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Risk Shocks and Divergence between the Euro area and the US

Thomas Brand & Fabien Tripier

Highlights

- Highly synchronized during the Great recession of 2008-2009, the Euro area and the US have diverged since 2011.
- The divergence is not limited to economic growth, the financing conditions also differed.
- A business cycle model is estimated with risk shocks to account for time-varying idiosyncratic uncertainty in the financial sector.
- Estimated risk shocks have played a crucial role in the divergence: they have stimulated the US credit and investment growth since the trough of 2009 whereas they have been at the origin of the double-dip recession in the Euro area.

Abstract

Why have the Euro area and the US diverged since 2011 while they were highly synchronized during the recession of 2008-2009? To explain this divergence, we provide a structural interpretation of these episodes through the estimation of a business cycle model with financial frictions for both economies. Our results show that risk shocks, measured as the volatility of idiosyncratic uncertainty in the financial sector, have played a crucial role in the divergence with the absence of risk reversal in the Euro area. Risk shocks have stimulated US credit and investment growth since the trough of 2009 whereas they have been at the origin of the double-dip recession in the Euro area. A companion website is available at http://shiny.cepii.fr/risk-shocks-and-divergence.

Keywords

Great recession, business cycles, uncertainty, divergence, risk Shocks.

JEL

E3, E4, G3.

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CEPII
113, rue de Grenelle
75007 Paris
+33 1 53 68 55 00

www.cepii.fr
Press contact: presse@cepii.fr

RESEARCH AND EXPERTISE ON THE WORLD ECONOMY

Risk Shocks and Divergence between the Euro area and the US[1]

Thomas Brand* and Fabien Tripier†

1. Introduction

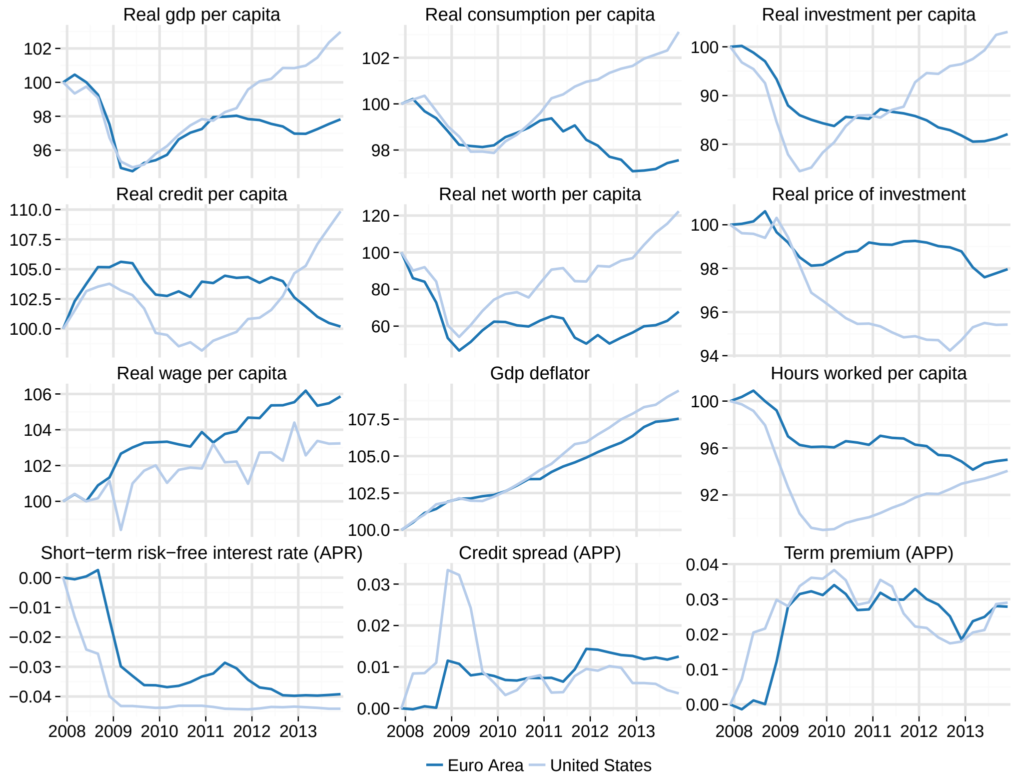
Highly synchronized during the Great recession of 2008-2009, Euro area and US economies have diverged since the former entered in a new recession, in the middle of 2011, while the latter pursued its expansion - see Figure 1.[2] The 3 percent growth of real GDP per capita over the last six years has been disappointing for the US economy, initiating a debate on the origins of the slow recovery,[3] but it outweighs the -2.2 percent of cumulated contraction in the Euro area.

The Euro area case corresponds to the pattern of a "double-dip recession" identified by Reinhart and Rogoff (2014) as typical after historically severe systemic banking crises.[4] The divergence is not limited to GDP or investment. Financing conditions also differed - see Figure 1. In the Euro area, credit to non-financial corporations is almost the same as before the Great recession while credit spreads on corporate debt are still high and their net worth thirty percent below its pre-crisis value. On the contrary, in the US, credit spreads returned to their pre-crisis values while growth rates of credit and net worth have been higher than GDP growth. Based on such evidence, we investigate the role of the volatility of idiosyncratic uncertainty in the financial sector, defined as risk shocks by Christiano et al. (2014a), in explaining the divergence between the two economies. We show that risk shocks have played a crucial role in the US because they

[1]The views expressed in this paper are those of the authors and do not necessarily reflect those of the institutions to which they belong.
*CEPII (thomas.brand@cepii.fr)
†University of Lille 1 - CLERSE & CEPII (fabien.tripier@univ-lille1.fr)
[2]The divergence is particularly striking given the strong similarity of the timing and the magnitude of the 2008-2009 recessions. The peak date is 2007Q4 for the US, and Euro area enters recession one quarter later, in 2008Q1, according to the NBER and the CEPR respectively. There is no difference in the trough dates, 2009Q2 for both, and the date of the second peak for the Euro area is 2011Q3. The cumulative loss of output between 2007Q4 and 2009Q2 is close to 5 percent in the Euro area and the US (5.2 and 5.0 respectively).
[3]See for instance Baker et al. (2012), Galí et al. (2012), Fatás and Mihov (2013) or Taylor (2014).
[4]According to the authors a double-dip recession occurs after 2008 in several economies of the Euro area (France, Ireland, Italy, Netherlands, and Portugal) but not in all. Recessions in Germany, Spain, and Greece, which differ with respect to their amplitude and duration, have a single dip - see the online appendix of Reinhart and Rogoff (2014). Using the author's definition of a double-dip as "any renewed downturn that takes place before the economy reaches the prior peak", the Euro area as a whole experienced a double-dip recession and not the US for the business cycle reference dates provided before.

have stimulated credit and investment growth since the trough of 2009 whereas they have been at the origin of the double-dip recession in the Euro area.

Figure 1 – Comparison of macroeconomic and financial variables between the Euro area and the US (2007Q4-2013Q4)



Note: Index in base 100 = 2007Q4, except for interest rates and spreads which are in deviation from 2007Q4 value in Annual Percentage Rate (APR) and Annual Percentage Points (APP) respectively. Source: see Appendix.

Idiosyncratic uncertainty in the financial sector has been introduced in dynamic and stochastic general equilibrium (DSGE) models by Bernanke et al. (1999). More recently, Christiano et al. (2014a) make this idiosyncratic uncertainty time-varying through risk shocks that modify the standard deviation of idiosyncratic shocks to the productivity of private borrowers and lead to macroeconomic fluctuations.[5] By doing so, the authors provide a new transmission channel of

[5]In this model, the entrepreneur combines personal wealth and loan provided by the financial intermediary to transform raw capital into effective capital. The technology through this process is specific to each entrepreneur, approximated by an idiosyncratic shock applied to raw capital. Entrepreneurs who draw a low value of this idiosyncratic shock experience failure and lenders have to pay to check the state of the firm because of asymmetric information *à la* Townsend (1979). An increase in risk means a higher dispersion of idiosyncratic shocks and therefore a higher risk of default. The outcome of optimal financial contract is modified: the credit spread between the loan interest rate and the risk free interest rate rises to cover the higher risk taken by the lender and the leverage ratio of entrepreneurs falls to limit the size of financial losses. Entrepreneurs diminish their demand for physical

uncertainty to business cycles through financial frictions that we use in this paper. This new transmission channel has also been developed by Arellano et al. (2012) who consider changes in the volatility of idiosyncratic demand shocks between hiring decision and sales revenues. For reasons explained below, we prefer a model which has an explicit physical capital accumulation, in order to account for the divergence in private investment.

The transmission channel traditionally considered in the literature is not the consequence of financial frictions but of irreversible investment or fixed costs as originally developed by Bernanke (1983) and more recently by Bloom (2009) and Bloom et al. (2012). Gilchrist et al. (2014) analyze the relative importance of these two channels and show that financial frictions are a powerful transmission channel of uncertainty fluctuations to macroeconomic activity through changes in credit spread, corporate debt and leverage ratio of indebted firms - variables who diverged substantially between the Euro area and the US as explained above.

