Fiscal Policy Uncertainty and Investment

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Abstract

This paper investigates the effects of fiscal uncertainty on investment. We first document that private investment decreases in response to positive public spending uncertainty shocks in the Euro Area. The uncertainty shock is estimated by resorting to a stochastic volatility model. We then build a New-Keynesian model enlarged with financial frictions and imperfect substitutability between capital and sovereign bonds. We show that our model is able to replicate the drop in investment observed in the data, unlike a typical New-Keynesian model. We also highlight the key role of the monetary policy in our results.

JEL classification: Government spending uncertainty, stochastic volatility, portfolio adjustment cost.

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1 Introduction

The fiscal stimulus packages implemented by several governments to counteract the global recession in late 2000' has renewed interest in fiscal policy analysis. While the impact of fiscal shocks on real economic activity is well known in the literature, there is still a debate regarding the effects of fiscal uncertainty. For instance, Fernandez-Villaverde et al. (2015) show that fiscal volatility shocks have detrimental effects on output, effects which are amplified when the central bank is constrained by the zero lower bound. On the opposite, Born and Pfeifer (2014) provide more contrasted results by arguing that fiscal uncertainty shocks are not sizeable enough to contribute to the business cycle. Both papers resort to quantitative New Keynesian models for the US economy.

This paper investigates the effects of government spending uncertainty on investment, paying a particular attention to financial imperfections in the transmission of this type of uncertainty shocks. On the empirical side, we consider Euro Area data to disentangle public spending level and public spending volatility shocks using a Stochastic Volatility estimator as in Born and Pfeifer (2014) and Fernandez-Villaverde et al. (2015). We then include the second-order moment innovations in a VAR for the Euro Area and find that public spending uncertainty shocks significantly lower ouptut, consumption, investment and inflation.[1]

Using a standard New-Keynesian DSGE model, including a stochastic volatility process on government spending and calibrating this model to the Euro Area, we show that an increase in government spending uncertainty results in a counterfactual rise in private investment.[2] Uncertainty has its negative effect through precautionary behavior of households (see Fernandez-Villaverde et al., 2011; Basu and Bundick, 2017). In the standard New-Keynesian model, all assets are perfect substitutes. Therefore, physical capital becomes more attractive over sovereign debt for consumption smoothing as a rise in volatility of government spending shocks generates higher uncertainty regarding future taxation. The oversupply of capital leads to a reduction in the return of capital which boosts investment over the medium-run. Consequently, the typical New-Keynesian model fails to reproduce

[1] These results are robust to alternative filtering methods.

[2] We plan to estimate in a near future some parameters of the model by Simulated Method of Moments to match key moments, taking advantage of the non-linear structure of the model. Structural estimation of model's parameters has two advantages. First, it allows us to assess to which extent fiscal volatility shocks contributed to the recent variations in sovereign spreads in the Euro Area, especially in GIIPS countries. Second, we can determine the channels through which investment dynamics is affected by fiscal uncertainty.

the decline in investment in response to higher fiscal policy uncertainty that we observe in the data.

We then develop an alternative New-Keynesian model, augmented with portfolio decisions and financial frictions à la Bernanke et al. (1999). Precisely, private financial intermediary distributes households' deposits to a portfolio-management sector. The latter is made up of a continuum of risk neutral portfolio investors who invest in a risky financial portfolio, including (*i*) private physical and (*ii*) risky long-term government bonds. Imperfect substitutability between these two assets is modelled through a quadratic portfolio adjustment cost, which captures the slow adjustment in the composition of the portfolio in the spirit of Jermann and Quadrini (2012), with potential wealth effects, which in turn affects private investment dynamics. We consider financial frictions between the financial intermediary and the portfolio investor, which stem from the asymmetric information regarding the default risk of the latter. The portfolio decision is made in two stages. In a first stage, the portfolio investor decides on the overall size of the portfolio, taking into account the possibility of idiosyncratic default. In a second stage, the portfolio manager determines the asset structure of the portfolio by choosing portfolio weights.

We show that the model with financial frictions and imperfect asset substitutability qualitatively overturns the prediction regarding the response of investment to a government spending uncertainty shock, as private investment falls, in line with the above empirical evidence. The intuition is the following. In reponse to higher fiscal uncertainty, portfolio investors have more incentive to substitute public bonds toward physical capital. Therefore, the share of capital in the portfolio increases which should drive investment up, as observed in the New-Keynesian model. However, as portfolio investors face portfolio adjustment costs, it is costly for them to modify the composition of portfolio implying that the substitution effect is incomplete. Imperfect substitutability between corporate and government bonds implies that on the one side, portfolio managers hold more corporate bonds as sovereign bonds are less attractive under fiscal uncertainty. On the other side, portfolio investors are also more likely to default, which restricts the holdings of private capital credit and ultimately depresses private investment. Therefore, the negative wealth effect comes on top of the usual financial accelerator mechanism, and drive private investment further down, aggravating the subsequent recession.

We perform a series of robustness analysis in order to stress the key factors that affect the transmission channels of the public spending uncertainty shock on investment. Unsurprisingly, the degree of substituability between capital and public bonds is a key determinant. The effect of the uncertainty shock on investment are magnified when it is very costly for the portfolio investors to adjust its portflio is high since the negative wealth effect is strong. More interestingly, we find that the central bank's behavior strongly affects the transmission channels of the shock. In particular, the drop in investment is prominent when the monetary policy is highly inertial or when it is slightly active. In the latter case, as the central bank does not strongly react to inflation, the recession led by the uncertainty shock generates a strong deflation which amplifies the cost of sovereign debt through the so-called Fisher effect. This "debt-deflation channel" in turn amplifies the rise portfolio investors default and generates a strong reduction in investment.

First, this paper relates to the literature on the impact of uncertainty on economic activity. The interest in the aggregate effects of uncertainty has been growing since the financial crisis of 2007-2009 and the importance of uncertainty for the business cycle has been established in the literature. The seminal paper by Bloom (2009) turned attention to uncertainty by documenting that volatility shocks to aggregate productivity produce large fluctuations in output and employment. However, there are only few studies that focus on policy uncertainty and, more precisely, the effects of fiscal policy uncertainty on real activity still remain underexplored. We already noted in the beginning contributions of Fernandez-Villaverde et al. (2015) and Born and Peifer (2014) to the study of fiscal policy uncertainty. These papers reach contrasting conclusions as for the role fiscal uncertainty can play in producing business cycle fluctuations. Our paper is different from these studies in that we incorporate in our model time-varying fiscal policy uncertainty jointly with financial market imperfections and portfolio decisions. While focus on the effects of fiscal policy uncertainty on firms' mark-ups, we are interested in the role financial market imperfections play in the transmission of uncertainty about fiscal policy.

Our paper also relates to the literature that jointly studies risk and financial frictions. After the financial crisis of 2007–2009, the importance of both financial market imperfections and volatility for real activity has been emphasized. This strand of literature shows that financial market frictions amplify the negative effects of uncertainty on macroeconomic outcomes. Differently from us, it studies idyosyncratic, or firm-level, uncertainty (Arellano et al., 2012; Christiano et al., 2014; Gilchrist et al., 2014; Balke et al., 2017) and TFP uncertainty (Alfaro and Bloom, 2018; Cesa-Bianchi et al., 2018) and does not talk about uncertainty of fiscal policy as we do in the present study. The paper by Bretscher, Hsu, Tamoni (2017) develops the model where fiscal volatility shocks cause the major part of fluctuations in term premia. However, they do not take into consideration the role of financial frictions and they look at the term premia, while our model incorporates the corporate and sovereign spreads.

