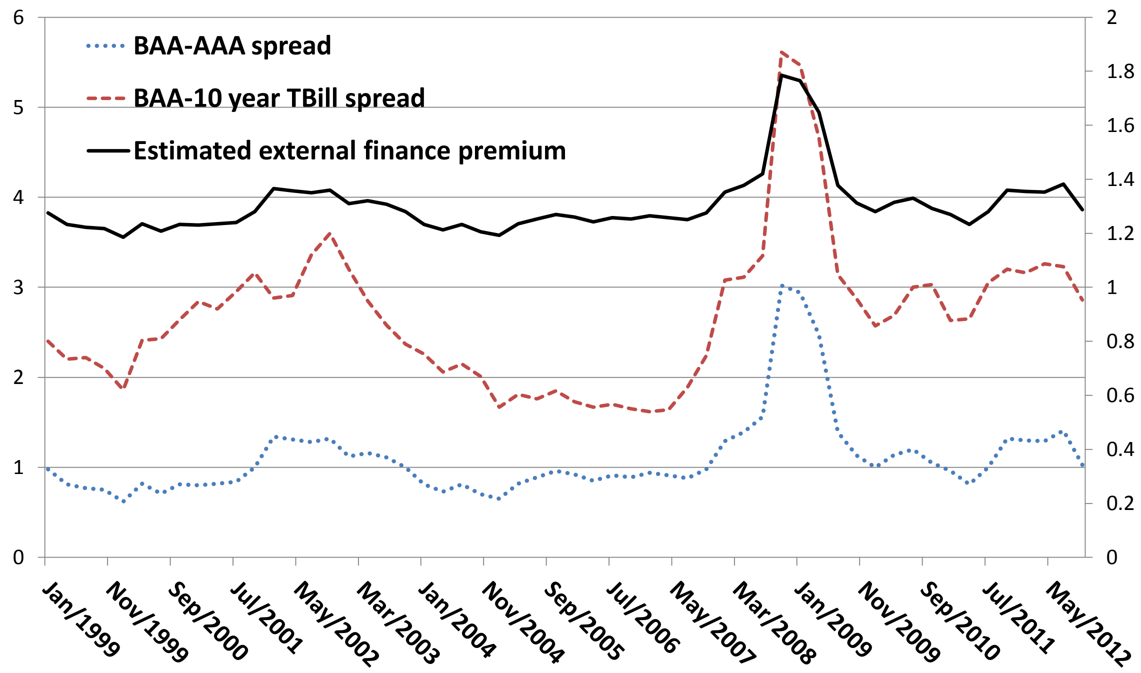

Figure 2: **IRFs to the investment shock**

*Variables are percentage deviations from the steady-state. The line marked with circles is from the original SW(2007) model. The line marked with triangles is from the SW(2007) model augmented by financial frictions. The IRFs are based on parameters estimated over the sample 1967-2012.*