To investigate the role of risk shocks, we choose to specify a DSGE model enriched with financial frictions. The choice of the model is delicate because, for comparison purposes, the selected DSGE model should be mostly identical for each economy (otherwise estimation results may be difficult to compare), while performing well for both (historical data are however different by definition). For this purpose, the model of BGG in an otherwise standard DSGE model, such as Christiano et al. (2014a) (henceafter CMR), has three advantages. First, CMR demonstrate the good empirical performances of this model for accounting US business cycles, especially for recent business cycles up to 2010Q2. It is therefore natural to extend its application to the last three years to get an insight on the origin of the US recovery. Second, such a model can be viewed as a reduced version of the model developed by Christiano et al. (2010) that has been precisely estimated to compare US and Euro area business cycles. If we abstract from the financial sector, the CMR model is also close to the DSGE model developed by Smets and Wouters (2005) to compare Euro area and US business cycles.[6] Third, this model proposes a good compromise between its generality (necessary to be applied identically to the two economies) and its detailed features that allows to account for differences in market frictions (as consumption habit formation, capital adjustment costs, markups, wage/price stickiness, and agency problem in the financial sector), in shocks (associated with shifts in demand, technology, policy or financial risk), and in policies (fiscal or monetary).

We estimate the model for US and Euro area economies over the period 1987Q1-2013Q4. We use quarterly observations of eight macroeconomic series that are standardly used in the estimation of DSGE models and four financial series : credit to non financial corporations, slope

capital leading to an aggregate reduction in investment and production. This countercyclical behavior of credit spread makes risk shocks different from financial shocks on the wealth of borrowers also referred as equity shocks (Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011).

[6] They estimate an identical DSGE model with real and nominal rigidities for the US and the Euro area and identify the similarities and the differences in their structural characteristics (e.g. type of shocks, propagation mechanisms or monetary policy rules). As Smets and Wouters (2005), we do not consider here heterogeneity in Euro area members neither common shocks between the Euro area and the US.

of the term structure of interest rates, entrepreneurial net worth and credit spread, defined as the difference between credit interest rate and risk-free rate.[7] Other papers based on estimated DSGE models do not provide a comparison between the Euro area and the US that covers the double-dip recession in the Euro area.[8]

We hightlight two sets of results. First, we show that an important part of the business cycle variance in output is accounted for by risk shocks in both economies (46 percent for the US and 49 percent for the Euro area). Those shocks are particularly useful to account for episodes of credit crunch, with contraction of both investment and ouptut, and high credit spread. Such a sequence has been observed during the last recessions in US and Euro area economies. According to our estimation results, risk shocks dominate all the other shocks to explain the recent divergence between the two economies: a steady reduction of risk supports US credit and investment growth since the trough of 2009Q2 whereas a substantial increase in risk after the peak of 2011Q2 has plunged the Euro area into a double-dip recession.

Second, even if risk shocks play an important role in business cycles and in the recent divergence between both economies, we also hightlight significant differences in the propagation of those shocks from the financial sector to the real economy. This second result helps to explain an important paradox, ie credit spreads are more volatile in the Euro area than in the US while the dispersion of macroeconomic variables like GDP are the same. Indeed, estimated standard deviations of risk shocks are higher in the Euro area than in the US, but these shocks have less impact in the Euro area. We suggest that the differential impact of risk shocks comes from lower costs to verify the borrower's state in the Euro area. Counterfactual experiments show the importance of those structural differences in the divergence between Euro area and US economies.

Both results are important because if there is a relative consensus on the central role of financial shocks in the US recession of 2008-2009 (Christiano et al., 2014a), it is not the case for the shocks at the origin of (*i*) the US "slow recovery" and (*ii*) the Euro area double-dip recession. Some papers such as Sala et al. (2013) or Galí et al. (2012) do not find that improvements of financial factors support US growth after the through of 2009. But they do not consider risk shocks as we do and, as suggested by CMR, Arellano et al. (2012) and Gilchrist et al. (2014) to account for the transmission of financial uncertainty to the real economy. Our results show that the US have succeeded in not only reducing but also inversing the risk problem in the economy. To the contrary, the Euro area, hit by a less negative impact of risk than in the US at the beginning of the crisis, have failed to manage this risk as exemplified by the longstanding

[7] All these variables, and their role in the estimation, are discussed below.

[8] The most recent papers which estimate DSGE model and focus on US economy do not consider the Euro area and those which focus on Euro area economy do not study the whole double-dip recession. See Galí et al. (2012), Merola (2013), Del Negro et al. (2013) or Christiano et al. (2014a,b) for the US economy - Sala et al. (2013) study the US, the UK, Sweden and Germany. For the Euro area economy, the last year of the data sample is 2008 in Darracq Pariès et al. (2011), Christiano et al. (2010) and Villa (2013), 2010 in Coenen et al. (2012) and Lombardo and McAdam (2012) and 2011 in Kollmann et al. (2013).

tensions in its banking sector highly affected by the sovereign debt crisis of 2011.[9]

The remainder is organized as follows. Section 2 provides a brief summary of the model and describes the estimation strategy. Section 3 provides our structural interpretation of the divergence. Section 4 discusses our results and their relations to other explanations of the Great recession. Section 5 concludes.

2. Methodology

We use the CMR methodology[10] and Dynare (Adjemian et al., 2011) to solve the model and estimate it using observed data for US and Euro area economies. A companion website to this paper is available at http://shiny.cepii.fr/risk-shocks-and-divergence. It provides the main results reported in this paper but can also be used to display supplementary results and robustness checks.

2.1. The model

A detailed exposition of the model and its economic foundations can be found in CMR. The purpose of this section is to provide a brief summary of the model that allows the reader to understand the estimation results provided below. We describe the general equilibrium structure of the model with a focus on the definition of shocks.

2.1.1. The general equilibirum model

The model belongs to the class of DSGE models with real and nominal rigidities developed by Christiano et al. (2005) and Smets and Wouters (2003, 2007) augmented to include financial accelerator mechanism *à la* Bernanke et al. (1999).

The economy is populated by identical households. Each household contains a unitary continuum of workers and a large number of entrepreneurs. The source of funds for households are labor earnings, bond yields, revenues of capital which is accumulated by households, and other lump-sum transfers. The household allocates funds to consumption purchase, short-term and long-term bonds acquisition, and the purchase of investment goods and existing capital in the economy. The long-term bond interest rate is determined in the model by the expectations for the short-term rate. A shock is included in the long-term bond interest rate to match the term premium in the data. This shock is referred as the "term structure shock". The representative household maximizes the expected value of the discounted utility of its members derived from

[9] Consistently with this result, it is recalled in the introduction of Pisani-Ferry (2014) that in 2009, "everyone was speaking of a global financial crisis" and "if a country could be singled out as being crisis hit, it was the US, where the subprime crisis originated".

[10] Material is avaible on the website of http://faculty.wcas.northwestern.edu/ lchrist/ including the manual entitled "The CMR Model" written by Benjamin K. Johannsen

leisure time and from consumption with habit formation. Preference shocks affect the household utility function. This shock is referred as the "consumption preference shock".

The final good is produced using a continuum of intermediate goods according to a Dixit-Stiglitz technology. The elasticity of substitution among intermediate goods is stochastic to account for markup fluctuations. This shock is referred as the "price markup shock". The producers of intermediate goods use the services of physical capital and labor, according to a stochastic Cobb-Douglas production function subject to transitory shocks on the total factor productivity and growth shocks on the trend of labor technological progress. These shocks are referred as the "temporary technology shock" and the "persistent technology growth shock", respectively. The second source of growth of the model is an investment specific technology growth, which decreases the price of investment. It is also submitted to a shock referred as the "investment price shock".

Prices and wages are subject to nominal rigidities *à la* Calvo. Monopoly suppliers of labor and of intermediate goods can reoptimize their wage and price only periodically (with an exogenous probability), otherwise they follow an indexation rule that depends on the target inflation rate fixed by the monetary authority. This target is submitted to the "inflation target shock". In addition to targeting inflation, the monetary authority sets the nominal interest rate given its past value, the deviations of inflation and output with respect to their steady-state values, and a stochastic disturbance, which is referred as the "monetary policy shock". A second policy shock is introduced through the government consumption of final good, which is affected by a stochastic disturbance referred as the "government consumption shock".

Households accumulate raw capital by purchasing the existing undepreciated capital of the economy and investment goods, which are subject to adjustment costs. Adjustment costs are stochastic because of a shock on the marginal efficiency of investment in producing capital, which is referred as the "marginal efficiency of investment shock". Raw capital cannot be directly used in the production sector that uses effective capital. Households sell raw physical capital to entrepreneurs who transform it into effective capital. To buy raw capital, entrepreneurs use their personal wealth and a loan obtained from a financial intermediary. The loan contract is characterized by agency problems subject to financial shocks. Given the importance of financial shocks for our analysis, we provide a more detailed description of these shocks below.

2.1.2. The financial shocks

The agency problem is associated with the asymmetric information between the entrepreneur and the financial intermediary that makes costly checking the state of defaulting entrepreneur - hence the expression costly-state verification proposed by Townsend (1979).