We contribute to the above literature in that our paper helps to understand the effects of rising fiscal policy uncertainty on real activity through the lens of financial market imperfections. In our model this uncertainty impacts portfolio returns and the cost of borrowing faced by firms and, thereby, private investment.

We will proceed as follows. Section 2 presents the estimation of a fiscal volatility shock and its emprirical effects. Section 3 describes the model setup. Section 4 describes the parametrization and solution method. Section 5 investigates the effects of fiscal volatility shocks in the model and provides robustness exercises. Finally, Section 6 concludes.

2 Government Spending Uncertainty Shocks

In this section, we estimate a stochastic volatlity process on public spending to identify fiscal volatility shocks. We then evaluate the effects of this shocks on key macroeconomic variables using a SVAR model.

2.1 Volatility Shocks Estimation

Following Born and Pfeifer (2014) and Fernandez et al. (2011), we estimate a stochastic exogenous government spending uncertainty shocks by resorting to a stochastic volatility model. We assume that government spending shocks follow an AR(1) process such that

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + \sigma_t^g \varepsilon_t^g, \quad (1)$$

$$\sigma_t^g = (1 - \rho_{\sigma^g})\,\sigma^g + \rho_{\sigma^g} \sigma_{t-1}^g + \eta_{\sigma^g} \varepsilon_t^{\sigma^g}, \quad (2)$$

where $\varepsilon_t^g \sim \mathrm{N}(0,1)$ and $\varepsilon_t^{\sigma^g} \sim \mathrm{N}(0,1)$ are i.i.d shocks and σ_t^g drives fiscal policy uncertainty. Parameters ρ_g and ρ_{σ^g} drive the persistence associated to the level and volatility spending shocks respectively, and η_{σ^g} drives the magnitude of the public spending uncertainty shock. We consider an exogenous stochastic driving processes with time-varying volatility for government spending. This process is estimated on quarterly time series for Euro Area countries from 1991Q1 to 2017Q1. Variable $\hat{g}_t$ is the series real general government final consumption expenditure from OECD database, from which we computed the cyclical component of the logarithms of the time series by applying a one-sided HP-filter.[3] The processes (1)-(2) are then estimated using a Sequential Monte Carlo method detailed in Born and Pfeifer (2014). The priors are obtained directly from the data using least squares regressions. Figures 2.1 displays the estimated volatility process of government spending, as well as innovations and residuals from the estimation. We observe that Euro Area countries have experienced a high volatility in government spending all over the sample. The implementation of fiscal stimulus packages in response to the Great Recession implemented by European government is captured by an peak in uncertainty between 2009 and 2010. Table 1 reports the prior value and the posterior mean of the parameters associated to the volatility shock along with 95 probability confidence intervals. Results show that all parameters are well estimated, the shock in level seems to be more persistent than the associated uncertainty shock ($\rho_g = 0.90$ and $\rho_{\sigma^g} = 0.68$) and the time varying volatility estimates is in the same range than Born and Pfeifer (2014) for the US, i.e. $\eta_{\sigma^g} = 0.36$.

Table 1: Estimated parameters

	Prior	Posterior Mean	5%	95%
ρ_g	0.80	0.904	0.900	0.901
ρ_{σ^g}	0.56	0.685	0.680	0.691
η_{σ^g}	0.33	0.362	0.359	0.366
$\bar{\sigma}^g$	-2.48	-5.81	-5.80	-5.82

Note: The prior are set by estimating a OLS regression on Equations (1) and (2).

[3] A one-sided, "causal' filter (Stock and Watson, 1999) assures that the time ordering of the data remains undisturbed and preserves the autoregressive structure.

Figure 2.1: Public spending volatility shock estimation

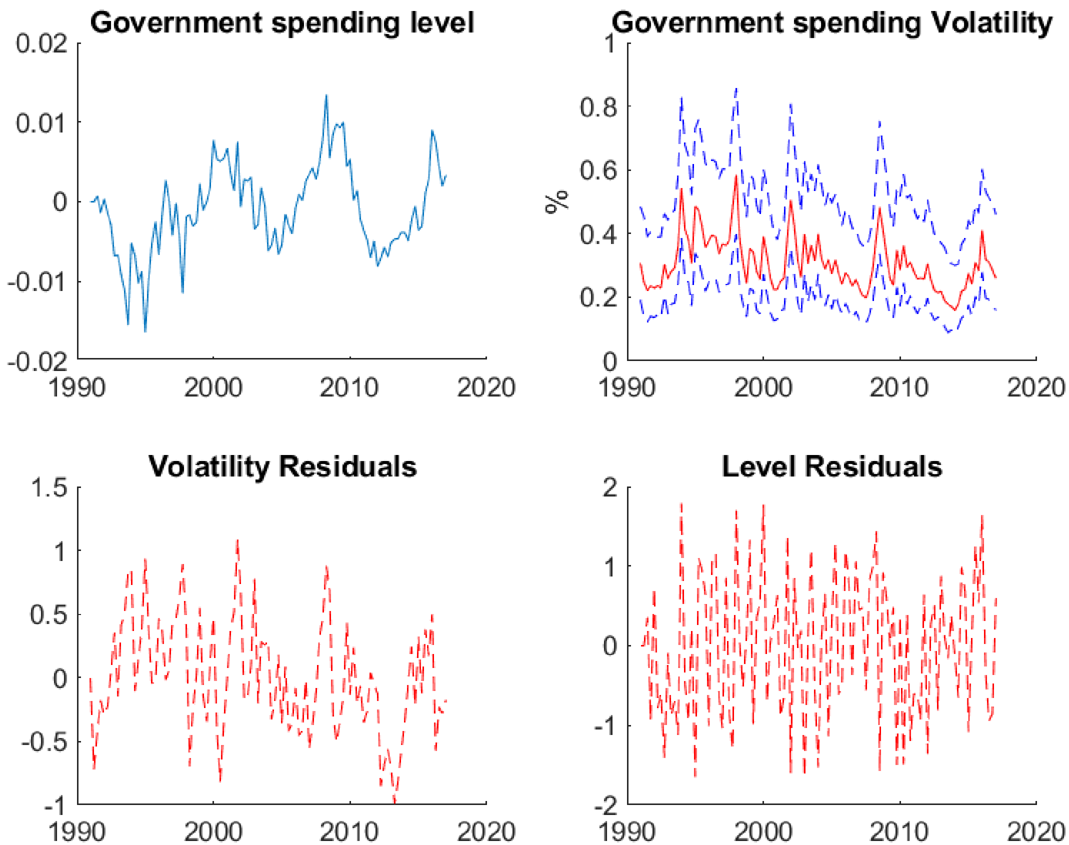
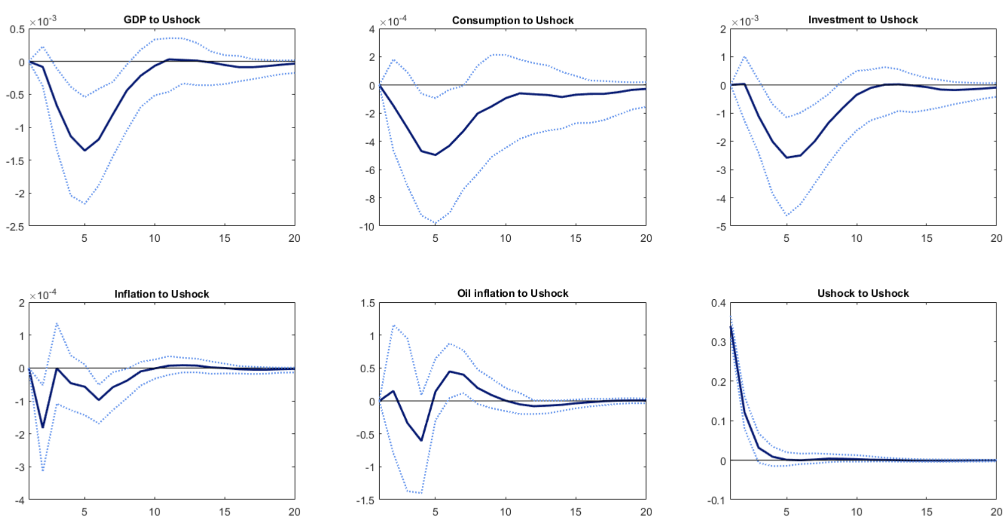


