The Transmission Channels of Government Spending Uncertainty

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Abstract

We investigate the effects of government spending uncertainty shocks in the Euro Area both empirically and theoretically. Empirically, a stochastic volatility model is used to extract a measure of uncertainty in the government spending to GDP ratio. This measure is then introduced in a structural VAR model to show that uncertainty shocks have recessionary, persistent and humped-shaped effects. We develop a dynamic New Keynesian model with financial frictions applying to a portfolio of equity and long-term government bonds where both assets are imperfectly substitutable to account for these effects. Key parameters of the model are then estimated using a mix of Simulated Method of Moments and Minimum Distance Estimation, and the effects of a government spending uncertainty shocks are correctly replicated. We discuss the various transmission channels and show that financial frictions in general and the portfolio channel – the fact that both assets are imperfectly substitutable – in particular, act as critical amplifiers of the usual transmission channels already discussed in the literature.

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

The large fiscal stimulus packages as well as the austerity plans adopted by several governments after the Great Recession have renewed interest in fiscal policy analysis. While the impact of fiscal-level shocks on the real economy has been widely documented in the literature, the effects of uncertainty about fiscal policy are still relatively unexplored.[1] In reality, policy decisions on public expenditure and taxation are subject to uncertainty, characterized in this paper by unexpected movements in the volatility of fiscal instruments. This uncertainty might arise either from changes in the political stance over time or from changes in the legislation like budget rules, which generate shifts in the distribution of fiscal shocks.[2] The traditional transmission channels of macroeconomic uncertainty shocks are well established in the literature, like for instance the real option effect, the precautionary saving effect or the effect of price stickiness.[3] In this paper, we offer new insights regarding the transmission channels of public spending uncertainty shocks.

The aim of this paper is to investigate both empirically and theoretically the implications of higher government spending uncertainty on macroeconomic aggregates. We proceed in two steps. First, we document the effects of government spending uncertainty shocks in the Euro Area by disentangling public spending level and public spending volatility shocks using a Stochastic Volatility estimator.[4] We then put these second-order moment innovations in a structural VAR (SVAR) model, and find that they trigger persistent, negative and humped-shaped responses of GDP, private consumption, private investment and inflation in the Euro Area. These results are robust to alternative identification schemes, lags, samples or variables included in the SVAR. Second, we build a general equilibrium model that replicates these empirical facts and rationalizes the transmission channels of these shocks.

In the model, we uncover a novel transmission channel of fiscal uncertainty shocks by linking long-term government bonds and private equity on the financial market. We consider a typical New-Keynesian model enriched with financial frictions *à la* Bernanke et al. (1999)

[1] On the empirical macroeconomics effects of fiscal shocks, see for among others Blanchard and Perotti (2002) or Ramey and Zubairy (2018).

[2] As Peter Praet (Member of the Executive Board of the ECB) said in his speech of 17 October 2018: "One of the important challenges for fiscal policymakers is how to avoid uncertainty arising from reform reversal. This should be an important consideration when designing reforms." One typical example for fiscal uncertainty in the US is the government shutdowns of 2013 and 2018. In the Euro Area, the sovereign debt crisis in 2012 has been followed by drastic austerity plans in most countries.

[3] See the literature survey by Bloom (2014). It is worth noticing that macroeconomic uncertainty shocks often refer to TFP-driven uncertainty or preference-driven uncertainty.

[4] Born and Pfeifer (2014) and Fernandez-Villaverde et al. (2015) use a Stochastic Volatility estimator in the estimation of fiscal policy uncertainty shocks in the US.

that apply to a portfolio of assets. Precisely, the financial sector is made up of a continuum of risk-neutral portfolio investors who can invest in public bonds and private equity to build their portfolio, while these investors face an idiosyncratic risk of default. Portfolio investors borrow from a representative lender who is in charge of collecting households' saving. Thus, financial frictions between the representative lender and the portfolio investor stem from the asymmetric information regarding the default risk of the latter, as in Bernanke et al. (1999). The probability of default of portfolio investors depends on the portfolio risk premium, *i.e.* the spread between the portfolio return and the risk-free interest rate. Our portfolio structure with two assets enriches the standard financial accelerator mechanism with a "portfolio channel": the portfolio risk premium now depends on the differential of expected returns between private equity and public bonds. The strength of the portfolio channel varies with the degree of substitutability between the two assets, captured by a quadratic portfolio adjustment cost, which illustrates the slow adjustment in the composition of the portfolio (see Jermann and Quadrini, 2012 or Iacoviello, 2015). When the expected return of two assets differ, the portfolio investor shifts the composition of its portfolio toward the asset featuring the higher return which also corresponds to the riskier asset. Therefore, the portfolio risk premium increases, leading to an increase in the cost of borrowing for portfolio investors and a higher probability of default. Therefore, the size of this adjustment cost drives the effectiveness of the portfolio channel as it affects the size of differentials in returns and thus the magnitude of the financial accelerator mechanism.

The model is estimated against European data using a mix of Minimum Distance Estimation (MDE) methods and Simulated Method of Moments (SMM) in the spirit of Basu and Budnick (2017). We find that the theoretical model does a good job in replicating the impulse response functions obtained in the SVAR model as well as a set of unconditional moments. Our estimates suggest that the size of the portfolio adjustment cost needs to be large enough to replicate the responses of output and investment to higher fiscal uncertainty. This result implies that the portfolio channel is a key element to understand the transmission channels of public spending uncertainty shocks.

The "portfolio channel" acts on the transmission channels of public spending uncertainty shocks as following. As higher public spending uncertainty looks like a negative demand shocks, portfolio investors face a negative wealth effect through a rise a the value of their debt. The demand for both assets is reduced leading to a decrease in the price of both equity and public bonds. However, higher uncertainty also reduces public bond issuance because it leads the government to lower government spending. Ultimately, the price of public bonds is reduced by less than the price of private equity, which in turn makes the latter more attractive, as its expected premium increases more than for sovereign bonds. Portfolio investors shift the portfolio composition towards equity, which increases the share of capital in the portfolio. As a result, the portfolio risk premium increases substantially, leading to more defaulted portfolios. This portfolio channel comes on top of the usual financial accelerator mechanism, drives private investment further down and aggravates the subsequent recession.