Let N be the personal wealth of the entrepreneur and B the size of the loan.[11] The purchase of K units of raw capital at price Q_K satisfies $Q_K K = N + B$. The K units of raw capital are

[11] To simplify the presentation we omit the time index.

transformed into ωK units of effective capital that will be sold to the final good producers. ω is the idiosyncratic shock that makes risky the business of entrepreneurs. The idiosyncratic shock has a unit-mean log normal distribution denoted $F(\omega)$. It is observed by the entrepreneur after its purchases of raw capital. If the realized value is too low, namely $\omega < \bar{\omega}$, the entrepreneur defaults because it cannot reimburse the loan. The equilibrium value of $\bar{\omega}$ satisfies

$$R^k \bar{\omega} Q_K K = BZ, \tag{1}$$

where R^k is the return on effective capital and Z the loan interest rate. The return on revenues received by the financial intermediary from its entrepreneur is

$$[1 - F(\overline{\omega})] ZB + (1 - \mu) \int_0^{\overline{\omega}} \omega dF(\omega) R^k Q_K K \tag{2}$$

With the probability of no-default $[1 - F(\overline{\omega})]$, the financial intermediary receives interest on its loan. Otherwise, the financial intermediary gets the share $1 - \mu < 1$ of the assets of the bankrupt entrepreneur (the collateral) where μ measures the size of the state verification costs.

The "risk shock" modifies the standard deviation of the idiosyncratic shocks ω. The standard deviation of $\log(\omega)$ is denoted σ_t and evolves as follow

$$\log(\sigma_t/\sigma) = \rho_\sigma \log(\sigma_{t-1}/\sigma) + u_t, \tag{3}$$

where u_t is an iid innovation to the risk in the economy, ρ_σ is the persistence of the risk shock, and σ the steady-state level of risk. An increase in σ_t makes higher the cross-sectional dispersion in ω. Because the mean of ω is unchanged, it means higher probabilities for low realizations of ω and therefore higher default risk in the economy. This shock is referred as the "risk shock".

The second financial shock modifies the net wealth of entrepreneurs. With a stochastic probability, the household takes all the wealth of the entrepreneur. The entrepreneur can however still get a loan thanks to an exogenous transfer from the households, but the agency problems are reinforced because the value of its assets (or the collateral) is reduced. This shock is referred as the "equity shock".

Finally, CMR consider news on the risk shock that evolves as follows

$$u_t = \xi_{0,t} + \xi_{1,t-1} + ... + \xi_{p,t-p}, \tag{4}$$

where $\xi_{0,t}$ is the unanticipated component of u_t and $\xi_{j,t-j}$ for $j > 0$ is the anticipated (or news) components of u_t. These shocks are referred to "news shocks".

2.2. Inference about parameters

2.2.1. Presentation of the data

We use quarterly observations on twelve variables covering the period 1987Q1-2013Q4. These include eight variables that are standard in bayesian estimation of DSGE models: GDP, consumption, investment, inflation, wage, price of investment, hours worked and short-term risk-free interest rate. As CMR, we also use four financial variables: credit, slope of the term structure of interest rates, entrepreneurial net worth and credit spread. See Appendix A for details about the different series.

For Euro area, we use the Area-wide Model (AWM) database (Fagan et al., 2001), up to 2010Q4.[12] We then link, where it is feasible, the data contained in the orginal AWM database to the official Euro area data. This seems legitimate because the AWM database has been constructed using both Euro area data reported in the ECB Monthly Bulletin and other ECB and Eurostat data where available.

Credit spread is a key variable in the estimation of a model with financial frictions. So the choice of a different definition from CMR in the European case has to be explained. We acknowledge that corporate bond spread appears as a good proxy of credit spread where lending is mostly done by financial markets, as in the US. However, when financial system is dominated by banks, as in the Euro area, it seems more appropriate to choose an average of the retail bank interest rates, that we choose here.[13]

2.2.2. Calibration

Table 1 contains a description of the parameters that we fix during the estimation. We comment here only on calibrated parameters which differ between the Euro area and the US.[14] We set the growth rate μ_z of the unit root technology shock and the growth rate of investment-specific technological change Υ to 1.66 percent and 1.70 percent respectively for the US, and to 1.90 percent and 0.40 percent respectively for the Euro area. The short-term risk-free rate and the inflation target are fixed at 4% and 2% respectively in annual percent rate for the Euro area and 4.7% and 2.4% for the US. The discount rate are deduced to allow equality of Euler equation at the steady state. η^g is fixed to obtain an appropriate government spending ratio to GDP. For Euro area data, tax rates are sample measn of Eurostat implicit tax rates (1995-2011). Shares of capital in production function differ to account for a lower stock of capital in Euro area.

2.2.3. Estimation

The model is estimated through Bayesian procedures surveyed by An and Schorfeide (2007). Prior and posterior of estimated structural parameters and shock processes, which are the same for both countries, are detailed in Table B.1, in the Appendix. Table 3 reports the steady-state properties of the model when parameters are set to their mean under the prior distribution. This table also reports the corresponding historical values. Overall, the model and the data match well. Even if capital to output ratio differ a little between the data and the model for both

[12] Here we use the 11th update of the AWM database.

[13] See De Fiore and Uhlig (2011) and Reichlin (2014) for evidence on the differences between the two financial system.

[14] The following figures correspond to the means of each variable during the period of the Great moderation.

Table 1 – Calibrated parameters

		EA	US
β	Discount rate	0.9998	0.9987
ψ_L	Disutility weight on labor	0.7705	0.7705
δ	Deprecation rate of the economy	0.025	0.025
α	Power on capital in production function	0.30	0.40
σ_L	Curvature on disutility of labor	1	1
Υ	Growth rate of investment specific technological change (APR)	0.40	1.70
μ_z	Growth rate of the economy (APR)	1.90	1.66
λ_w	Steady state markup, suppliers of labor	1.05	1.05
λ_f	Steady state markup, intermediate good firms	1.20	1.20
$1-\gamma$	Fraction of entrepreneurial net worth transferred to households	1-98.50	1-98.50
W^e	Transfer received by new entrepreneurs	0.005	0.005
Θ	Share of resources for state verification	0.005	0.005
η_g	Steady state government spending-GDP ratio	0.21	0.20
π^{target}	Steady state inflation rate (APR)	2.00	2.43
R	Short-term risk-free interest rate (APR)	4.00	4.70
τ^c	Tax rate on consumption	0.195	0.05
τ^k	Tax rate on capital income	0.256	0.32
τ^l	Tax rate on labor income	0.381	0.24

economies, with a lower stock of capital in the US model than in the data, and a higher stock in the Euro area model than in the data, there is still a higher stock of capital in the US than in Euro area, consistently with the data.

For the US economy, results can be compared with those reported by CMR to assess how estimation results are sensitive to the selected period. Actually, the single difference for the US economy is that our sample period is 1987Q1-2013Q4 against 1985Q1-2010Q2 in CMR.[15] Our posterior modes are very close to that of CMR. We therefore focus our analysis on the differences between the Euro area and the US - see Table B.1. We compare the 80 percent interval confidences to identify some structural differences between the two economies. One parameter value is considered as significantly different when its posterior mode for one economy does not fall within the confidence interval of the other economy.

As in Smets and Wouters (2005) and Christiano et al. (2010), we do not observe significant differences in real frictions, namely the degree of habit formation and the curvatures of the investment and utilization-cost technologies.

Our estimation results indicate however significant differences in the degree of nominal rigidities both for prices and wages. Wages are more stickiness in the Euro area than in the US whereas it is the opposite for price stickiness.[16] In Christiano et al. (2010) the Calvo parameters are

[15]We restrict here the beginning of the US data sample to have the same time span in both economies.

[16]For the posterior distributions, wages are not revised with a probability equal to 0.85 in the Euro area whereas it is 0.75 in the US. For prices, the probability of no-revision is 0.80 in the US against 0.72 in the Euro area.

very close for the two markets and for the two economies without significant differences.[17]. In Smets and Wouters (2005), there is no significant difference for price rigidities but the Calvo parameter for wage stickiness is significantly higher in the US than in the Euro area. However, this difference vanishes when they restrict the data sample to the period after 1983. Substantial differences also concern the indexing of prices and wages in the case of no-revision. The weight of inflation target is lower in the Euro area than in the US for wage indexing whereas it is the opposite for prices.

The most striking difference between the two economies lies in financial frictions. Monitoring costs, namely μ, are estimated to represent 6.8% of seized assets in the Euro area (the 80% confidence interval is [5.4-17.9]) against 23.4% in the US (the 80% confidence interval is [13.9-35.4]). Consistently, given a lower verification cost of default in the Euro area, the probability of default and the leverage ratio of non-financial corporations are higher in this economy when compared with the US.[18] Financial frictions are also less important in the Euro area because the steady state level of idiosyncratic uncertainty, namely σ, is 0.18 against 0.29 in the US.

Concluding that financial frictions are less severe in the Euro area than in the US deserve some discussion. This conclusion is rationale if we keep in mind that we consider two different financial systems. For the US, the series of credit spread is calculated for market debt and the series of credit includes all credit instruments in which market debt is the most important part. For the Euro area, the credit spread and the amount of credit are both defined for bank debt, which is the main source of credit to non financial corporations in this economy.[19] Actually, our estimation suggests that verification costs are less expensive for banks in the Euro area than for bond holders in the US, which is consistent with the traditional view of banks as agents specialized in auditing and monitoring activities.