Figure 2.2: Impulse response to a 1-sd uncertainty shock - linear detrending



2.2 Empirical Effects of Fiscal Volatility Shocks

We imbed the above estimated innovations in a simple VAR including the log of GDP, private consumption, private investment and CPI inflation. We also include the inflation of oil prices to "clean" the relation between output and inflation from non-core inflation variations. The data sample is quarterly and ranges from 1991Q1 to 2017Q1. Variable y_t is the GDP in volume at market prices, c_t is the total private consumption expenditure at market prices, i_t is the gross fixed capital formation at market prices, π_t is the quarterly growth rate of the GDP deflator, and π_t^{oil} is the quarterly growth rate of the West Texas Intermediate (WTI), expressed in dollars per barrel. GDP, consumption and investment are simply summed to get an area-wide measure of each variable. The inflation rate is build using time-varying GDP weights. The uncertainty shock is ordered last in every case, and we use a Cholesky decomposition to uncover the structural uncertainty shock, *i.e.* assuming that uncertainty has no contemporaneous effect on all variables. The data vector is thus

$$X_t = \left[\log y_t \;\; \log c_t \;\; \log i_t \;\; \pi_t \;\; \pi_t^{oil} \;\; \varepsilon_t^{\sigma^g}\right]' \tag{3}$$

Figure 2.2 reports the impulse response functions of variables to the public spending volatility shock estimated in a first step. All variables are HP-filtered and we report in the online appendix the SVAR estimated on linearly detrended series. A exogeneous rise in public spending volatility is recessionary and generates a hump-shaped response of GDP with a peak reached after one year. Private consumption and investment also decrease in response to the shock, investment reacting three times more than output. Interestingly, this uncertainty shock can be associated to a demand shock as generates a reduction in inflation.

These empirical evidence suggest that a rise in public spending uncertainty generates a reduction in investment. We now turn to develop a model that this able to generate this feature.

3 The Model

The framework builds on a New Keynesian model expanded with financial frictions à la Bernanke et al. (1999) applied to a portfolio asset combining physical capital and long-term government bonds. Precisely, a representative private financial intermediary distributes the households' deposits to the portfolio-management sector. The latter is made up of a continuum of risk neutral portfolio investors which invest in a financial portfolio, including (*i*) private capital rented to firms producing intermediate goods and (*ii*) government bonds. Each portfolio investor might go bankrupt as a result of an idiosyncratic shock on the ex-post return on its portfolio. Financial friction comes from asymmetric information between the private financial intermediary and the investor regarding the realization of the shock. The portfolio decision is made in two stages. In a first stage, the portfolio investor decides on the overall size of the portfolio, taking into account the possibility of idiosyncratic default. In a second stage, the portfolio manager determines the asset structure of the portfolio investor by choosing portfolio weights.

3.1 Households

The economy is populated by a continuum of identical households. A typical household selects a sequence of consumption, labor supply and deposits to maximize the discounted lifetime utility. The objective of the representative household is thus to maximize

$$\mathrm{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} - \psi \frac{\left(\ell_t^h\right)^{1+\omega_w}}{1+\omega_w} \right\}, \tag{4}$$

subject to the budget constraint

$$c_t + A_t \leq w_t \ell_t^h + R_{t-1} \frac{A_{t-1}}{\pi_t} + \frac{\mathcal{A}_t}{P_t} - \frac{\mathrm{T}_t}{P_t} + \mathrm{div}_t, \tag{5}$$

where E_t is the expectation operator conditional to the information available in period t. $\beta \in (0,1)$ is the subjective discount factor; ω_w^{-1} is the Frisch elasticity of labor supply, ψ is a normalizing constant (governs the relative disutility of labor effort) and σ is the inverse of the risk aversion coefficient. Let c_t denote real consumption; P_t is the price of final goods; $w_t \equiv W_t/P_t$ is the real wage rate; ℓ_t^h denotes labor supply. Let $\pi_t = (P_t/P_{t-1} - 1)$ denote the inflation rate; A_t denotes holdings of net deposits in nominal terms provided to a lender; R_t is the gross nominal interest rate associated with one-period-maturity nominal deposits. For simplicity, we assume that the household does not hold long-term bonds issued by the government. Finally, $\mathrm{div}_t, \mathrm{T}_t$, $\mathcal{A}_t$ denote real profits from monopolistic firms, lump sum taxes from the government and nominal transfers from entrepreneurs, respectively, each one redistributed as a lump sum. The FOCs with respect to A_t, c_t and ℓ_t^h yields

$$\lambda_t = \beta \mathrm{E}_t \left\{ \lambda_{t+1} \frac{R_t}{\pi_{t+1}} \right\}, \tag{6}$$

$$c_t^{-\sigma} = \lambda_t, \tag{7}$$

$$\psi \left(\ell_t^h \right)^{\omega_w} = \lambda_t w_t. \tag{8}$$

The representative lender collects deposits from households with an uncontingent return of R_t and distributes those deposits to portfolio investors. Portfolio investors will repay them back at a rate R_t^d if they do not experience any bankruptcy. As we show next, the market clearing condition implies that $A_t = D_t$.

3.2 Competitive Intermediary

The representative lender collects deposits A_t from households with an uncontingent *nominal* return of R_t and distributes those deposits to portfolio investors who will repay them back at a *nominal* rate R_t^d if they do not experience any bankruptcy (internalizing the possibility of bankruptcy by the portfolio investor). The lender maximizes its equity value by choosing the amount of deposits it accepts so as to maximize its profit. Its optimal choice is given by, for all t,

$$\mathrm{E}_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} \left(R_{t+1}^d - R_t \right) \right\} = 0. \tag{9}$$

Following Bernanke et al. (2001) we assume that the lender makes zero profits state-by-state such that $R_{t+1}^d = R_t$, $\forall t$.

3.3 Portfolio Decisions

The decisions in the portfolio sector are made in two steps. In a first stage, the portfolio investor decides on the total size of its portfolio, given the moral hazard problem. The portfolio is made up of government bonds and capital lent to intermediate firms. In a second stage, the portfolio manager determines the assets structure by choosing portfolio weights.