A set of counterfactual exercises highlights the critical importance of the amplification effect induced by the portfolio channel. First, we shut down this channel by assuming that the portfolio investor can only invest in private equity, as assumed in the standard financial accelerator model. Second, a counterfactual exercise consists in assuming that the two assets are perfect substitutes in the portfolio. For given estimated values of our parameters, both alternative models produce responses to public spending uncertainty shocks that are severely dampened, and fall short in replicating the empirical evidence. Third, even when the standard financial accelerator model – with equity only – is estimated using the same SMM-MDE method on the very same data, we find that this model is outperformed by our baseline model. We conclude that the portfolio channel is key to match quantitatively the empirical effects of a government spending uncertainty shock.

The contribution of this paper lies in the introduction of a novel channel of the propagation of government spending uncertainty shocks that we call portfolio channel. We show that stronger financial frictions, that arise from the diversification of portfolios, are critical in accounting for the effects of fiscal policy uncertainty on real economic activity. This mechanism acts on top of other transmission channels through which uncertainty generally affects macroeconomic aggregates, that are also present in the model. The inverse Oi–Hartman–Abel effect (see Born and Pfeifer, 2014 among others) and the Basu-Bundick effect (see Basu and Budnick, 2017) based on sticky prices, predict that consumption and investment fall jointly. In addition, financial frictions amplify the quantitative importance of both transmission mechanisms (see Cesa-Bianchi and Fernandez-Corugedo, 2017).

Our 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 investigated in the literature. The seminal paper by Bloom (2009) turned attention to uncertainty by documenting that shocks to the volatility of aggregate productivity produce large fluctuations in output and employment. However, only few studies focus on policy uncertainty and, more precisely, on the effects of fiscal policy uncertainty on real activit. Fernandez-Villaverde et al.

(2011) show that fiscal volatility shocks have detrimental effects on output, especially when the central bank is constrained by the zero-lower bound. Born and Pfeifer (2014) provide more contrasted results, and argue that fiscal uncertainty shocks are not sizable enough to contribute significantly to the business cycle. Our paper differs from these studies in that we consider financial market imperfections and portfolio decisions in our model to investigate the effects of time-varying government spending uncertainty. While previous studies 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 government spending uncertainty shocks.

Our paper also relates to the literature that studies the role of financial frictions on fluctuations. After the financial crisis of 2007–2009, the importance of both financial market imperfections and time-varying volatility for real activity has been emphasized. A strand of literature shows that financial market frictions amplify the negative effects of uncertainty on macroeconomic outcomes. Differently from us, it studies idiosyncratic – or firm-level – uncertainty (Arellano et al., 2019; Christiano et al., 2014; Gilchrist et al., 2014; Balke et al., 2017) or TFP uncertainty (Alfaro et al., 2018; Cesa-Bianchi and Fernandez-Corugedo, 2017) and abstracts from fiscal policy uncertainty. Bretscher et al. (2019) develop a model where fiscal volatility shocks cause the major part of fluctuations in term premia. However, they disregard from financial frictions, and look at the term premia, while our model considers corporate and sovereign spreads, as well as their interaction in magnifying the negative effects of uncertainty. Another strand of the literature, known as the intermediary asset pricing literature, shows that the net worth of financial intermediaries can affect portfolio decisions when the financial market features some frictions (Brunnermeier et al., 2013 for a survey and He and Krishnamurthy, 2018). Ultimately, portfolio choices depend on preferences of financial intermediates, *i.e.* their degree of risk aversion. In this paper, we contribute to this literature by assuming that portfolio investors are risk-neutral, in the spirit of Silva (2020) while they face a portfolio adjustment cost. This breaks the Modigliani-Miller theorem and opens the doors of portfolio rebalancing effects. We emphasize the importance of portfolio adjustment under fiscal uncertainty. Finally, our paper relates to Gertler and Karadi (2011) and Gertler and Karadi (2012) who focus on the financial frictions arising from the financial contract between the depositors and the banks. We offer an alternative way of modelling financial frictions in which portfolio investors can be seeing as financial entrepreneurs facing limited asset participation issues.

Section 2 presents the estimation of government spending uncertainty shocks and their empirical effects. Section 3 describes the model setup and Section 4 the parametrization, solution and estimation methods. Section 5 explains the main results produced by the benchmark estimation. Section 6 takes a closer look at the portfolio transmission channel, and offers various counterfactual exercises to highlight its contribution to account for the effects of government spending uncertainty shocks. Section 7 concludes.

2 The Effects of Government Spending Uncertainty Shocks

In this section, we document the effects of government spending uncertainty on the economic activity of the Euro Area. We proceed in two steps. First, we extract a measure public spending uncertainty over time in the Euro Area from the data using a time-varying volatility Bayesian estimator. Second, we incorporate the resulting measure of uncertainty in a SVAR model to quantify the impact of public spending uncertainty shocks on a set of key macroeconomic variables.

2.1 Estimation of Government Spending Uncertainty Shocks

We first estimate a fiscal rule for government spending with time-varying volatility based on the method of Fernandez-Villaverde et al. (2011) and Born and Pfeifer (2014). Let $\tilde{g}_t$ denote the share of government spending in GDP. The fiscal rule driving the deviations of $\tilde{g}_t$ from its mean $(\tilde{g}_t - \tilde{g})$ reacts to the lagged deviations of the ratio from its mean $(\tilde{g}_{t-1} - \tilde{g})$ and to the lagged output gap $(\tilde{y}_{t-1})$. The rule also features stochastic volatility shocks, as its time-varying standard deviation σ_t^g is assumed to follow an AR(1) process:

$$(\tilde{g}_t - \tilde{g}) = \rho_g (\tilde{g}_{t-1} - \tilde{g}) + \rho_{gy} (\tilde{y}_{t-1}) + \exp(\sigma_t^g)\varepsilon_t^g, \quad (1)$$

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

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 is our time-varying measure of government spending uncertainty. Parameters ρ_g and ρ_{σ^g} drive the persistence respectively associated with the level (first-order) and the volatility (second-order) shocks, η_{σ^g} drives the magnitude of the government spending volatility shock and ρ_{gy} measures the feedback effect of lagged output gap on the government spending ratio. We use quarterly data for the Euro Area over the sample 1970q1 to 2017q4 extracted from the Area Wide Model (AWM) database. Notice that $\tilde{g}_t$ is measured as the share of government spending to GDP, output gap $\tilde{y}_t$ is computed by applying a one-sided HP-filter to the log of the GDP time series and

$\tilde{g}$ is the average value of $\tilde{g}_t$ in the data, *i.e.* $\tilde{g} = 0.194$.[5]

The two processes (1)-(2) capture the fiscal rule as well as the time-varying standard-deviation of the government spending ratio. Using the algorithm of Born and Pfeifer (2014), Equations (1)-(2) are estimated jointly with Bayesian methods. We obtain priors directly from the data using simple least squares regressions. The historical series of the unobserved volatility shock are extracted using a (non-linear) particle filter from the posterior distribution computed using the MCMC algorithm. The posterior distributions of parameters are computed from 20 000 draws, and we use 20 500 particles where the first 500 are discarded.