One important consequence of the difference in the estimated parameters of the financial contract is the difference in the propagation of risk shocks, from the financial sector to the real economy. To understand that, we must explain the link between the degree of financial frictions and the sensitivity of macroeconomic variables to risk shocks. Consider the credit spread as the premium asked by lenders given the risk of default. Risk fluctuations implie negative co-movements between credit spread and the growth rate of credit: when risk is higher, lenders lent less and asked a greater premium. The credit crunch is then transmitted to macroeconomic ac-

[17]The lowest probability of no-revision is 0.693 for prices in the US and the highest is 0.712 for wages in the EA - see Table 4 in Christiano et al. (2010)

[18]The default probability is 1.5% for the Euro area against 0.6% for the US and the leverage ratio k/n, is 2.94 in the Euro area against 1.86 for the US. These figures are for the mode of the posterior distribution of parameters and therefore differ from the figures reported in Table 3 computed for the prior distribution. In von Heideken (2009), the costly-state verification parameter μ is estimated lower in the US than in the Euro area, contrary to us, but the author does not include financial series in the estimation.

[19]The lack of market debt in the Euro area can be viewed as a the consequence of other financial frictions than the costly-state verification considered herein, which are not present in our model. For example, De Fiore and Uhlig (2011) suggest that the availability of public information about firms' credit worthiness and the efficiency of banks in acquiring this information can explain the observed gap between the two economies.

tivity through physical capital market and investment decisions as illustrated by Figure 2, which shows the Bayesian impulse response functions of main variables to an anticipated innovation in the risk shock.

Other things being equal, stronger financial frictions amplify the responses of macroeconomic variables to risk shocks. However, we show that the volatility of real GDP and credit per capita are almost identical in the two economies while the credit spread is half time more volatile in the Euro area than in the US - see Table 2. Consistently with the high volatility of credit spreads in the Euro area, estimated risk shocks are more volatile for this economy than in the US - but less persistent. Moderate financial frictions in the Euro area are therefore necessary to dampen the impact of credit spread fluctuations, which are higher than in the US, to aggregate series, which are not more volatile than in the US.

Table 2 – Standard deviations of some macroeconomic and financial variables

	GDP	Investment	Credit	Credit spread
Euro area	0.58%	1.49%	1.14%	0.29%
United States	0.62%	2.40%	1.05%	0.19%

Note: Standard deviations are calculated for annualized growth rates of GDP, investment and credit over the period 1988Q1-2013Q4.

Table 3 – Steady state properties : Model at Priors versus Data

		Model EA	Data EA	Model US	Data US
i/y	investment/GDP	0.20	0.21	0.25	0.24
c/y	private consumption/GDP	0.59	0.57	0.54	0.59
g/y	public consumption/GDP	0.21	0.21	0.20	0.16
k/y	capital/GDP	6.5	5	7.6	11
$n/(k-n)$	equity to debt	1.7	1.6	1.91	1.3-4.7
	transfer received by new entrepreneurs/GDP	0.29	not known	0.18	not known
	banks monitoring costs/GDP	0.41	not known	0.45	not known
	credit velocity	1.6	1.2	1.5	1.7

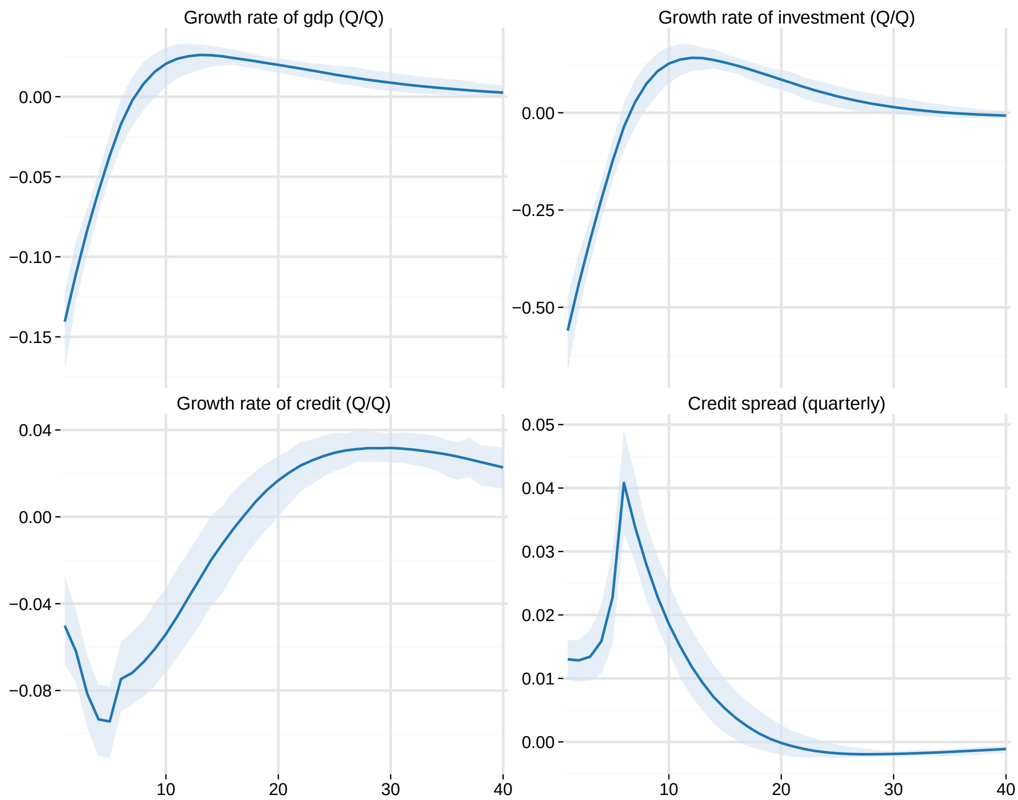
Note: For US data, all sample averages are computed over the period 1985Q1:2008Q2, except inflation, short-term interest rate and finance premium, which are computed over 1987Q1:2008Q2 (data come from CMR). For Euro area data, all sample averages are computed over the period 1987Q1:2008Q2, except inflation, short-term interest rate and external finance premium, which are computed over 1994Q1:2008Q2 (from the beginning of the Maastricht Treaty) and the equity to debt ratio (for non financial corporations), from 1999Q1.

3. Explaining the divergence

3.1. The role of risk shocks in the divergence

The fluctuation of risk shocks is historically an important source of business cycles for both economies as shown in Figure 3 and Table 4, that is consistent with Christiano et al. (2010,

Figure 2 – Bayesian IRFs after increasing an anticipated risk shock in the Euro area (percent)



Note : The solid line is the mean of the Bayesian impulse response functions, i.e. the mean of the distribution of the IRFs generated when parameters are drawn from the posterior distribution. Shaded areas are between the lower and the upper bound of a 80% highest posterior density interval. Variables are in deviation from their steady-state values.

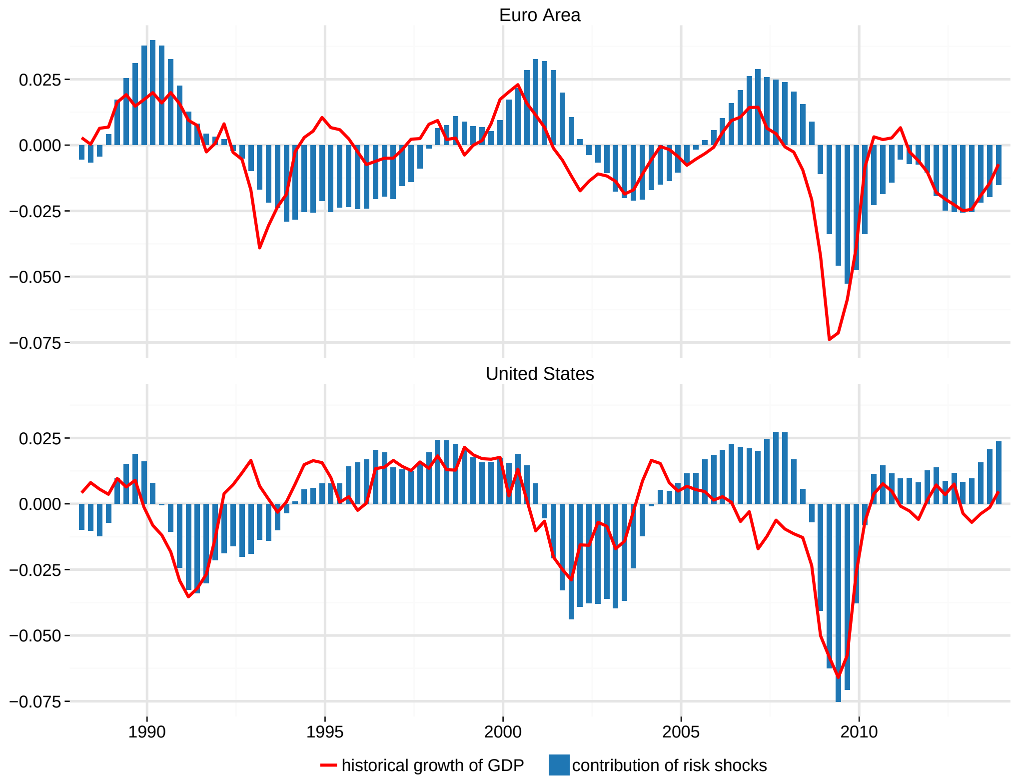
2014a). Around the half of the business cycle variance in output is accounted for by the risk shock in both economies (46 percent for the US and 49 percent for the Euro area), and more than three-quarters for the variance in investment (73 percent for the US and 82 percent for the Euro area).[20]

The role of risk shocks is central in explaining the divergence between Euro area and US economies during last recessions. Figure 4 compares actual real GDP per capita with its simulated values, feeding only risk shocks to the model, since 2007Q4.[21] In the US, risk shocks

[20] Darracq Pariès et al. (2011) also conclude that roughly 50 percent of unconditional variance of real macroeconomic variables are explained by financial and housing-specific shocks. Contrary to us, some other contributions have concluded on a minor role of financial shocks to explain the volatility of real macroeconomic variables in Europe as Quint and Rabanal (2014). The differences come from the definition of financial shocks. In Quint and Rabanal (2014) the financial accelerator mechanism is placed on the household side and the risk shocks concern the quality of housing stock.