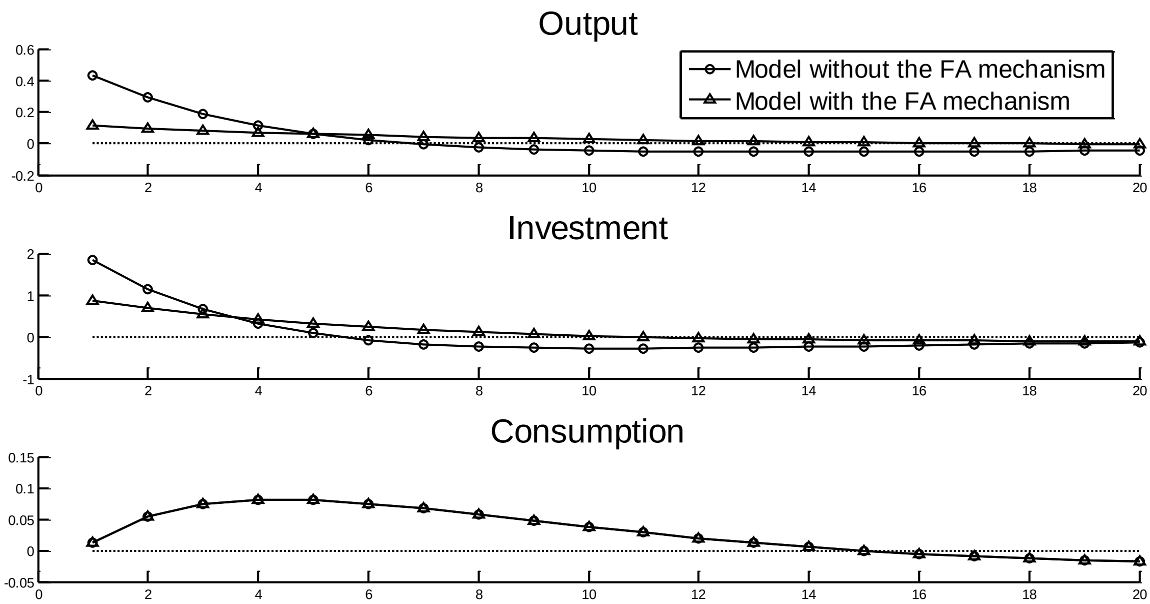

Figure 3: **IRFs to the government spending shock**

*Variables are percentage deviations from the steady-state. The line marked with circles is from the original SW(2007) model. The line marked with triangles is from the SW(2007) model augmented by financial frictions. The IRFs are based on parameters estimated over the sample 1967-2012.*

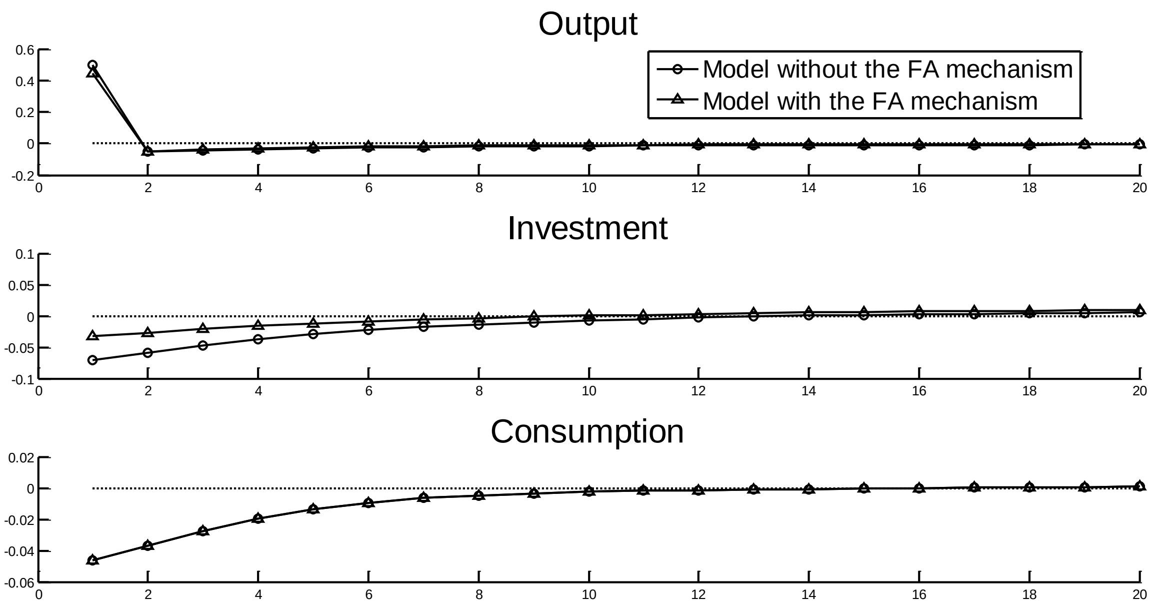

Figure 4: **Conditional forecast for the policy interest rate**
*The black solid line depicts the observed interest rate. The line marked with circles depicts the conditional forecast of the interest rate in the SW model with financial frictions. Parameters are set at the values estimated over the sample 1967:Q1-2008:Q2. The conditional forecast assumes that the path for the shock from 2008:Q2 inwards is exactly that one yield by the model estimated over the sample 1967-2012, except for the monetary shocks which are set equal to zero over the conditional path 2008:Q2-2012:Q4.*