Table 1 reports the median point estimates along with the 10$^{\text{th}}$ and 90$^{\text{th}}$ percentiles in the baseline estimation (first column), together with point estimates resulting from two alternative estimations, to give a sense of the robustness of our baseline estimates. The first alternative estimation (second column) imposes $\rho_{gy} = 0$, meaning that the government spending ratio does not respond to the output gap component. The second one (third column) uses a different measure of the output gap, taking the log-difference of GDP ($\tilde{y}_t = \Delta y_t$) instead of a one-sided HP filter. For each alternative estimation, the Metropolis-Hastings parameter is adjusted to get an acceptance rate of roughly 25%. In the baseline estimation, the government spending ratio $\tilde{g}_t$ exhibits a strong degree of persistence ($\rho_g = 0.98$) and is counter-cyclical ($\rho_{gy} = -0.029$). The two other specifications provide persistence parameters between 0.97 and 0.98, and using GDP growth as an alternative measure of output gap also points to the countercyclicality of the government spending ratio. In addition, the average standard deviation of the spending ratio is $100 \times \exp(-6.948) \simeq 0.096\%$, which is sightly lower than in Fernandez-Villaverde et al. (2011) for U.S. data. This order of magnitude is robust across specifications. When it comes to the volatility series, we find that they are quite persistent ($\rho_{\sigma^g} = 0.761$ in the baseline case) and a one standard deviation uncertainty shock increases the volatility of government spending ratio from $\exp(-6.948) = 0.096\%$ to $\exp(-6.948 + 0.37) = 0.139\%$, *i.e.* a 45% increase in uncertainty.

The upper panel of Figure 1 reports $\tilde{g}_t$, the observed level of the government spending ratio. The latter is characterized by an upward trend from mid-70's to mid-80's. The 1980s are marked by increased budget deficits and public debts in the Euro Area. This trend reversed from 1993 to 2007, which is consistent with Euro Area countries trying to comply with the guidelines imposed by the Maastricht Treaty. In response to the Great Recession starting in 2007, Euro Area countries substantially increased their levels of public spending as a

[5] Section 2.1 in the online Appendix describes the data.

Table 1. Estimated parameters of the stochastic volatility process

	Baseline	$\rho_{gy} = 0$	$\tilde{y}_t = \Delta y_t$
Persistence of $\tilde{g}_t$ (ρ_g)	0.98 [0.98,0.98]	0.98 [0.98,0.98]	0.97 [0.97,0.97]
Persistence of σ_t^g (ρ_{σ^g})	0.76 [0.76,0.77]	0.71 [0.70,0.71]	0.75 [0.74,0.75]
Impact effect of shock on σ_t^g (η_{σ^g})	0.37 [0.36,0.37]	0.39 [0.39,0.40]	0.36 [0.35,0.36]
Log of the average σ_t^g (σ^g)	−6.95 [−6.96,−6.94]	−6.89 [−6.89,−6.88]	−6.91 [−6.91,−6.90]
Output gap response (ρ_{gy})	−0.03 [−0.03,−0.03]	–	−0.04 [−0.05,−0.04]

Note: The main values correspond to the median estimates and values under brackets are the 10th and 90th percentiles. The first column is the estimation of the processes (1)-(2). In the second column, we impose $\rho_{gy} = 0$ and in the third column, output gap ($\tilde{y}_t$) is proxied by the real GDP output growth.