3.3.1 Portfolio investor

Portfolio investors collect deposits from the private intermediary, which are then converted into financial portfolios. The portfolio investor acts in a perfectly competitive market but it faces an idiosyncratic shock. The continuum of risk neutral portfolio managers is indexed by $e \in [0,1]$. At time t, type-e bank managers invest in a portfolio $P_{e,t}$ by using deposits from the private intermediary, $D_{e,t}$, and internal funds, $N_{e,t}$,

$$\mathcal{P}_{e,t} = D_{e,t} + N_{e,t}, \tag{10}$$

where the composition of $\mathcal{P}_{e,t}$ is described below. The portfolio investor faces an idiosyncratic shock, denoted by $\varepsilon_{e,t+1}$, which follows a log-normal distribution, where there is a threshold from which the bankers go bankrupt, $\bar{\varepsilon}_{e,t+1}$ such that

$$\mathrm{E}_t \left\{ \bar{\varepsilon}_{e,t+1} R^p_{t+1} \mathcal{P}_{e,t} \right\} = \mathrm{E}_t \left\{ R^L_{e,t+1} D_{e,t} \right\}, \tag{11}$$

where $R^L_{e,t+1}$ is the gross non-default loan rate. If $\varepsilon_{e,t+1} > \bar{\varepsilon}_{e,t+1}$, the banker can reimburse the private intermediary the loaned funds. We assume that $\varepsilon_{e,t+1}$ is an i.i.d. random variable across time and types, with a continuous and once-differentiable c.d.f., $F(\varepsilon)$, over a non-negative support. Also, we consider that ε is unknown to both the intermediary and the banker prior to the portfolio investment decision, with $\mathrm{E}(\varepsilon) = 1$ and $\mathrm{V}(\varepsilon) = \sigma_{\varepsilon,t}$. However, the realization of $\varepsilon_{e,t+1}$ is private information such that there is asymmetric information between the private intermediary and the banker regarding the realized returns of the portfolio. We follow the costly state verification environment of Townsend (1979), in which private intermediary bear a fixed monitoring cost in order to observe an individual banker's portfolio realized return, while bankers observe it for free. For convenience, following Bernanke et al. (1999) we assume that the monitoring cost is a proportion $\mu \in [0,1]$ of the realized gross payoff to the banker's portfolio, $\mu \varepsilon_{e,t+1} R^p_t \mathcal{P}_{e,t}$. We assume that the private intermediary perfectly diversifies the idiosyncratic risk involved in lending. Thus, since the banker is risk neutral and the private intermediary is risk averse, the former will absorb all the risk associated with the lending contract.

The banker chooses the value of portfolio, $P_{e,t}$, and the associated level of loaned funds it needs $D_{e,t}$, prior to the realization of an idiosyncratic shock $\varepsilon_{e,t+1}$. The optimal contract consists in choosing x and $\bar{\varepsilon}$ in order to maximize type$-e$ portfolio investor's expected returns with respect to the participation constraint of the private intermediary. The equilibrium at the credit market can be written as follows

$$\mathrm{E}_t\left\{\frac{R^p_{t+1}}{R_t}\right\} = x\left(\frac{\mathcal{P}_t}{N_t}, \bar{\varepsilon}_{t+1}\right), \tag{12}$$

where $x(\cdot)$ is a function with $\frac{\partial x(\cdot)}{\partial x_t} > 0$ for $N_{t+1} < \mathcal{P}_t$. Let $\mathcal{P}_t/N_t$ denote the leverage ratio.

3.3.2 Portfolio manager

Once the portfolio investor has chosen the size of the portfolio, the manager chooses its composition. A type-e portfolio, $\mathcal{P}_{e,t}$, is made of private physical capital, $k_{e,t}$, and government bonds, $B_{e,t}$, i.e.,

$$\mathcal{P}_{e,t} = Q_t k_{e,t} + Q^c_t B_{e,t}, \tag{13}$$

where Q_t and Q^c_t are the market prices of one unit of capital and one bond, respectively. The proportion $\omega_{e,t}$ of the portfolio is composed of private capital, while the proportion $1-\omega_{e,t}$ is composed of public bonds, such that $\omega_{e,t} = Q_t k_{e,t}/\mathcal{P}_{e,t}$. The total gross return on the portfolio bought in period t and redeemed in period $t+1$ is denoted by $R^p_{t+1}\mathcal{P}_{e,t}$, and it is defined as

$$R^p_{t+1}\mathcal{P}_{e,t} \equiv R^k_{t+1}Q_t k_{e,t} + R^b_{t+1}Q^c_t B_{e,t} - \Omega(\omega_{e,t})\mathcal{P}_{e,t}, \tag{14}$$

where $\Omega(\omega_{e,t}) = \frac{\varpi}{2}\left(\omega_{e,t}-\omega\right)^2$ with $\varpi \geq 0$ is a portfolio adjustment cost. A type-e manager chooses the optimal degree of diversification by choosing the weight $\omega_{e,t}$ to maximize the portfolio returns, yielding

$$\mathrm{E}_t\left\{R^k_{t+1}\right\} - \mathrm{E}_t\left\{R^b_{t+1}\right\} = \varpi\left[\omega_t - \omega\right]. \tag{15}$$

Since index-e does not appear in the equation except for $\omega_{e,t}$, we obtain that $\omega_{e,t} = \omega_t$.

3.3.3 Returns on capital and government bonds

At the end of period t, type$-e$ portfolio manager buys the stock of capital $k_{e,t}$ at price Q_t. In time $t+1$, and after observing all the shocks, she rents her capital stock to intermediate firms at a real rental rate z_{t+1}. She then sells the un-depreciated capital to the capital producer. In a model with investment adjustment costs and capital depreciation, we need to distinguish between the return on capital, R_t^k, and the rental rate of capital, z_t. The former depends on the latter as well as on the value of the capital stock net of depreciation, adjusted for asset price valuation effects (fluctuations in the price of capital, q_t). The gross nominal rate of capital returns, R_t^k, equals to

$$R_t^k \equiv \pi_t \frac{z_t + (1-\delta) q_t}{q_{t-1}}, \tag{16}$$

where $q_t \equiv Q_t / P_t$ and δ is the capital depreciation rate.

We also consider government bonds with maturity. Following Woodford (2001), we assume that a government bond issued in period t pays ρ euros $j+1$ periods later, for each $j \geq 0$ and some decay factor $0 \leq \rho \leq \beta^{-1}$. The average maturity of the bond is therefore $\mathcal{M} = (1-\beta\rho)^{-1}$. This assumption allows to analyze bonds of arbitrary durations. As mentioned in Woodford (2001), a bond issued k periods ago has the same equilibrium price that ρ^k new bonds do. The gross nominal one-period return on a bond is defined as follows

$$r_t^b = \frac{1 + \rho q_t^c}{q_{t-1}^c}, \tag{17}$$

where $q_t^c \equiv Q_t^c / P_t$.