[21] Another way to look at the Figure 4 is that the solid lines correspond to simulated values feeding all the shocks to the model (approximately because of some measurement errors).

Figure 3 – Historical contribution of risk shocks to the growth rate of real GDP per capita, year-on-year (1988Q1-2013Q4)



Note : The solid line is the historical growth of real GDP per capita (year-on-year). The "contribution of risk shocks" is the sum of the contributions to GDP fluctuations explained by anticipated and unanticipated components of the risk shocks.

have negatively contributed to growth between 2008Q3 and 2010Q1, with a trough in 2009Q2. After this period, we observe a reversal in risk shocks that contribute positively to the US output growth. Actually, the US recovery would have been weaker without this reversal in risk shocks. Real GDP per capita growth is 3.0 percent between 2007Q4 and 2013Q4 whereas it would have been more than 10 percent without any shocks (given the steady-state growth) and 7.3 percent with only risk shocks, despite their negative contribution to growth during the recession.

The contribution of risk shocks to growth has been different in the Euro area. First, the deterioration of risk in the financial sector comes later with lesser impact on growth during the first recession than in the US. Indeed, the first recession in the Euro area started in 2008Q1 but the negative contributions of risk shocks to growth started in 2008Q4. However, the key difference between the two economies is the absence of risk reversal in the Euro area. Actually, it is even worse for the Euro area because the negative contribution of risk increases after 2011Q1 giving rise to the double-dip recession. As shown in Figure 4, the real GDP per capita growth is -2.2 percent between 2007Q4 and 2013Q4 whereas it would have been more than 10 percent

Table 4 – Variance decomposition at business cycle frequency (Percent)

	risk	equity	investment	technology	markup	cons. pref.	mon. pol.	gov. cons.
United States								
gdp	46.1	0.4	9.3	14.6	8.6	3.8	2.0	15.0
consumption	7.2	0.0	7.7	26.3	13.6	41.8	2.5	0.9
investment	73.1	0.6	19.9	1.5	3.7	0.4	1.0	0.0
credit	39.9	35.6	11.5	3.5	7.3	0.9	0.7	0.2
net worth	65.6	2.6	28.1	0.3	1.0	0.0	2.5	0.0
credit spread	93.9	1.0	4.4	0.0	0.1	0.0	0.4	0.0
inflation	35.3	0.2	11.9	11.1	36.5	2.9	1.3	0.5
hours worked	50.3	0.3	15.4	11.9	13.3	3.1	1.8	3.8
wage	0.9	0.0	0.3	90.3	8.5	0.0	0.0	0.0
interest rate	53.4	0.3	16.4	5.4	14.1	3.3	6.5	0.4
slope	53.1	0.3	12.8	2.6	12.1	1.8	7.0	0.2
invest. price	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Euro Area								
gdp	49.4	1.2	1.0	12.0	9.7	11.3	3.2	12.2
consumption	2.6	0.2	7.4	15.1	10.7	60.5	1.9	1.6
investment	82.2	2.7	4.0	3.3	5.2	0.0	2.6	0.0
credit	17.9	67.6	4.5	3.9	4.8	0.2	0.9	0.1
net worth	51.6	7.8	36.4	0.1	0.5	0.0	3.5	0.0
credit spread	91.2	2.0	6.1	0.0	0.1	0.0	0.6	0.0
inflation	22.6	0.7	2.1	29.0	41.1	1.3	2.5	0.5
hours worked	52.3	1.0	1.8	13.9	18.3	6.3	3.1	3.3
wage	2.3	0.1	0.4	80.1	16.7	0.1	0.2	0.2
interest rate	43.9	1.6	4.0	14.2	18.7	1.2	15.9	0.4
slope	45.8	1.1	3.2	7.0	11.0	0.7	13.6	0.1
invest. price	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0

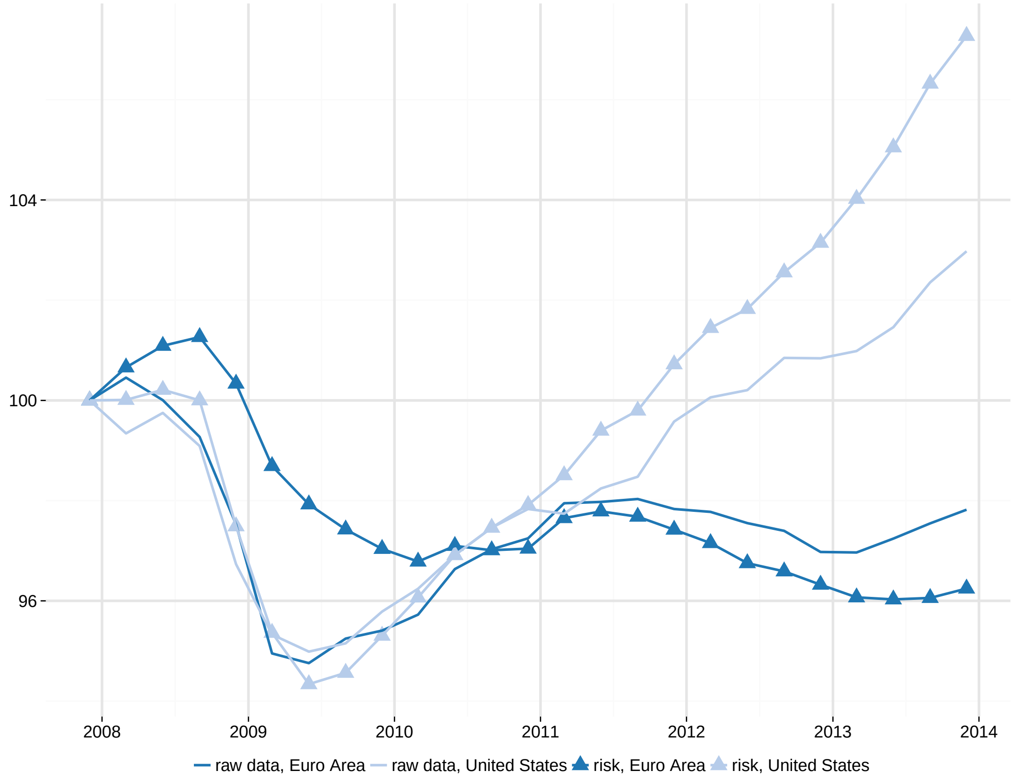
Note : For each observed variable in row, "risk" column is the sum of the variance explained by anticipated and unanticipated components of the risk shocks, "investment" column is the sum of the variance explained by investment price and investment efficiency shocks and "technology" column is the sum of the variance explained by temporary technology and persistent technology growth shocks. We omit the contributions of inflation target and term structure shocks. Numbers in each row may not add up to 100 as we ignore the correlation between the shocks when we add explained variances. Business cycle frequency is measured with HP filter ($\lambda = 1600$).

without any shocks (given the steady-state growth) and -3.8 percent with only risk shocks.

Figure 5 provides a detailed view of the role of risk shocks during the Great recession for four key variables: GDP, investment, credit and credit spread. Consistently with the previous analysis of the IRFs, since 2007 risk fluctuations are at the origin of the sharp rise and fall in the US credit spread associated with the credit crunch, followed by a rapid credit growth that drives the growth of investment and output. For the Euro area, we do not observe a substantial fall of the credit spread after the first recession of 2008-2009, on the contrary it increases once again in 2011. Consequently, credit growth has continued to fall and the growth rates of investment and output are still below their steady-state values.

Cumulated growth from 2007Q4 to 2013Q4 is 5.2 percentage points higher in the US than

Figure 4 – Historical and simulated real GDP per capita in the US and the Euro area in level (base 100 = 2007Q4)



Note: The solid lines are the historical data and the starred lines are the simulated data, feeding only the estimated anticipated and unanticipated components of the risk shock to the model.