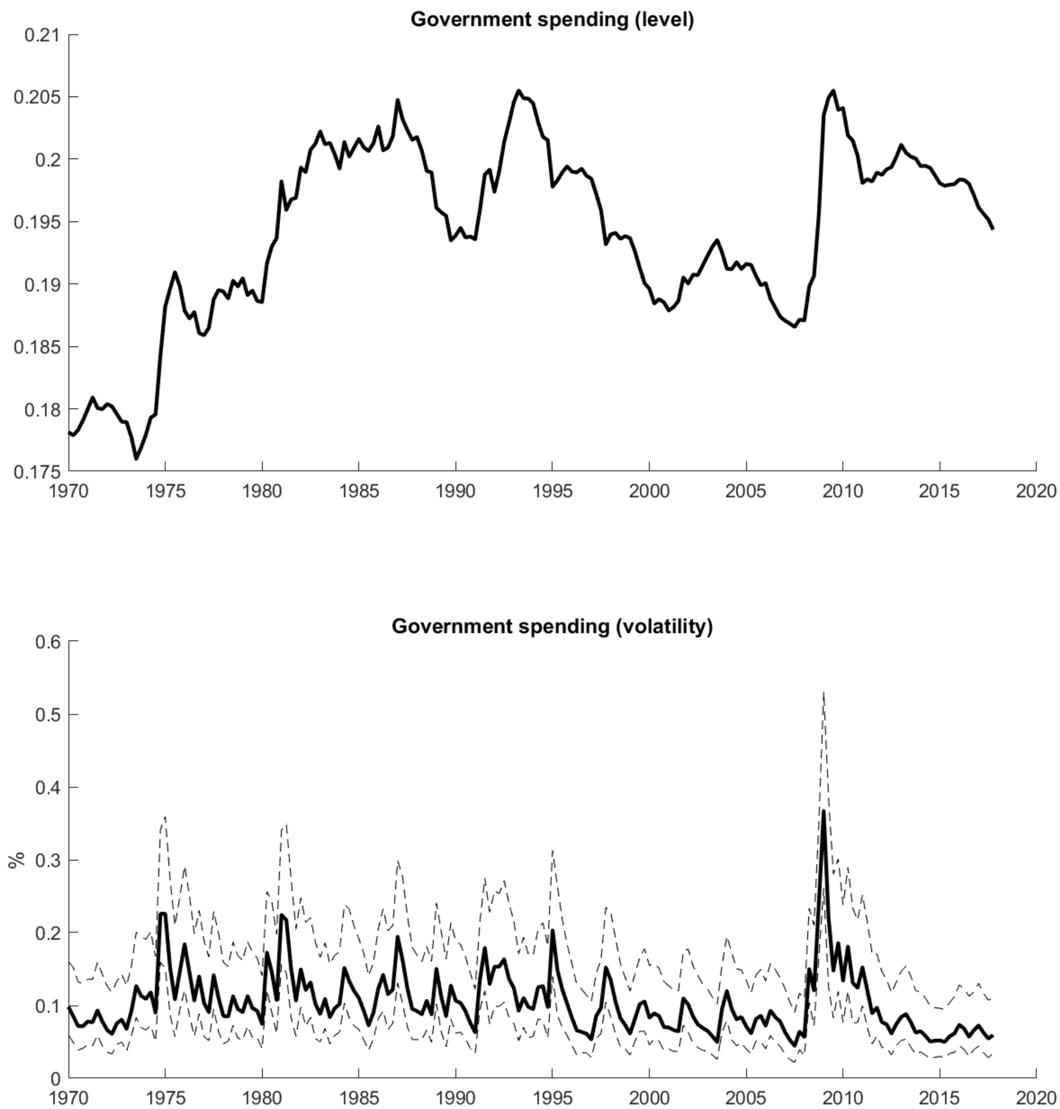
share of GDP through fiscal stimulus packages. Inversely, the switch of several countries toward austerity plans after 2010 has resulted in a reduction of $\tilde{g}_t$. The lower panel of Figure 1 reports the historical (extracted) series of public spending uncertainty. The solid line is the median historical smoothed estimate of σ_t^g and the dashed lines are the first and last deciles, respectively. The volatility series features a major peak in 2009, which reflects the implementation of fiscal stimulus packages by several governments of Euro Area countries in response to the financial crisis. Uncertainty lasted for about two years, as some governments carried out austerity measures. Interestingly, the period 1999-2009 has been characterized by less pronounced government spending volatility, as the series is below its unconditional mean. Before the creation of the Euro Zone in 1999, the public spending volatility shocks experienced several peaks, notably in 1975 and 1982, two periods of high public debt and deficit levels in Euro Area countries. Figure 2 of the online Appendix displays the public spending uncertainty series under the three specifications (baseline, $\rho_{gy} = 0$ and $\tilde{y}_t = \Delta y_t$). We find that the three series are strongly correlated.[6]

2.2 Empirical Macroeconomic Effects

We now quantify the effects of public spending uncertainty shocks on macroeconomic variables in the Euro Area. To do so, we imbed the series of smoothed estimates $\sigma_t^{\tilde{g}}$ into a

[6]Correlation coefficients between the three series of public spending uncertainty are roughly 0.95.

Figure 1: Government spending ratio in the Euro Area.



SVAR(p) model with the vector of observable

$$X_t = \left[\sigma_t^{\tilde{g}} \quad \log(y_t) \quad \log(i_t) \quad \log(c_t) \quad (r_t^{lt} - r_{t-1}^{st}) \quad \pi_t\right]', \tag{3}$$

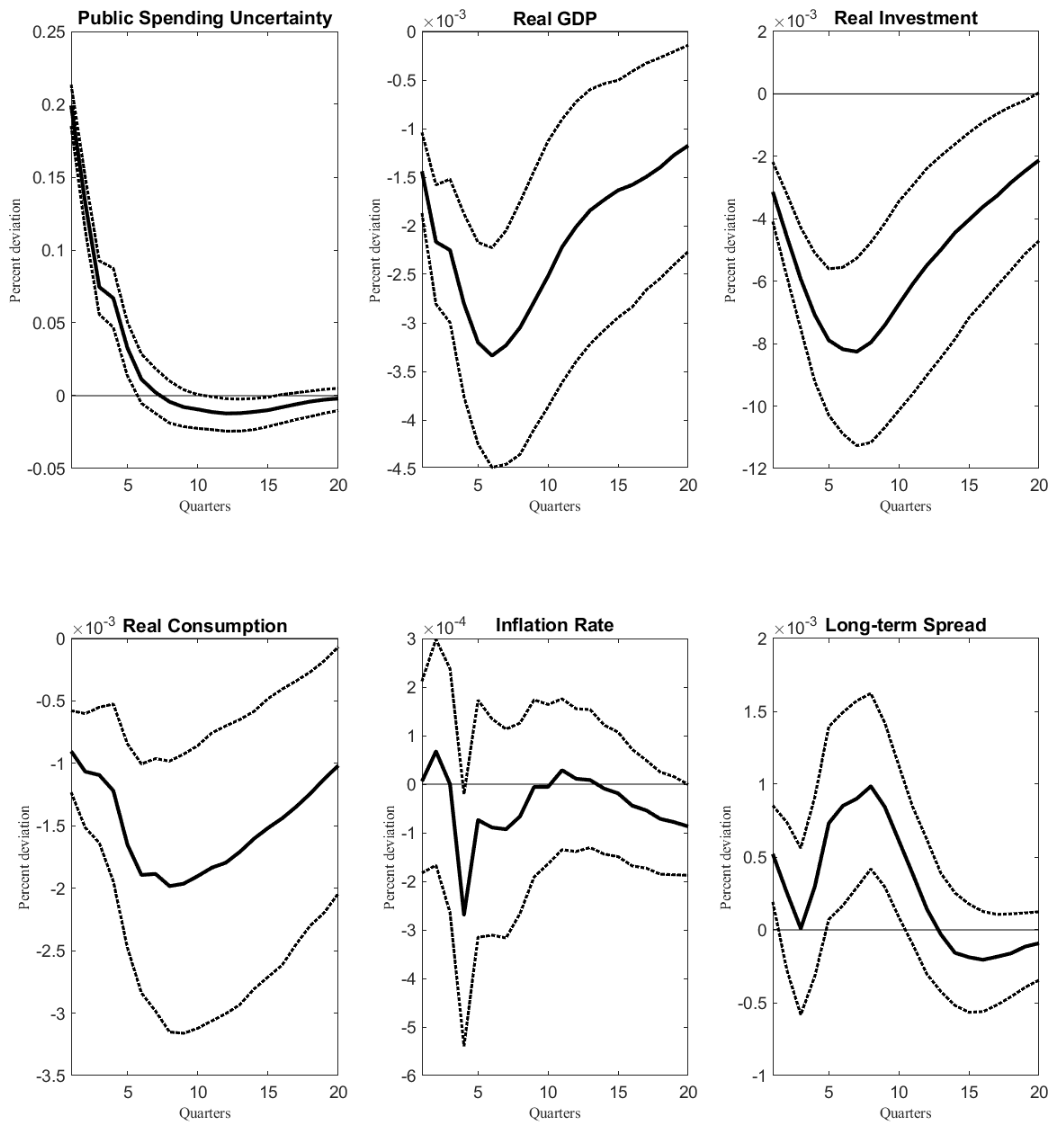
where $\sigma_t^{\tilde{g}}$ is recovered from Equations (1)-(2) and p is the number of lags. Variable y_t denotes the real GDP, i_t real private investment, and c_t real private consumption. Variable $(r_t^{lt} - r_{t-1}^{st})$ is a measure of interest rate spread, measured as the difference between the long-term and the lagged short-term interest rate. Last, π_t is the quarterly inflation rate of the GDP deflator. Data sources are detailed in the online Appendix and the sample, as for the stochastic volatility estimation, ranges from 1970q1 to 2017q4. We use a Cholesky decomposition to orthogonalize the uncertainty shock and order the public spending uncertainty shock first. In line with several studies such as Bloom (2009), Fernandez-Villaverde et al. (2015), Leduc and Liu (2016) and Basu and Budnick (2017), this identification strategy implies that all macroeconomic variables included in the SVAR model are affected with delay of one quarter by the identified shock. Following the AIC criteria, the number of lags p is set to 4.[7]