3.3.4 Net worth

We follow Bernanke et al. (1999) by considering that bank managers live for finite horizons. Thus, we assume that each of them has a probability to exit the economy of $1-\gamma$. The nominal aggregate net worth at the end of period t, N_t, is given by

$$N_t = \gamma V_t + W_t^e \tag{18}$$

and V_t is aggregate equity from portfolio holdings in period t which equals in real terms

$$v_t = R_t^p \frac{\mathcal{P}_{t-1}}{P_t} \left(1 - \mu G(\bar{\varepsilon}_t)\right) - R_{t-1} \frac{d_{t-1}}{\pi_t}, \tag{19}$$

where $\mu G(\bar{\varepsilon}_t) = \mu \int_0^{\bar{\varepsilon}} \varepsilon f(\varepsilon) d\varepsilon$. Following Bernanke et al. (1999) and Carlstrom and Fuerst (1997), we assume that bankers participate in the general labor market.[4] Also, we assume that bankers supply one unit of labor at each and every period and earn the nominal wage W_t^e. In definition (18), γV_t is the equity held by bankers who survive in t. Those who die in t, transfer their wage to new bankers entering the economy and consume part of their equity, such as $c_t^e = (1-\gamma)\varrho \frac{V_t}{P_t}$, while the rest, $\frac{\mathcal{A}_t}{P_t} = (1-\gamma)(1-\varrho) \frac{V_t}{P_t}$, is lump-sum transferred to households.

3.3.5 Capital producer

At time t, capital producers sell to entrepreneurs the capital stock k_t, which has been built by combining investment goods, i_t, and un-depreciated capital:

$$k_t = (1-\delta) k_{t-1} + \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right] i_t, \tag{20}$$

where $\vartheta > 0$ controls the size of the adjustment cost. In equilibrium, the relative price of capital, $q_t \equiv Q_t / P_t$, is given by

$$/i_t : q_t = \left[\phi_{1,t} + \beta \mathrm{E}_t \left\{ \frac{\lambda_{t+1} q_{t+1}}{\lambda_t q_t} \phi_{2,t} \right\}\right]^{-1} \quad \text{where} \tag{21}$$

$$\phi_{1,t} = 1 - \Phi\left(\frac{i_t}{i_{t-1}}\right) - \Phi'\left(\frac{i_t}{i_{t-1}}\right) \frac{i_t}{i_{t-1}} \quad \text{and} \quad \phi_{2,t} = \left(\frac{i_{t+1}}{i_t}\right)^2 \Phi'\left(\frac{i_{t+1}}{i_t}\right)$$

3.3.6 Retailer

The final good y_t, used for consumption and investment, is produced in a competitive market by combining a continuum of intermediate goods indexed by $j \in [0,1]$, via the CES production function

$$y_t = \left(\int_0^1 y_{j,t}^{\frac{\theta_p - 1}{\theta_p}} \mathrm{d}j\right)^{\frac{\theta_p}{\theta_p - 1}}, \tag{22}$$

[4] This is a technical issue, since it is necessary to start bankers off with some net worth in order to allow them to begin operations.

where $y_{j,t}$ denotes the overall demand addressed to the producer of an intermediate good j and θ_p is the elasticity of demand for a producer of intermediate goods. The maximization of profits yields typical demand functions

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\theta_p} y_t, \quad \text{with } P_t = \left(\int_0^1 P_{j,t}^{1-\theta_p} \mathrm{d}j\right)^{\frac{1}{1-\theta_p}}, \tag{23}$$

where $P_{j,t}$ denotes the price of an intermediate good produced by firm j.

3.3.7 Intermediate goods

Intermediate firms produce differentiated goods by assembling services of labor and capital, namely $\ell_{j,t}$ and $k_{j,t-1}$, respectively. Capital services are rented from the portfolio investor which owns the capital stock. Type-j firm's total labor input, $\ell_{j,t}$ is composed of household labor, $\ell^h_{j,t}$, and banking labor, $\ell^e_{j,t}$, according to $\ell_{j,t} = [\ell^h_{j,t}]^{\Xi}[\ell^e_{j,t}]^{1-\Xi}$. Type-$j$ intermediate good is produced with the following constant returns to scale technology

$$y_{j,t} = \mathcal{Z}_t \ell_{j,t}^{1-\alpha} k_{j,t-1}^{\alpha}, \tag{24}$$

where $\mathcal{Z}_t$ is a TFP shock defined below. In each period of time, type-j monopolistic firm are subject to a quadratic price adjustment cost of the Rotemberg (1982)-type. The New Keynesian Phillips Curve when at the symmetric equilibrium yields

$$1 - \kappa_p (\pi_t - 1) \pi_t + \kappa_p \beta \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} (\pi_{t+1} - 1) \pi_{t+1} \frac{y_{t+1}}{y_t} \right\} = \theta_p (1 - s_t), \tag{25}$$

where s_t is the real marginal cost and $\kappa_p > 0$ measures the degree of price rigidity.

3.3.8 Fiscal and monetary policies

The budget constraint of the government is given in real terms by

$$q^c_t B_t + \mathrm{t}_t = r^b_t q^c_{t-1} B_{t-1} + g_t - R^p_t \frac{\mathfrak{p}_{t-1}}{\pi_t} \mu G(\bar{\varepsilon}_t), \tag{26}$$

where g_t is the exogeneous government spending shock defined below. We also assume that the central bank follows a standard Taylor rule

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_R} \pi_t^{(1-\rho_R)a_\pi} \left(\frac{y_t}{y}\right)^{(1-\rho_R)a_y}, \tag{27}$$

where $\rho_R \in (0,1)$ is a smoothing parameter, a_π is the elasticity of R_t with respect to inflation deviations and $a_y \hat{y}_t$ is the elasticity of R_t with respect to output gap, R is the steady-state gross nominal interest rate.

3.3.9 Exogenous shocks and equilibrium

The law of motion of shocks has already been presented in Section 2, see Equations (1) and (2). At equilibrium, all markets clear, the final good is given by $y_t = c_t + c_t^e + i_t + g_t + \frac{\mathfrak{p}_{t-1}}{\pi_t}\Omega(\omega_{t-1}) - \frac{\kappa_p}{2}\left(\pi_t - 1\right)^2 y_t$, and a sequence of prices and allocations satisfies the equilibrium conditions of each sector.

4 Parameterization and Solution

Parametrization The model is parametrized on a quarterly basis based on either values commonly retained in the literature or by making the steady-state model replicate some empirical targets, that we base on evidence reported for European countries over the recent period. The subjective discount factor, β, is set to 0.99, implying an annual real interest rate of 4 percent. The degree of risk aversion, σ, is set to 2, while υ is chosen to ensure that household's labor in the steady state, ℓ^h, equals 1/3. The capital share in the intermediate sector technology, α, is set to 0.36; the depreciation rate, δ, equals 0.02; and the investment adjustment cost parameter, Φ, is set to 5 Further, we assume a markup of 10 percent in the intermediate sector (i.e., $\theta_p = 11$). The Rotemberg parameter κ_p is set to correspond to an average contract duration of about 6 quarters in the Calvo model ($\kappa_p = 357.52$).

Regarding the financial sector, we adopt an original calibration by fitting European data of corporate and sovereign spread over the recent period. The entrepreneurial labor-income share is set to 0.01, implying a value of $\Omega = 0.9846$. The steady-state capital-to-net-worth ratio x, is calibrated to 2, so that half of the portfolio is financed with debt. The steady-state gross external finance premium, $\check{r} = r^k/r$, is set to $1.02^{0.25}$, corresponding to an annual risk spread of 200 basis points. The annual business failure rate, $F(\bar{\omega})$, is set to 3 per cent. The idiosyncratic productivity shock, ω_t, obeys a log-normal distribution with an unconditional expectation of 1 and a standard deviation σ_ω. These moments imply that $\gamma = 0.98$, $\mu = 0.12$, $\sigma_\omega = 0.28$ and $\bar{\omega} = 0.50$. The elasticity of the external finance premium with respect to leverage, χ, is deduced from the model's steady-state levels and equals 0.04.