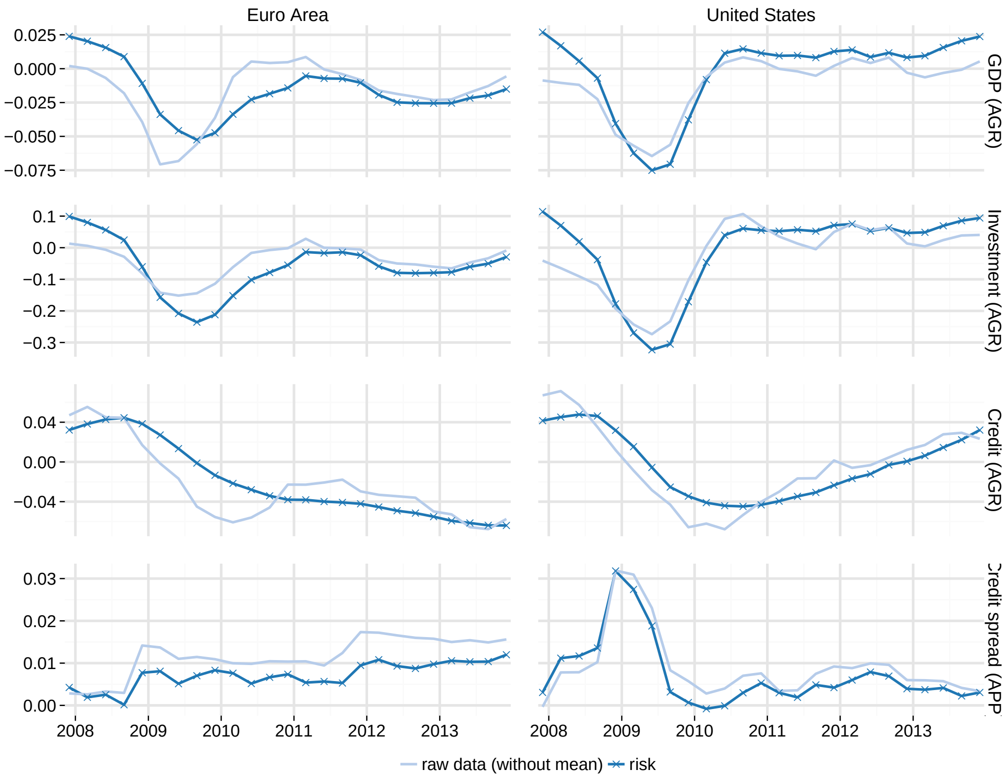
in the Euro area, whereas it would have been more than twice higher if only risk shocks had occurred in these economies. It means that other shocks have increased growth in the Euro area and decreased it in the US in a way that dampens the divergence between the two economies.

3.2. The role of other shocks and structure

Risk shocks are not the only reason of the 2008-2009 Euro area recession. Another reason is a sequence of negative temporary productivity shocks between 2008Q3 and 2010Q3. However, their contribution to the first recession is half of that of risk shocks. Risk shocks are by far the most important negative source of growth during the second recession.[22] Other sources of shocks have helped to mitigate the effects of the rising risks since 2007: a temporary fall in price mark-up and an expansion of government consumption (only during the first recession), improvements in marginal efficiency of investment, and monetary policy shocks.

[22]See the companion website for the historical decomposition of all shocks: http://shiny.cepii.fr/risk-shocks-and-divergence.

Figure 5 – The role of the risk shock in observed variables in the Euro area and the US (2007Q4-2013Q4)

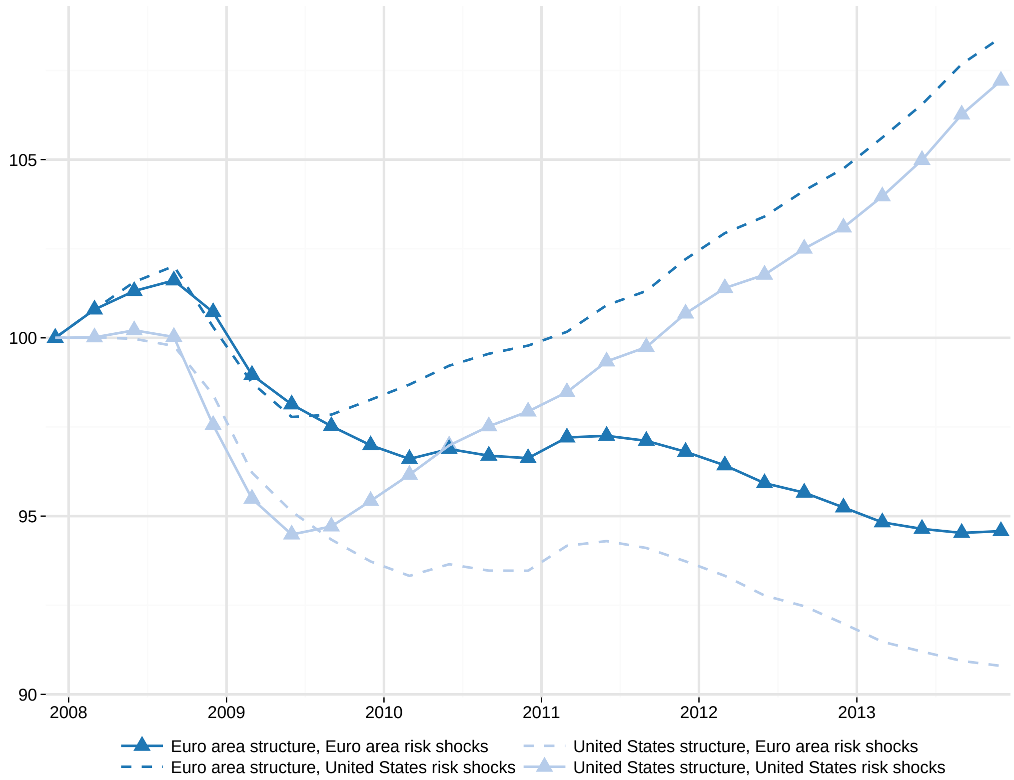


Note : Solid lines correspond to the annual growth rates (AGR) of real GDP, investment and credit per capita and annual percentage point (APP) of credit spread, without mean. Starred lines are the simulated data, feeding only the estimated anticipated and unanticipated components of the risk shock to the model.

As in the Euro area case, risk shocks are not the sole reason of the first recession in the US. In the US, the second reason of negative growth by order of importance is price markup shock. The rise of risk and of price markup are mitigated by a positive temporary productivity shocks (contrary to the Euro area) and positive government consumption shocks (the last turned negative after the recession).

The Euro area and the US can also differ by their structures, and not only by the various shocks that hit their economies. In Section 2, we highlight important differences between the financial structures of the two economies: the cost of state verification and the dispersion of idiosyncratic productivity are both lower in the Euro area than in the US. To assess the role of the financial structure in the divergence between Euro area and US economies, we perform a counterfactual analysis that imposes in the US economic structure the estimated risk shocks of the Euro area economy and, reciprocally, in the Euro area economic structure the estimated risk shocks of the US economy. Results are depicted in Figure 6. It appears that the US economy would also have experienced a double-dip recession assuming the Euro area sequence of shocks and the US

Figure 6 – Euro area and US specific economic structures hit by Euro area and US risk shocks



Note : The starred lines are the simulated data, feeding only the estimated anticipated and unanticipated components of the risk shock to the model. The dashed lines are counterfactual simulated data.

economic structure. Importantly, given the size of the financial frictions in the US, the second recession would have been even more severe than in the Euro area - the dark blue starred line for the Euro area is above the light blue dashed line for the US in Figure 6. Conversely, no double-dip recession would have occurred in the Euro area if this economy had experienced the US shocks and the 2008-2009 recession would have been less severe than observed in the US - the dark blue dashed line for the Euro area is above the light blue starred line for the US in Figure 6.

4. Relation to other narratives of the Great recession

Why did the Euro area economy fall a second time into recession in 2011 and not the US economy? According to our estimation results, risk shocks are central to explain the divergence because they are at the origin of both the US recovery and the Euro area double-dip recession. This section compares this interpretation with alternative explanations of these recent recessions.

4.1. What drives the US slow recovery?

For the US economy, our analysis is by construction close to that of CMR. Our contribution is to extend the data sample up to 2013Q4 while the sample of CMR stopped in 2010Q2. CMR demonstrated that risk shocks account for the same magnitude of the GDP variations between 2008 and 2010. Our results complement this analysis by demonstrating the positive role of risk shocks between 2010 and 2013. After the financial crisis of 2007-2009, the amount of risk in the US economy not only return to its normal level, but it goes below in such a way that it is the main source of growth of the current expansion. It is worth to emphasize that this interpretation of the recent US experience is still under debate especially for the last years. Indeed, if there is a consensus on the role of financial shocks in the contraction/recovery of 2008-2010, it is not the case for the period after 2010.

In Del Negro et al. (2013), risk shocks increase output growth during three quarters in 2009 and then decrease it. Sala et al. (2013) and Galí et al. (2012) estimate DSGE models with equity premium shocks as financial shocks (but no risk shocks) and conclude that the contribution of financial shocks to GDP is always negative between 2008 and 2011. To explain our results on the positive role of risk shocks, it is important to notice that, contrary to Sala et al. (2013) and Galí et al. (2012), we consider risk shocks as financial shocks, and not only equity premium shocks as they do, and that, contrary to Del Negro et al. (2013) who use only the credit spread, we also use the volume of credit to non-financial corporations series to estimate the model, as suggested by CMR. Actually, the credit spread returned to its average value or slightly above since 2010Q1 while credit growth is clearly above its average value during the 2012-2013 years, a situation that can be explained by a decrease of risk in the financial sector in our model.

This outcome of our estimation procedure is consistent with the recent analysis of the US credit market provided in the Global Financial Stability Report (IMF, 2013a). Credit growth is qualified as weak in most advanced countries except for the non financial corporations in the US economy. The very low market interest rates are pointed out as the potential source of this credit expansion and recently, Stein (2013) and Rajan (2013) warn about the risk of this credit expansion for financial stability. They suggest that this credit expansion may be the outcome of an excessive risk taking behavior similar to that observed before the 2008-2009 recession. According to our estimation results, the positive contribution of risk shocks in US growth is effectively close to that observed during the years before the crisis - see Figure 3.