The SVAR model is estimated by OLS and confidence intervals are computed by bootstrapping the residuals. Figure 2 reports the impulse response functions (IRFs) of all variables to a public spending ratio volatility shock. The Figure shows the median bootstrapped IRFs (solid lines) and the 68% confidence interval. An exogenous increase in public spending uncertainty generates a negative and hump-shaped response of GDP for three years, with a peak occurring after six quarters. In Table 1 of the online Appendix, we show that the identified uncertainty shock contributes by 16% to the variance of GDP at the horizon of one year. Private consumption and investment also decrease in response to the shock, and also feature hump-shaped responses. Investment reacts about two times more than output and consumption, and therefore appears to be an important driver of the responses, which justifies the focus of our theoretical model on financial frictions. Interestingly, the uncertainty shock looks like a demand shock, as it is deflationary, a feature that our theoretical model is able to replicate (see Section 5). Leduc and Liu (2016) and Basu and Budnick (2017) obtain similar results looking at TFP uncertainty shocks. The long-term spread increases for two years, which suggests that an increase in government spending uncertainty is associated with a larger term/risk premium of government bonds.

In Section 2.3 of the online Appendix, we conduct a series of robustness exercises to check the validity of our results. In particular, we show that our results are robust to the introduction

[7]In Section 2.3 of the online appendix, we show that our results are robust to the number of lags and the ordering of variables.

Figure 2: IRFs to a one standard-deviation government spending uncertainty shock.



Note: Solid lines correspond to the median-IRFs while the dashed lines are the 14th and 86th percentiles. Horizontal axes indicate quarters. All responses are in percent.

of additional variables. Interestingly, we find in Figure 3 of the online Appendix that the *level* of public spending decreases in response to an exogenous rise in government spending uncertainty. Additionally, the shock generates a reduction in the short-term interest rate in the medium run (Figure 3 of the online Appendix). The next section shows that our theoretical model replicates these two features, at least qualitatively. Finally, our results are robust to a sub-sample analysis, from 1999q1 to 2017q4, as shown in Figure 4 of the online Appendix. We now build a theoretical model that allows us to replicate the above empirical facts and to analyze the transmission channels of government spending uncertainty shocks.

3 The Model

We build a New-Keynesian model enriched with a financial accelerator mechanism *à la* Bernanke et al. (1999). One innovation of the model is that financial frictions not only affect capital assets (or equity) but also long-term bonds. Indeed, in our model, a representative lender distributes the households' deposits to a continuum of financial intermediaries called portfolio investors. Those financial intermediaries use deposits to buy (i) equity – private capital rented to firms producing intermediate goods – and (ii) long-term government bonds. Portfolio investors make two successive decisions. In a first stage, they choose the total size of the portfolio taking into account the possibility of idiosyncratic default. Each portfolio investor may indeed go bankrupt as a result of an idiosyncratic shock on the *ex-post* return of its portfolio, as in Bernanke et al. (1999). Financial frictions thus arise from the presence of asymmetric information between the private lender and each portfolio investor regarding the realization of the idiosyncratic shock. In a second stage, portfolio investors take as given the size of the portfolio and determine the share of each asset – equity and long-term bonds – in the portfolio to maximize its value, taking into account a quadratic adjustment cost implying that the two assets are imperfect substitutes. The rest of the model is a standard New-Keynesian model with households, capital producers, final and intermediate goods producers, a government and a central bank.

3.1 Households

The economy is populated by a continuum of identical households. A representative household chooses a sequence of consumption (c_t), labor supply (ℓ_t^h) and deposits (A_t) to maximize the discounted lifetime utility *à la* Jaimovich and Rebelo (2009)