We now turn to the calibrated values of monetary and fiscal policy parameters. The interest-rate smoothing parameter, ρ_R, is set to 0.80. We set $a_\pi = 1.5$ and $a_y = 0$. The ratio of public purchases to output, g/y, is set to 0.2. These values are standard in the literature. Steady-state inflation, π, equals zero. For this version, we abstract from the TFP shock while calibration of parameters related to government spending shocks follow Table 1.

Solution DSGE models are normally solved by taking a linear or log-linear (i.e., first-order) approximation around their non-stochastic steady-state equilibrium. However, we are interested in the effects of an increase in volatility or a positive shock to $\epsilon_t^{\sigma^g}$, while the level shock to an exogenous process, TFP and government spending, is zero, $\epsilon_t^z = 0$ and $\epsilon_t^g = 0$. When using first-order approximations, shocks to the variance of the exogenous processes do not play any role, since the decision rule of the representative agent is independent of shocks' second (or higher) moments. For second (or higher) moments to enter the decision rules of economic agents, a higher approximation to the policy functions is needed. A second-order approximation only captures volatility indirectly via cross products $\epsilon_t^g \epsilon_t^{\sigma^g}$. Volatility only has an effect if the government spending changes. Therefore, we need to obtain a third-order approximation of the policy functions as with lower-order approximations the effect of a volatility shock will not apprear by its own. A third-order approximation of the policy functions allows for volatility (second moments) to play an independent role in the approximated policy function and the volatility shock enters as an independent argument.

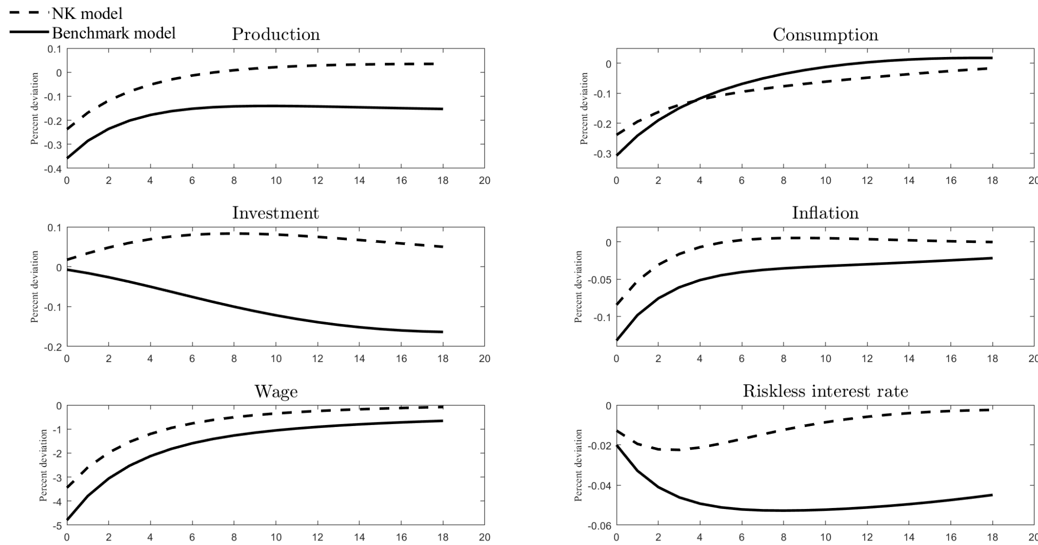


Figure 5.1: IRFs to a government spending uncertainty shock in New Keynesian vs. Benchmark model. Horizontal axes indicate quarters. All responses are in percent.

5 Investigating the Effects of Spending Uncertainty Shocks

In this section, we investigate the effects of a public spending uncertainty shock in our baseline model and we perform robustness exercices.

5.1 Baseline model

Figure 5.1 reports the IRFs responses of key macroeconomic variables to a government spending uncertainty shock. The solid lines correspond to the IRFs in the baseline model and the dashed lines correspond to the responses in a typical New-Keynesian model ($R_t^k = R_t^b = R_t^p$).[5]

In both models, spending uncertainty generates a recession in the short-run although it is more pronounced in our baseline model. Interestingly, private investment increases in response to uncertainty shocks in the New-Keynesian model while it decreases in our baseline model.

We start considering the effects of an exogenous increase in government spending volatility in a New-Keynesian model. As agents experience higher uncertainty on government spending, private consumption drops as households expect more uncertainty on future taxation, based on the pre-

[5]The NK model is based on the assumption of the absence of portfolio adjustment cost ($\varpi = 0$) and no-risky portfolio, i.e. Equation 15 simplifies to $R_{t+1}^p = R_t$.

cautionary saving behavior of the agents. This increases the expected return on capital and the price of capital (marginal Tobin's q). As physical capital and government bonds are perfect substitutes in this model, investment in capital as opposed to bonds increases. The decline in the return on capital is prolonged over time, caused by the oversupply of physical capital. This shock makes capital investment more attractive over debt for consumption smoothing because households expect more uncertainty on future taxation. Firms shift production from today to tomorrow and decrease labor and capital, which causes marginal costs to decline. The decline in marginal costs raises markups of firms because prices adjust slowly due to the price rigidity. In the New Keynesian model, lower marginal costs drive inflation down. Nominal rigidities help generate a reduction in output in response to higher uncertainty with at the same time rising investment.

Public spending uncertainty in the full model generates a stronger recession than in the New-Keynesian model driven by a reduction in private investment. To understand this result, it is worth noting physical capital and government bonds are imperfect substitutes in this model, unlike in the New-Keynesian model. When portfolio investors face an increase in public spending uncertainty, they have more incentive to substitute public bonds toward physical capital. Therefore, the share of capital in the portfolio increases which should drive investment up, as in the New-Keynesian model. However, as portfolio investors face portfolio adjustment costs, it is costly for them to modify the composition of portfolio implying that the substitution effect is incomplete. The net worth of portfolio investor is reduced as the portfolio contains uncertain bonds, implying that the default probability increases in response to the uncertainty shock. Bankruptcy for portfolio investors induces a sharp fall in investment, which in turn lead to a strong recession. Interestingly, these findings are in line with the empirical evidence stressed in Section **??**.

5.2 Sensitivity analysis

In this section, we perform some robustness exercises in order to fully understand the transmission channels of the public spending uncertainty shock in the full model. We consider a number of modifications with respect to our benchmark calibration, focusing on (*iii*) the portfolio adjustment cost, (*ii*) monetary policy, and (*iii*) the degree of risk aversion.