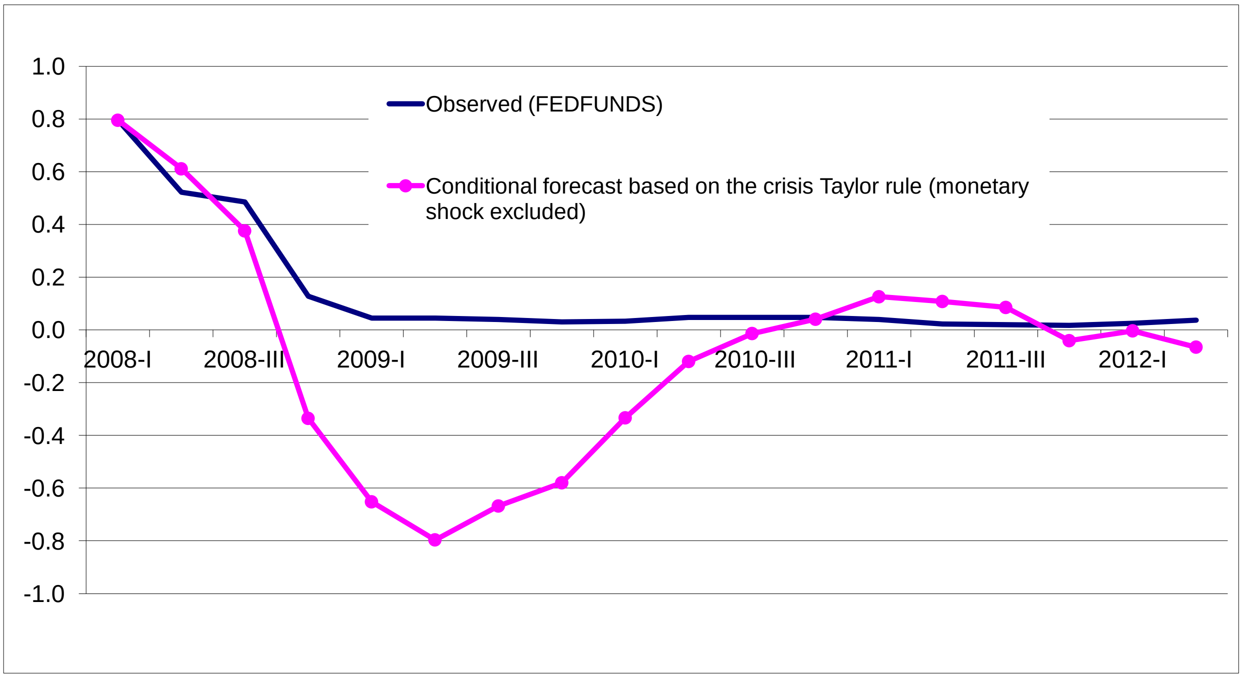

Figure 5: **IRFs of the external finance premium to each shock**
*IRFs of the external finance risk premium are showed as deviations from the steady-state expressed as percentage points. The IRFs are based on estimated parameters from the SW model with financial frictions estimated over the sample 1967-2012.*