4.2. Is the Euro area double-dip recession due to financial factors?

The first Euro area recession of 2009 can be interpreted as a financial recession given the important contributions of risk shocks even if they do not account for the full magnitude as for the US case. This result is consistent with the earlier finding of Christiano et al. (2010) who compare the role of financial frictions in Euro area and US business cycles up to 2008Q2. In a similar vein, Gerali et al. (2010) and Kollmann et al. (2013) attribute the output contraction of 2008-2009 to shocks originating in the banking sector.[23] Less evidence are provided in the literature to the second recession of 2011, which is one of our contributions to this literature. An exception is Sala et al. (2013), but they report a weak role for financial shocks in the business cycles of three European countries (namely the UK, Sweden, and Germany)[24] during the period 2007-2011. Moreover, they do not consider risk shocks as financial shocks but only equity premium shocks. Last, countries they have selected do not experienced a double-dip recession as observed by ourselves for the Euro area and by Reinhart and Rogoff (2014) for the following members of the Euro area: France, Ireland, Italy, Netherlands and Portugal.

To the best of our knowledge, we provide the first structural interpretation based on an estimated DSGE of the 2011 recession in the Euro area and attribute it to an increase of the risk in the financial sector. Since 2011, Euro area has been marked by sovereign debt crisis in Greece, Portugal, Ireland, Spain, and Cyprus. Because of the "doom loop" between the sovereign and bank debts, the sovereign debt crisis has been a major source of tensions in the European banking sector which contaminates the real activity.[25] Corsetti et al. (2014) develop a New Keynesian DSGE model to show how the implementation of a procyclical fiscal policy during a sovereign debt crisis can lead to a belief-driven recession. Our model is not suitable to provide a full analysis of the sovereign debt crisis as done by Corsetti et al. (2014), given the absence of the public sector debt in the model. Still, we can establish a link between the observed distress of banks during the sovereign debt crisis and the positive risk shocks that we estimated for this period.

Christiano and Ikeda (2013) explain that risk shocks can be interpreted as shocks on the riskiness of the business done by entrepreneurs, i.e. non-financial corporations, or by financial firms, since we consider households as the ultimate lenders. In the former case, there is no agency problem between households and financial intermediaries who lent to entrepreneurs with asymmetric information. In the latter, information is asymmetric between households and financial intermediaries, but not with the entrepreneurs. Using the second interpretation of the model, we establish a link between the financial distress of banks during the sovereign debt crisis in the Euro area and the high contribution of risk shocks in the 2011 recession: the high level of idiosyncratic uncertainty estimated concern the risk of banks, which have been excessively exposed to sovereign bond risk.

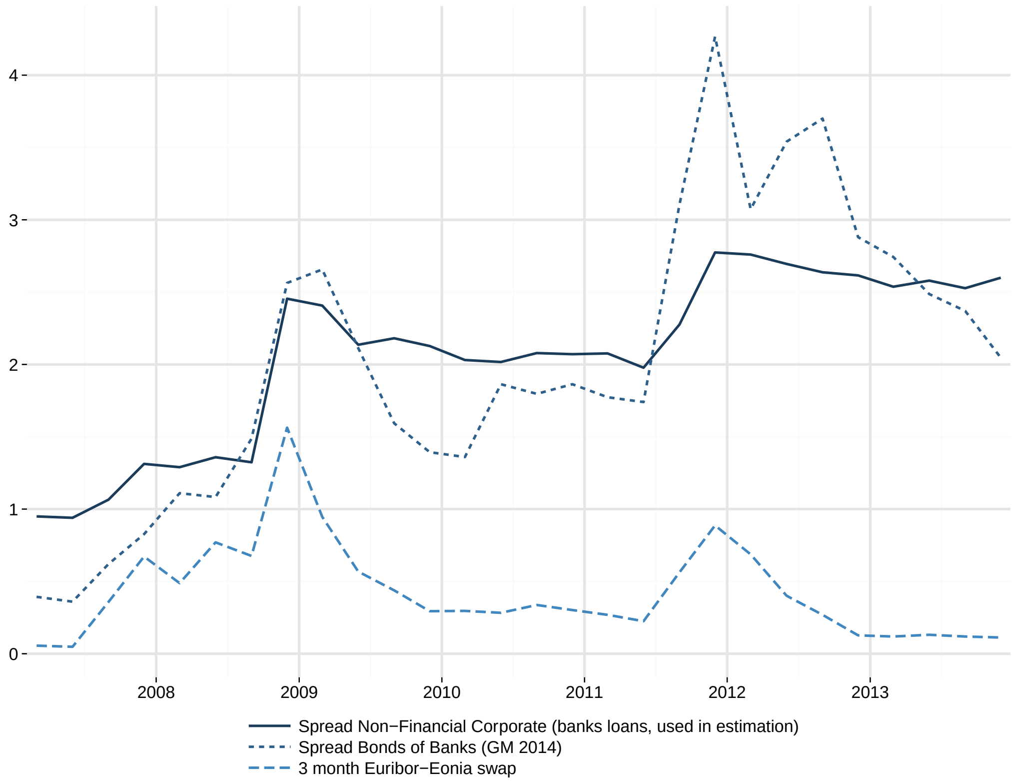
To develop this interpretation, the definition of the credit spread is essential. In our estimation, the credit spread measures the cost of external finance for non-financial firms and not for banks as calculated by Gilchrist and Mojon (2014). The two spreads for financial and non-financial

[23] In Lombardo and McAdam (2012), financial shocks contribute strongly to the fluctuations of house prices and to a lesser extent to those of output between 2008 and 2010.

[24] Even if the first two countries does not take part of the Euro area, Germany is the biggest.

[25] Shambaugh (2012), Lane (2012), and Reichlin (2014) are excellent narratives of the European debt crisis. Acharya et al. (2013) and IMF (2013b) study the determinants of public debt costs and the interplay with the bank debt cost. Neri (2013) and ECB (2012) attempt to quantify the transmission of these tensions to the bank lending rates for the non financial corporations in the Euro area.

Figure 7 – Interest rates spread in percent (2007Q1-2013Q4)



firms have increased in 2011 as shown in Figure 7, but they also diverge after 2012: it falls for banks whereas it remains high for non financial corporations. This high value of credit spreads explain the important role attributed to risk shocks in the persistence of low growth in the Euro area. It is worth mentioning that Gilchrist and Mojon (2014) report also a fall in the credit spread for non financial corporations after 2012 when they consider the interest rate for corporate debt securities instead of the interest rate for bank loans. As discussed above, we choose the latter instead of the former given the high importance of bank credit when compared with debt securities in the external financing of non financial corporations - see ECB (2011). Further researches should be devoted to explain the recent divergence between these two spreads and why the loan interest rate does not fall after 2012, contrary to the yield of debt securities, given its strong macroeconomic consequences highlighted in this paper.

5. Conclusion

The recent divergence between the Euro area and the US, abundantly commented in the public debate, will surely constitute an important field for future research. Why did the Euro area economy fall a second time in 2011 and not the US economy? We propose an answer based on the estimation of a DSGE model with financial frictions. According to our estimation, based on CMR methodology, risk shocks are central to explain the divergence because they are at the origin of both the US recovery and the Euro area double-dip recession. The second financial recession of 2011 in Euro area can be explained by the sovereign debt crisis that has increased the risk in the financial sector given the "doom loop" between bank and sovereign debts. Explaining the sources of the reduction in financial risk after 2009 in the US is also puzzling and remains a field for further research.

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Appendix

A. Data

- GDP
  - US : Real Gross Domestic Product, Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate (Fred series)
  - EA :
    - 1987Q1 - 2010Q4 : Real Gross Domestic Product (AWM: YER)
    - 2011Q1 - 2013Q4 : Gross domestic product at market price, Chain linked volumes, reference year 2005, Quarterly, Working day and seasonally adjusted, EA 17 fixed composition (ECB series)
- Consumption
  - US : Real Personal Consumption Expenditures: Nondurable Goods + Real Personal Consumption Expenditures: Services, Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate (Fred series1 + series2 and before 1999, BEA NIPA Table 2.3.3)
  - EA :
    - 1987Q1 - 2010Q4 : Real Private Consumption (AWM: PCR)
    - 2011Q1 - 2013Q4 : Final consumption of households and NPISH's, Chain linked volumes, reference year 2005, Quarterly, Working day and seasonally adjusted, EA 17 fixed composition (ECB series)
- Investment
  - US : Real Personal Consumption Expenditures: Durable Goods + Real Gross Private Domestic Investment, Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate (Fred series1 + series2 and before 1999, BEA NIPA Table 2.3.3)
  - EA :
    - 1987Q1 - 2010Q4 : Real Gross Investment (AWM : ITR)
    - 2011Q1 - 2013Q4 : Gross fixed capital formation, Chain linked volumes, reference year 2005, Quarterly, Working day and seasonally adjusted, EA 17 fixed composition (ECB series)
- Inflation
  - US : GDP Implicit Price Deflator, Index 2009=100, Quarterly, Seasonally Adjusted (Fred series), logarithmic first difference
  - EA :
    - 1987Q1 - 2010Q4 : Deflator of Gross Domestic Product (AWM: YED), logarithmic first difference
    - 2011Q1 - 2013Q4 : Deflator of Gross domestic product at market price, Quarterly, Working day and seasonally adjusted, EA 17 fixed composition (ECB series), logarithmic first difference
- Price of investment
  - US : Gross Private Domestic Investment Implicit Price Deflator, Index 2009=100, Quarterly, Seasonally Adjusted (Fred series), divided by GDP Deflator
  - EA :
    - 1987Q1 - 2010Q4 : Deflator of Gross Investment (AWM: ITD), divided by GDP Deflator
    - 2011Q1 - 2013Q4 : Deflator of Gross fixed capital formation, Quarterly, Working day and seasonally adjusted, EA 17 fixed composition (ECB series), divided by GDP Deflator
- Hours worked
  - US : Nonfarm Business Sector: Hours of All Persons, Index 2009=100, Quarterly, Seasonally Adjusted (Fred series)
  - EA :
    - 1987Q1 - 1999Q4 : Hours worked by Total Employment, Annually, EA 12 fixed composition (The Conference Board Total Economy Database), converted to quarterly data by the weight of Total Employment, Quarterly, Working day and seasonally adjusted, EA 17 fixed composition (ECB series)