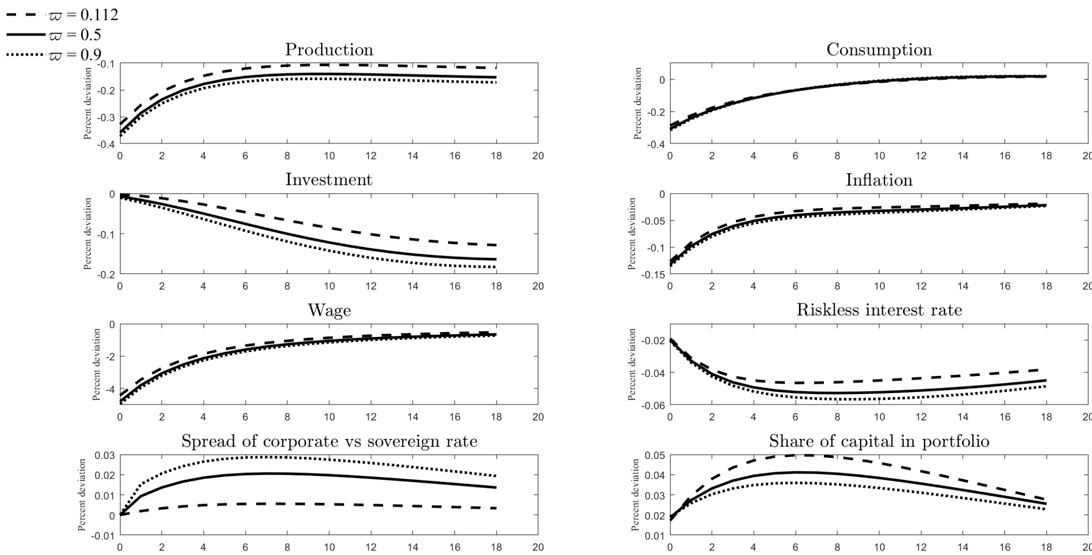


Figure 5.2: IRFs to a government spending uncertainty shock under different degree of portfolio adjustment costs. The blue solid line always depicts the response under the benchmark parametrization. Horizontal axes indicate quarters. All responses are in percent.

Portfolio adjustment costs Baseline parametrization of the coefficient of portfolio adjustment costs ϖ is set to 0.5. Figure 5.2 displays the IRFs in the baseline model in our benchmark paramerization (solid lines), $\varpi = 0.1$ (dashed lines) and $\varpi = 0.9$ (lines with circles). Unsurprisingly, the degree of portfolio adjustment costs affects the transmission channels of the uncertainty shock on investment and therefore output. Large values of ϖ implies that a change in the portflio composition is costly, implying that portfolio investors are more likely to default as they can hardly get rid of their risky assets. Therefore, the share of capital in the portfolio increases by less when portfolio adjustment costs are high, the default probability is higher which ultimately leads to a sharper reduction in private investment.

Monetary policy We explore the role of monetary policy in propagating volatility shocks in our model by looking at the two parameters associated to the Taylor rule (27). We first look at the responses of macroeconomic variables under different values of the interest rate smoothing parameter, ρ_R, in the Taylor rule. Figure 5.2 displays the responses of variables for $\rho_R = 0.5$, $\rho_R = 0.8$ (baseline calibration) and $\rho_R = 0.95$.[6] We find that the negative response of investment

[6] There is some evidence that monetary policy is in fact inertive. Higher values of ρ_R correspond to higher monetary policy inertia. Born and Pfeifer (2014) estimate the interest smoothing parameter, ρ_R, at 0.863. Rudebusch (2006)

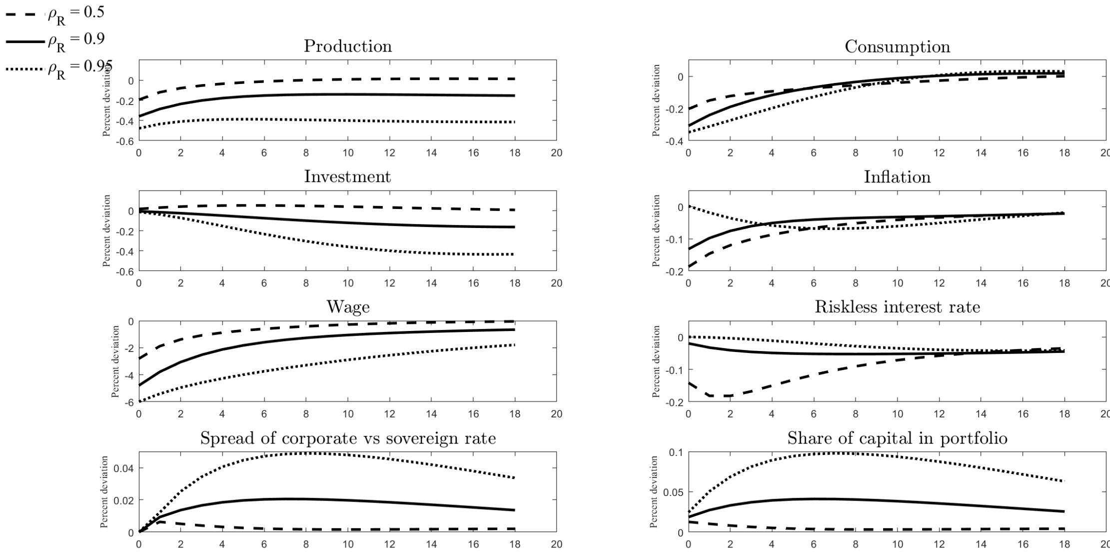


Figure 5.3: IRFs to a government spending uncertainty shock under different parametrization of interest rate smoothing. The blue solid line always depicts the response under the benchmark parametrization. Horizontal axes indicate quarters. All responses are in percent.

to a rise in public spending uncertainty is lower for small values of ρ_R. Unsurprisingly, the response of the riskfree interest rate to the uncertainty shock is strong when the Taylor rule features a small degree of inertia, implying that the central bank responds to the deterioration of economic conditions by significantly lowering the nominal interest rate.

We now turn to investigate the effect of a_π, the degree of reaction of the interest rate to inflation, on the transmission channels of the public spending shock. Figure 5.2 reports the IRFs under the baseline calibration ($a_\pi = 1.5$) and $a_\pi = 1.25$ and $a_\pi = 1.7$ as well. When the central bank slightly respond to variation in inflation (low a_π), fiscal uncertainty generates a large reduction in inflation due to the recessionary effects of the shock, which leads to a rise in the value of debt through the so-called Fisher effect. This "debt-deflation channel" which in turn amplifies the rise in the probability of default of portfolio investors and generates a strong reduction in investment.

Risk aversion Finally, we investigate whether the degree of household's risk aversion, σ, affects the transmission channels of the public spending uncertainty shock. Figure 5.2 shows the responses

estimates an inertial policy rule on U.S. quarterly data 1987-2004 and finds ρ_R to be 0.78. Sims and Wolff (2017) use Bayesian methods to estimate ρ_R on U.S. quarterly data 1984-2008 to be 0.82. Similar estimates are discussed by Kozicki (1999) and Rudebusch (2002) for the United States and by Sauer and Sturm (2003), Gerdesmeier and Roffia (2004), and Castelnuovo (2006) for the euro area.