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{1-\sigma} \left[\left(c_t - \psi \left(\ell_t^h \right)^{\omega_w} X_t \right)^{1-\sigma} - 1 \right] \right\}, \tag{4}$$

where E_0 is the expectation operator conditional to the information available in period 0, $\beta \in (0,1)$ is the subjective discount factor, $(\omega_w - 1)^{-1}$ is the Frisch elasticity on labor supply, ψ is a scale parameter, σ is the intertemporal elasticity of substitution, and where

$$X_t = c_t^{\sigma_X} X_{t-1}^{1-\sigma_X}. \tag{5}$$

Parameter σ_X drives the strength of the wealth effect on labor supply. Imposing $\sigma_X = 1$ gives rise to the King et al. (1988) preferences while assuming $\sigma_X = 0$ gives rise to Greenwood et al. (1988) preferences, where the wealth effect on labor supply is shut down. As explained by Basu and Budnick (2017), removing the wealth effect rules out the "precautionary labor supply" effect and therefore amplifies the size of uncertainty-driven recessions. As shown later, our approach is to let the data speak regarding the value of σ_X, given its importance and the lack of empirical evidence regarding its value. The representative household maximizes (4) subject to the budget constraint

$$c_t + A_t \leq w_t \ell_t^h + R_{t-1} \frac{A_{t-1}}{\pi_t} + \frac{\Pi_t}{P_t} - \frac{\mathrm{T}_t}{P_t} + \mathrm{div}_t, \tag{6}$$

where $w_t \equiv W_t/P_t$ is the real wage rate, with P_t the price of final goods. In addition, $\pi_t = P_t/P_{t-1}$ is the gross inflation rate, A_t denotes the holdings of net deposits in nominal terms, and R_t is the gross nominal interest rate associated with one-period-maturity nominal deposits. We assume that the household does not hold public long-term bonds directly but she provides deposits to the lender, who contracts with a portfolio investor to invest in equity and long-term bonds. Finally, div_t, T_t, and Π_t respectively stand for nominal profits from monopolistic firms, lump-sum taxes paid to the government and transfers from portfolio investors. The FOCs with respect to A_t, c_t, X_t and ℓ_t^h are

$$\beta \mathrm{E}_t \left\{ \lambda_{t+1} \frac{R_t}{\pi_{t+1}} \right\} = \lambda_t, \tag{7}$$

$$\left(c_t - \psi X_t \left(\ell_t^h \right)^{\omega_w} \right)^{-\sigma} + \sigma_X \upsilon_t c_t^{\sigma_X - 1} X_{t-1}^{1-\sigma_X} = \lambda_t, \tag{8}$$

$$\upsilon_t + \psi \left(\ell_t^h \right)^{\omega_w} \left(c_t - \psi \left(\ell_t^h \right)^{\omega_w} X_t \right)^{-\sigma} = \beta \left(1 - \sigma_X \right) \mathrm{E}_t \left\{ \upsilon_{t+1} c_{t+1}^{\sigma_X} X_t^{-\sigma_X} \right\}, \tag{9}$$

$$\psi \omega_w \left(\ell_t^h \right)^{\omega_w - 1} X_t \left(c_t - \psi X_t \left(\ell_t^h \right)^{\omega_w} \right)^{-\sigma} = \lambda_t w_t, \tag{10}$$

where υ_t and λ_t are the Lagrangian multipliers associated respectively to Equations (5) and (6), respectively. Equation (7) is the Euler equation on nominal deposits and determines the intertemporal dynamics of the marginal utility of consumption as a function of the real return on deposits. Equation (8) describes the evolution of consumption as a function of the marginal disutility of hours worked, and the dynamics of the wealth effect on labor supply. Equation (9) determines the dynamics of the wealth effect on labor supply and Equation (10) is the labor supply equation. A representative lender collects deposits from the representative household, pays a nominal return R_t and transfers the deposits to portfolio investors. The latter repays them back at nominal rate R_t^L if they do not experience any bankruptcy, as explain below.

3.2 Financial sector

In the financial sector, decisions are made in two steps. First, each portfolio investor determines the total size of its portfolio, given the moral hazard problem. Second, he determines the structure of the portfolio by choosing the relative weight of the two assets, equity and long-term government bonds, while facing a portfolio adjustment cost.

3.2.1 Portfolio decisions

Portfolio size There is a continuum of risk neutral portfolio investors indexed by $e \in [0,1]$, who make decisions in a perfectly competitive market but facing an idiosyncratic shock.[8] At time t, type–e portfolio investor invests in a portfolio $P_{e,t}$ using deposits from the representative lender, $D_{e,t}$, and internal funds, $N_{e,t}$:

$$\mathcal{P}_{e,t} = D_{e,t} + N_{e,t}, \tag{11}$$

where the composition of $\mathcal{P}_{e,t}$ is described below. Each type–e portfolio investor faces an idiosyncratic shock, denoted by $\varepsilon_{e,t+1}$. The shock is distributed as a log-normal and there is a threshold from which the portfolio investor goes bankrupt, $\bar{\varepsilon}_{e,t+1}$ such that

$$\mathrm{E}_t\left\{\bar{\varepsilon}_{e,t+1} R^p_{t+1} \mathcal{P}_{e,t}\right\} = \mathrm{E}_t\left\{R^L_{e,t+1} D_{e,t}\right\}, \tag{12}$$

[8] In most setups using contracts with agency costs to model the financial accelerator, financial frictions apply to firms, that are considered risk-neutral. An exception is Candian and M. (2019), who consider risk-averse agents and show that their precautionary behavior leads them to be more resilient to idiosyncratic risk, dampening the importance of financial frictions and therefore of the associated financial accelerator mechanism. In our model, the financial contract applies to financial entrepreneurs, which we believe are more likely to be risk-neutral or less likely to be risk-averse than households or producing firms.

where $R^L_{e,t}$ is the gross non-default loan rate and R^p_t is the portfolio return. If $\varepsilon_{e,t+1} > \bar{\varepsilon}_{e,t+1}$, the portfolio investor can reimburse the private lender and pay interests. 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 lender and the portfolio investor before the 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 information is asymmetric between the lender and the portfolio investor regarding the realized return of the portfolio. We follow the costly state verification environment of Townsend (1979), in which the representative lender bears a fixed monitoring cost in order to observe an individual portfolio's realized return, while the portfolio investor observes 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 investor's portfolio, $\mu\varepsilon_{e,t+1}R^p_t\mathcal{P}_{e,t}$. We assume that the lender perfectly diversifies the idiosyncratic risk involved in lending.

The portfolio investor chooses the value of portfolio, $\mathcal{P}_{e,t}$, and the associated level of loaned funds needed $D_{e,t}$, before the realization of the 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 lender. The equilibrium relation writes

$$\mathrm{E}_t\left\{\frac{R^p_{t+1}}{R_t}\right\} = x\left(\frac{\mathcal{P}_t}{N_t}, \bar{\varepsilon}_{t+1}\right), \tag{13}$$

where $x(\cdot)$ is a function with $\frac{\partial x(\cdot)}{\partial x_t} > 0$ for $N_{t+1} < \mathcal{P}_t$, and where $\mathcal{P}_t/N_t$ is aggregate the leverage ratio, $\mathcal{P}_t$ the aggregate portfolio and N_t the aggregate level of net worth.