    * 2000Q1 - 2013Q4 : Hours of All Employees, Quarterly, Working day and seasonally adjusted, EA 17 fixed composition (ECB series)

- Wage
  - US : Nonfarm Business Sector: Compensation Per Hour, Index 2009=100, Quarterly, Seasonally Adjusted (Fred series), divided by GDP Deflator
  - EA :
    * 1987Q1 - 2010Q4 : Nominal Compensation to Employees (AWM: WIN), divided by Hours worked and by GDP Deflator
    * 2011Q1 - 2013Q4 : Compensation of Employees, received by Households and NPISH's, Quarterly, Seasonally adjusted, EA 17 fixed composition (Eurostat Quarterly sector accounts), divided by Hours worked and by GDP Deflator
- Short-term risk-free rates
  - US : Effective Federal Funds Rate, Percent, Quarterly, Not Seasonally Adjusted (Fred series)
  - EA :
    * 1987Q1 - 2005Q1 : Nominal Short-Term Interest Rate (AWM: STN) and Euribor 3-month, Historical close, Quarterly, average observation through period, Euro area changing composition (ECB series)
    * 2005Q2 - 2013Q4 : 3-month EONIA swap (Datastream: EUEON3M)
- Credit
  - US : Nonfinancial Noncorporate Business; Credit Market Instruments; Liability + Nonfinancial Corporate Business; Credit Market Instruments; Liability, Level, Billions of Dollars, Quarterly, Not Seasonally Adjusted (Fred series1 + series2), divided by GDP Deflator
  - EA :
    * 1987Q1 - 1998Q4 : Loans to Non-MFIs excluding general government sector, Outstanding amounts at the end of the period (stocks), Monthly, Neither seasonally nor working day adjusted, Euro area changing composition (ECB series), divided by GDP Deflator
    * 1999Q1 - 2013Q4 : Loans to Non-financial corporations, Closing balance sheet, Quarterly, Neither seasonally nor working day adjusted, Euro area changing composition (ECB series), divided by GDP Deflator
- Credit spread
  - US : Moody's Seasoned Baa Corporate Bond Yield, Percent, Quarterly, Not Seasonally Adjusted (Fred series), less 10-year Government Bond Yield
  - EA :
    * 1987Q1 - 1999Q4 : Weighted average of individual country historical lending rates (IMF International Financial Statistics), less Short-term risk free interest rate
    * 2000Q1 - 2013Q4 : Interest Rates on Loans to Non-Financial Corporations (other than revolving loans and overdrafts, convenience and extended credit card debt), Total amount, New business, Euro area changing composition (ECB series), less Short-term risk free interest rate
- Slope of the term structure
  - US : Long-Term Government Bond Yields: 10-year: Main (Including Benchmark) for the United States, Percent, Quarterly, Not Seasonally Adjusted (Fred series), less Effective Federal Funds Rate
  - EA :
    * 1987Q1 - 2010Q4 : Long-term Interest Rate (AWM: LTN), less Short-term Interest Rate
    * 2011Q1 - 2013Q4 : Long-term government bond yields (in most cases 10 years), Quarterly, average observation through period, Euro area 18 (OECD StatExtracts General Statistics, Key Short-Term Economic Indicators), less Short-term Interest Rate
- Entrepreneurial net worth
  - US : Wilshire 5000 Total Market Index, Quarterly, Not Seasonally Adjusted (Fred series), divided by GDP Deflator

- EA : Dow Jones Euro Stoxx Price Index, Historical close, Quarterly, average observation through period, Euro area changing composition (ECB series), divided by GDP Deflator
- Population
  - US : Working Age Population: Aged 15-64: All Persons for the United States, Persons, Quarterly, Seasonally Adjusted (Fred series)
  - EA :
    - 1987Q1 - 2004Q4 : Total Population from 15 to 64 years on 1 January, converted to quarterly data by interpolation (Eurostat Population)
    - 2005Q1 - 2013Q4 : Working Age Population: Aged 15-64: All Persons for the Euro Area, Persons, Quarterly, Seasonally Adjusted (Fred series, from OECD: Main Economic Indicators, Labour Force Survey)

B. Other estimation results

Table B.1 – Posterior

	Prior mean	Prior stdv	Post. mode EA	10% EA	90% EA	Post. mode US	10% US	90% US
Economic Parameters								
Calvo wage stickiness	0.750	0.003	0.851	0.757	0.842	0.747	0.682	0.782
Consumption habits	0.500	0.003	0.643	0.721	0.846	0.742	0.694	0.819
Steady state probability of default	0.008	0.003	0.015	0.004	0.017	0.006	0.003	0.009
Monitoring cost	0.275	0.003	0.068	0.054	0.179	0.234	0.139	0.354
Curvature, utilization cost	1.000	0.003	2.215	0.927	3.201	2.821	1.905	4.093
Curvature, investment adjust cost	5.000	0.003	11.485	6.243	9.677	9.530	6.145	11.188
Calvo price stickiness	0.500	0.003	0.722	0.650	0.766	0.804	0.743	0.857
Monetary policy weight on inflation	1.500	0.003	2.407	2.154	2.703	2.504	2.169	2.734
Autocorrelation, monetary policy shock	0.750	0.003	0.871	0.846	0.895	0.870	0.846	0.895
Price indexing weight on inflation target	0.500	0.003	0.916	0.828	0.963	0.819	0.652	0.912
Wage indexing weight on inflation target	0.500	0.003	0.381	0.158	0.433	0.625	0.358	0.786
Wage indexing weight on persistent technology growth	0.500	0.003	0.930	0.868	0.971	0.949	0.903	0.980
Monetary policy weight on output growth	0.250	0.003	0.394	0.241	0.562	0.371	0.210	0.532
Shocks								
Correlation among signals	0.000	0.003	0.354	0.292	0.560	0.453	0.216	0.524
Autocorrelation, price markup shock	0.500	0.003	0.872	0.849	0.977	0.871	0.791	0.935
Autocorrelation, investment price shock	0.500	0.003	0.958	0.933	0.983	0.973	0.951	0.990
Autocorrelation, government consumption shock	0.500	0.003	0.988	0.963	0.999	0.916	0.871	0.954
Autocorrelation, persistent technology growth shock	0.500	0.003	0.122	0.038	0.268	0.042	0.007	0.106
Autocorrelation, temporary technology shock	0.500	0.003	0.935	0.911	0.952	0.961	0.928	0.984
Autocorrelation, risk shock	0.500	0.003	0.942	0.835	0.920	0.974	0.959	0.988
Autocorrelation, consumption preferences shock	0.500	0.003	0.863	0.333	0.679	0.921	0.867	0.945
Autocorrelation, investment efficiency shock	0.500	0.003	0.945	0.970	0.983	0.945	0.909	0.962
Autocorrelation, term structure shock	0.500	0.003	0.961	0.926	0.984	0.941	0.887	0.975
Std dev., anticipated risk shock	0.001	0.003	0.042	0.034	0.056	0.035	0.022	0.031
Std dev., unanticipated risk shock	0.002	0.003	0.071	0.000	0.084	0.001	0.035	0.066
Std. dev., price markup shock	0.002	0.003	0.008	0.005	0.010	0.017	0.011	0.027
Std. dev., investment price shock	0.002	0.003	0.003	0.003	0.004	0.004	0.003	0.004
Std. dev., government consumption shock	0.002	0.003	0.015	0.014	0.017	0.019	0.017	0.022
Std. dev., persistent technology shock	0.002	0.003	0.005	0.004	0.006	0.010	0.009	0.012
Std. dev., equity shock	0.002	0.003	0.015	0.012	0.019	0.006	0.005	0.007
Std. dev., temporary technology shock	0.002	0.003	0.005	0.004	0.005	0.006	0.005	0.007
Std. dev., monetary policy	0.583	0.003	0.428	0.398	0.527	0.416	0.371	0.478
Std. dev., consumption preferences	0.002	0.003	0.016	0.016	0.026	0.023	0.019	0.029
Std. dev., investment efficiency	0.002	0.003	0.059	0.130	0.193	0.082	0.045	0.116
Std. dev., term structure shock	0.002	0.003	0.002	0.001	0.003	0.002	0.001	0.005
Std. dev., measurement error on net worth	0.010	0.003	0.014	0.011	0.016	0.018	0.017	0.020

Note : Prior means and standard deviations are the same for both countries.