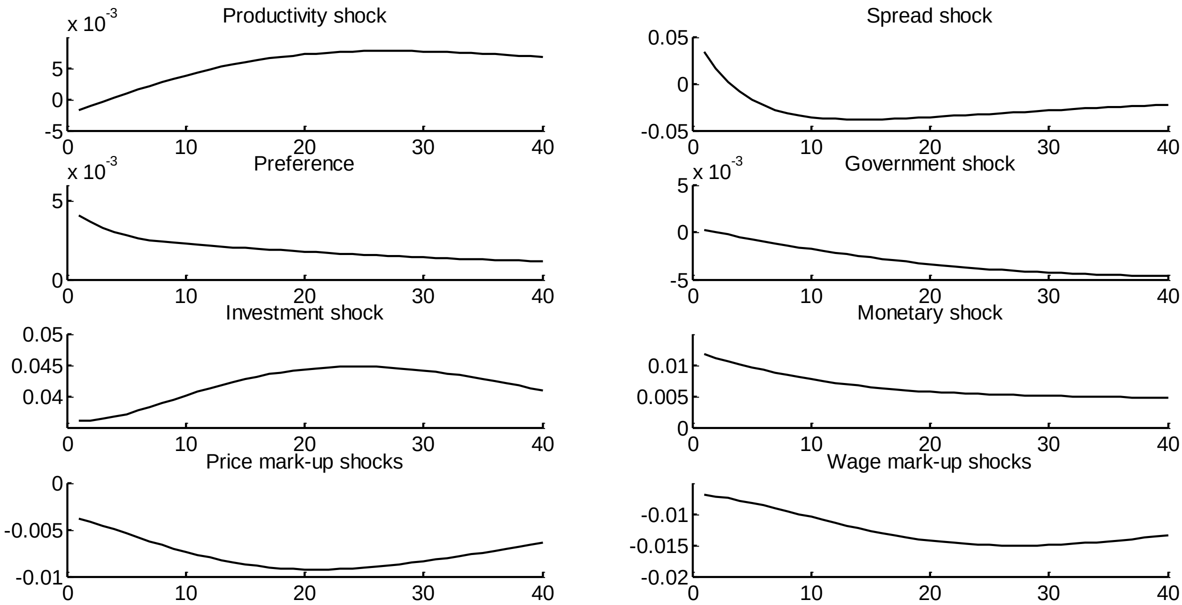

Figure 6: **Historical decomposition of the output growth**

*The figure shows how various shocks contribute to the (percentage) deviations from steady-state of the real GDP growth (solid black line) in the SW model with FA estimated over the sample 1967-2012.*