Portfolio composition Once each type–e portfolio investor has chosen the size of the portfolio, she chooses its composition. A type-e portfolio, $\mathcal{P}_{e,t}$, is composed of capital asset, $k_{e,t}$ acquired at nominal price Q_t and government bonds, $b_{e,t}$ acquired at nominal price Q^c_t:[9]

$$\mathcal{P}_{e,t} = Q_t k_{e,t} + Q^c_t b_{e,t}, \tag{14}$$

Let $\omega_{e,t} \equiv Q_t k_{e,t}/\mathcal{P}_{e,t}$ denote the share of capital asset in type–e portfolio, while $1 - \omega_{e,t}$ denotes the share of long-term government bonds. The total gross return on the portfolio

[9] As in Gertler and Karadi (2011), investors issue claims to acquire the capital stock, where the number of claims equals the number of units of capital acquired, each of which has a market price Q_t. There is thus an equivalence between the stock of physical capital and the stock of equity, that we ignore for simplicity.

composed at time t and redeemed in period $t+1$ is denoted by $R^p_{t+1}\mathcal{P}_{e,t}$ and defined as

$$R^p_{t+1}\mathcal{P}_{e,t} = R^k_{t+1}Q_t k_{e,t} + R^b_{t+1}Q^c_t b_{e,t} - \frac{\varpi}{2}\left(\omega_{e,t} - \bar{\omega}\right)^2 \mathcal{P}_{e,t}, \tag{15}$$

where $\frac{\varpi}{2}\left(\omega_{e,t} - \bar{\omega}\right)^2$ is a portfolio adjustment cost with $\bar{\omega}$, the steady-state value of ω_t and $\varpi \geq 0$, as assumed in Andres et al. (2004). In the spirit of Jermann and Quadrini (2012) or Iacoviello (2015), this cost is a reduced-form way of capturing deeper behavioral assumptions that affect the substitution between assets, namely equity and long-term government bonds in this setup. In particular, it may capture a form habit in trading or a collection of behavioral biases leading to temporary misvaluation (see Daniel et al., 2002) and hence to sluggish adjustments in the composition of the portfolio.[10] As made clear in Sections 4 and 6.1, this cost is estimated to be positive and statistically different from zero, and crucially affects the dynamics of investment by amplifying the effects of financial frictions.

The portfolio manager chooses the optimal weight $\omega_{e,t}$ to maximize the portfolio returns, which gives

$$\mathrm{E}_t\left\{R^k_{t+1}\right\} - \mathrm{E}_t\left\{R^b_{t+1}\right\} = \varpi\left[\omega_t - \bar{\omega}\right]. \tag{16}$$

Therefore, the portfolio adjustment cost generates a gap between the two assets expected returns which breaks the Modigliani-Miller theorem. Since index–e does not appear in the equation except for $\omega_{e,t}$, the optimal composition of the portfolio is symmetric and we simply drop the e index: $\omega_{e,t} = \omega_{t\cdot}$. Using Equation (15), the expected portfolio return writes

$$R^p_{t+1} = \omega_t R^k_{t+1} + \left(1 - \omega_t\right) R^b_{t+1} - \frac{\varpi}{2}\left(\omega_{e,t} - \bar{\omega}\right)^2 \tag{17}$$

These two last equations show the main amplification mechanism at work through the portfolio channel. Any difference in returns between equity and bonds pushes portfolio investors to rebalance the portfolio towards the asset with the largest return (Equation 16), which then gives more weight to this asset in the portfolio and raises the portfolio risk premium. This is what we call the portfolio channel, which is further amplified by large portfolio adjustment costs, ϖ. Indeed, larger adjustment costs introduce larger deviations in the relative returns of both assets, which in turn trigger larger rebalancing effects – larger movements in ω_t – and then a stronger amplification effect on the portfolio risk premium.

[10] Prospect theory (Johnson and Thaler, 1990) applied to the choice of a financial portfolio (Benartzi and Thaler, 1995, Barberis et al., 2001) may also be invoked to rationalize sluggish portfolio adjustments.

3.2.2 Net worth

We follow Bernanke et al. (1999) and consider that portfolio investors have finite life-time horizons. Each of them faces a probability $1-\gamma$ to exit the economy. 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 the portfolio investor's value in period t. The dynamics of $v_t \equiv V_t/P_t$ is

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

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), portfolio investors participate in the general labor market.[11] Also, we assume that they supply one unit of labor each period and earn the nominal wage W_t^e. In Equation (18), γV_t is the nominal value held by surviving portfolio investors. Those who exit in t transfer their wage to the new portfolio investors and consume part ϱ of their value, such that $c_t^e = (1-\gamma)\varrho v_t$, while the rest $\Pi_t/P_t = (1-\gamma)(1-\varrho) v_t$, is transferred to the representative household.

3.2.3 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 to capital producers. In time $t+1$, and after observing all the shocks, the capital stock is rented to intermediate goods producers at a real rate z_{t+1}. Later on, the undepreciated capital is sold to the capital producers. 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 real price of capital, $q_t \equiv Q_t/P_t$). The gross nominal rate of capital returns, R_t^k, is equal to

$$R_t^k = \pi_t \frac{z_t + (1-\delta) q_t}{q_{t-1}}, \tag{20}$$

where δ is the capital depreciation rate. In our model, the second type of asset is a long-term government bond. Indeed, following Woodford (2001), we assume that the government issues

[11] We denote Ω the proportion of investors among all workers. This is a purely technical trick since it is necessary to start bankers off with some net worth in order to allow them to begin operations.

bonds each period with a maturity larger than one to finance its streams of expenditure. 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 $\mathcal{M} = (1-\beta\rho)^{-1}$, which allows us 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. Given these assumption, the gross real one-period return on a bond is defined as follows

$$r_t^b = \frac{1+\rho q_t^c}{q_{t-1}^c}, \tag{21}$$

where $q_t^c \equiv Q_t^c/P_t$ is the real price of government bonds.