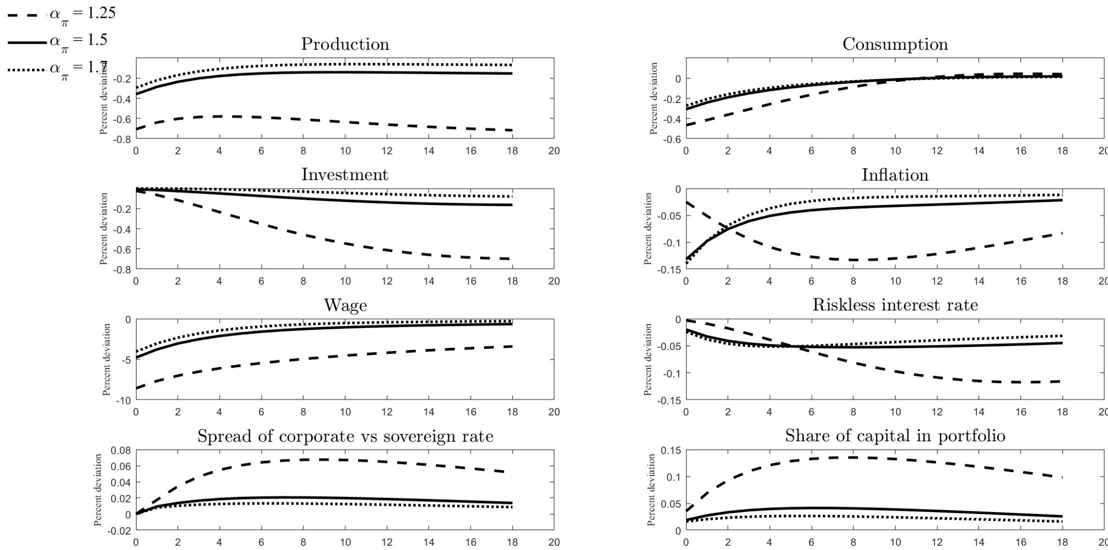


Figure 5.4: IRFs to a government spending uncertainty shock under different response of monetary authority to inflation. The blue solid line always depicts the response under the benchmark parametrization. Horizontal axes indicate quarters. All responses are in percent.

under the baseline calibration ($\sigma = 2$), and for alternative parametrization, i.e. $\sigma = 1.3$ and $\sigma = 5$. The IRFs show higher risk aversion leads to stronger responses of macroeconomic variables to volatility shock to government spending.[7] The fall in investment is especially pronounced under higher risk aversion. As our model features financial frictions, the negative wealth effect and financial accelerator mechanism comes on top of a standard precautionary savings mechanism. Thus, with agents being more averse in our model, the fall in output and investment amplified.

6 Conclusion

In this paper we have shown that government spending uncertainty can have important negative impact on private investment if financial markets are imperfect. On the empirical side, we estimate a second-order moment innovations to public spending and we find that public spending uncertainty shocks significantly lower ouptut, consumption, investment and inflation in a VAR for the Euro

[7]This result is in line with Bretscher, Hsu and Tamoni (2018) who study the interaction between volatility shocks and different degrees of risk aversion. When they increase risk aversion from 5 to 15, they document a sharper response of macroeconomic variables to uncertainty in a DSGE model. On the other hand, Balke et al. (2017) find that higher risk aversion dampens the response of output to TFP uncertainty and monetary policy uncertainty. Their result is driven by the precautionary behaviour of households, who are now more risk averse and less likely to substitute consumption over time. In contrast to their result, in our experiment higher risk aversion aggravates the fall in output and investment.

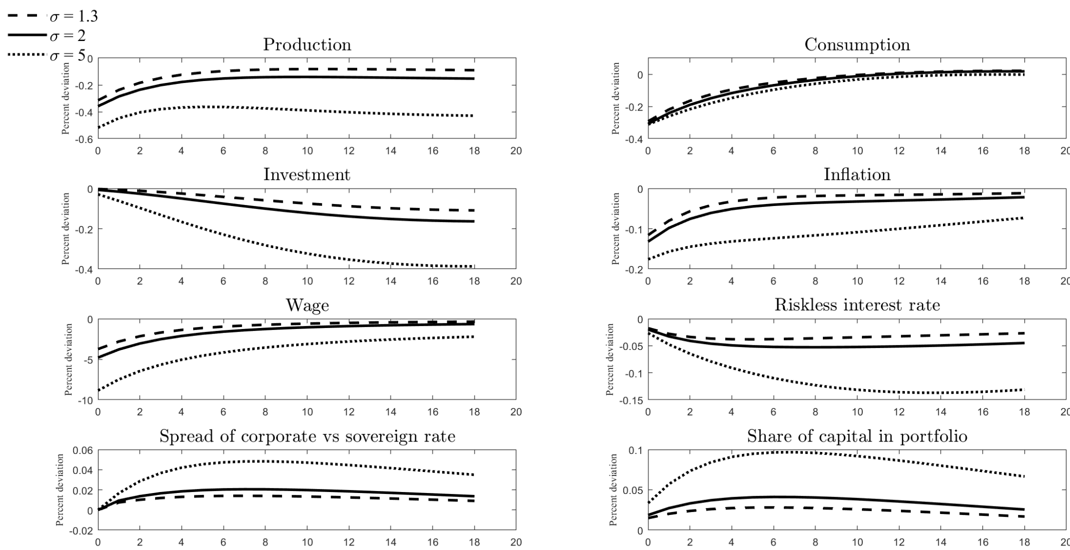


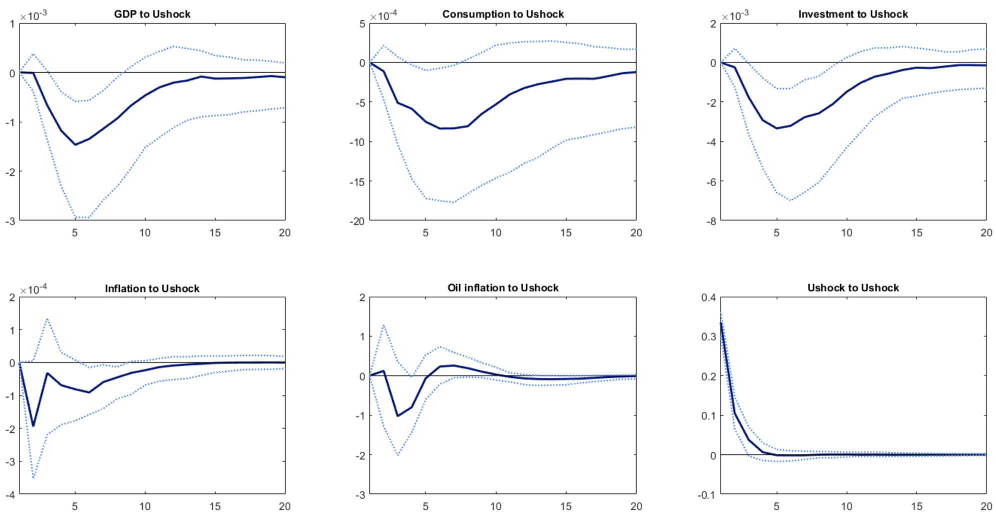
Figure 5.5: IRFs to a government spending uncertainty shock under different parametrization of risk aversion coefficient. The blue solid line always depicts the response under the benchmark parametrization. Horizontal axes indicate quarters. All responses are in percent.

Area. Therefore, these type of shocks present an important source of macroeconomic fluctuations.

We recover this contractionary effect of public spending volatility shocks in an alternative New-Keynesian model with portfolio decisions and financial frictions. On the contrary, a standard New-Keynesian model is unable to reproduce a fall in private investment in line with the empirical evidence. Our results indicate that fiscal policy uncertainty shocks can have a significant adverse effect on output, investment and consumption and the role of financial imperfections in the transmission of these shocks is crucial.

Appendix

Figure 6.1: Impulse response to a 1-sd uncertainty shock - one-sided HP-filtering



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