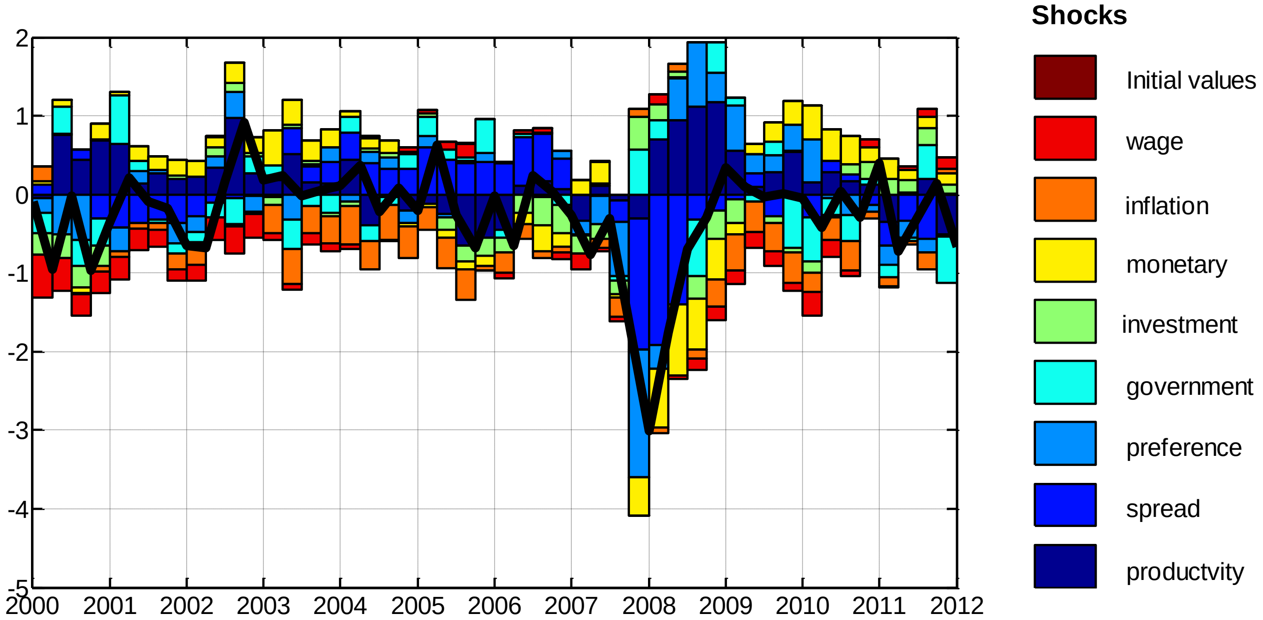

Figure 7: **Historical decomposition of investment**
*The figure shows how various shocks contribute to the (percentage) deviations from steady-state of investment (solid black line) in the SW model with FA estimated over the sample 1967-2012.*

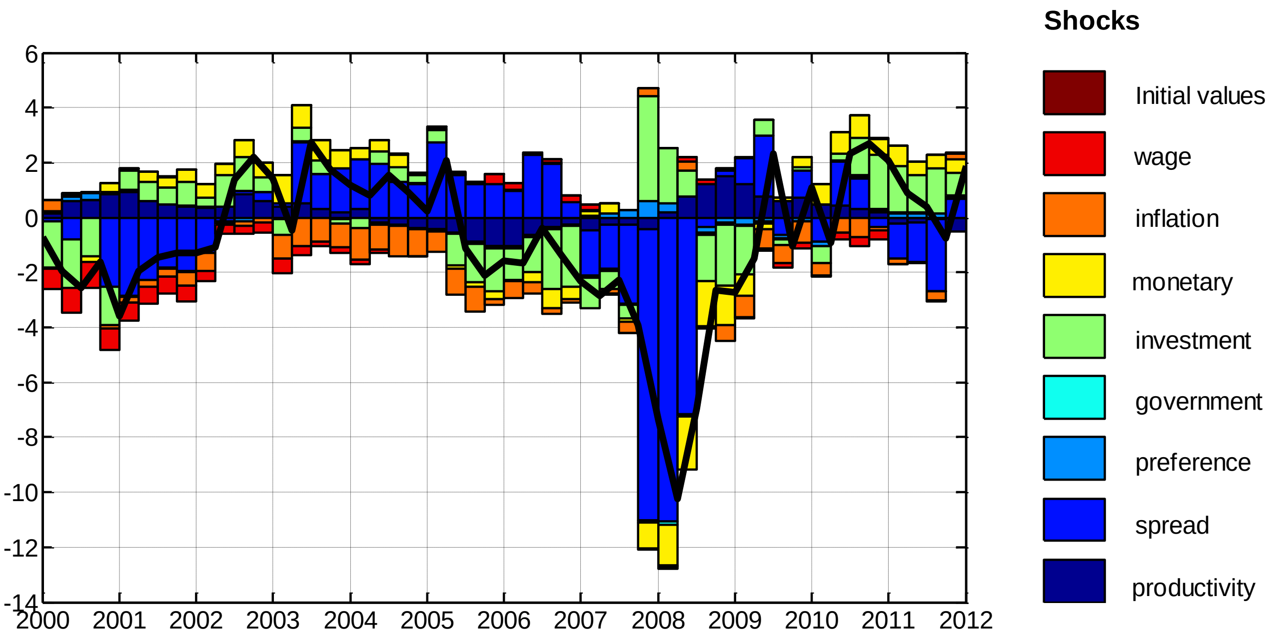

Figure 8: **Financial Condition Index (source: OECD Economic Outlook N. 90**
*The figure reports on the left scale the spread shock (based on estimated parameters from the SW model with financial frictions over the sample 1967-2012) and on the right scale the OECD Financial Condition Index for the US economy (for further details, see the Appendix B).*