3.3 Capital producers

At time t, capital producers sell the capital stock k_t to portfolio investors. The latter has been built by combining investment goods, i_t with the past undepreciated capital stock

$$k_t = (1-\delta)\, k_{t-1} + \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right] i_t, \tag{22}$$

where $\Phi\left(\frac{i_t}{i_{t-1}}\right) \equiv \frac{\varkappa}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2$ is a function that controls the size of investment adjustment costs with $\varkappa \geq 0$. In equilibrium, the relative price of capital, q_t, is given by

$$q_t = \left[\phi_{1,t} + \beta \mathrm{E}_t\left\{\frac{\lambda_{t+1} q_{t+1}}{\lambda_t q_t}\phi_{2,t}\right\}\right]^{-1} \tag{23}$$

with $\phi_{1,t} \equiv 1 - \Phi\left(\frac{i_t}{i_{t-1}}\right) - \Phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}$, and $\phi_{2,t} \equiv \left(\frac{i_{t+1}}{i_t}\right)^2 \Phi'\left(\frac{i_{t+1}}{i_t}\right)$.

3.4 Intermediate good producers

A unit continuum of intermediate producers assemble labor and capital services to produce differentiated varieties of goods. Varieties are then sold on monopolistically competitive markets subject to Rotemberg (1982) adjustment costs. Capital services are rented from portfolio investors, who own the capital stock on behalf of the representative household. The total labor input of firm j, $\ell_{j,t}$ is made of labor supplied by the representative household, $\ell_{j,t}^h$, and of labor supplied by the portfolio investor, $\ell_{j,t}^e$, according to $\ell_{j,t} = [\ell_{j,t}^h]^{\Xi}[\ell_{j,t}^e]^{1-\Xi}$. The amount of intermediate good produced produced by firm j is then given by

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

where $\mathcal{Z}_t$ is a total factor productivity (TFP) shock following an AR(1) process

$$\hat{\mathcal{Z}}_t = \rho_{\mathcal{Z}} \hat{\mathcal{Z}}_{t-1} + \sigma^{\mathcal{Z}} \varepsilon_t^{\mathcal{Z}}. \tag{25}$$

Further, the price of the good produced by firm j is chosen to maximize the present value of its profits subject to a Rotemberg (1982) quadratic price adjustment cost, given the demand for intermediate goods by final good producers. The New Keynesian Phillips Curve (NKPC) at the symmetric equilibrium yields

$$1 - \kappa_p (\pi_t - 1) \pi_t + \kappa_p \beta \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} (\pi_{t+1} - 1) \pi_{t+1} \frac{y_{t+1}}{y_t} \right\} = \theta_p (1 - s_t), \tag{26}$$

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

3.5 Final good producer

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 following CES production function

$$y_t = \left(\int_0^1 y_{j,t}^{\frac{\theta_p - 1}{\theta_p}} \mathrm{d}j \right)^{\frac{\theta_p}{\theta_p - 1}}, \tag{27}$$

where $y_{j,t}$ denotes the overall demand addressed to the producer of an intermediate good j and θ_p is the elasticity of substitution between intermediate goods. Profit maximization yields the following standard demand functions

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t} \right)^{-\theta_p} y_t, \quad \text{with } P_t = \left(\int_0^1 P_{j,t}^{1-\theta_p} \mathrm{d}j \right)^{\frac{1}{1-\theta_p}}, \tag{28}$$

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

3.6 Government, central bank and equilibrium

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

$$q_t^c b_t + \mathrm{T}_t / P_t = r_t^b q_{t-1}^c b_{t-1} + g_t - r_t^p \mathfrak{p}_{t-1} \mu G(\bar{\varepsilon}_t), \tag{29}$$

where $\mathfrak{p}_t = \mathcal{P}_t / P_t = q_t k_t + q_t^c b_t$ is the real value of the portfolio and r_t^p its real return. In addition, g_t is the amount of government spending and the government spending ratio ($\widetilde{g}_t = g_t / y_t$) follows the processes introduced in Equations (1)-(2). Further, T_t is the nominal amount of lump-sum taxes, evolving according to the following feedback rule

$$\log\left(\left(\mathrm{T}_t/P_t\right)/\left(\bar{\mathrm{T}}/\bar{P}\right)\right) = \phi_b \log\left(b_{t-1}/\bar{b}\right) + \phi_y \log\left(y_t/\bar{y}\right), \tag{30}$$

where bars refer to steady-state values. We also assume that the Central Bank follows a simple Taylor rule

$$R_t/\bar{R} = \left(R_{t-1}/\bar{R}\right)^{\rho_R} \left(\pi_t/\bar{\pi}\right)^{(1-\rho_R)\phi_\pi}, \tag{31}$$

where $\rho_R \in (0,1)$ is a smoothing parameter, ϕ_π is the elasticity of R_t with respect to inflation.

A competitive equilibrium in this economy is defined as a sequence of prices and quantities such that (i) for a given sequence of prices, the first-order conditions of all agents/sectors are satisfied, and (ii) for a given sequence of quantities, prices adjust so that all markets clear. In particular, the final good market clearing condition is given by

$$y_t = c_t + c_t^e + i_t + g_t + \frac{\varpi}{2}\left(\omega_{t-1} - \bar{\omega}\right)^2 \frac{\mathfrak{p}_{t-1}}{\pi_t} + \frac{\kappa_p}{2}\left(\pi_t - \bar{\pi}\right)^2 y_t. \tag{32}$$

4 Parametrization

In line with the literature on the effects of time-varying volatility, we solve and simulate the model using a third-order approximation of the policy functions around the deterministic steady state.[12] While a subset of parameters are set endogenously using empirical evidence, previous studies or matching steady-state targets, another subset of parameters is estimated using a mixture of Simulated Method of Moments (SMM) and Minimum Distance Estimation (MDE), as in Basu and Budnick (2017). The SMM part minimizes the distance between empirical moments computed from the data and their model-based counterparts, while the MDE part minimizes the distance between the empirical and model-based IRFs. Hence, our estimation strategy relies on the ability of the model to match both unconditional and conditional moments of the data.

[12]Models are usually solved by taking a linear or log-linear (*i.e.* first-order) approximations around their non-stochastic steady-state. However, we are interested in the effects of an increase in the volatility of government spending. With a first-order approximation, volatility shocks do not affect any variable of the model. A second-order approximation only captures volatility indirectly, *via* cross-products, and volatility only has an effect if the level of government spending changes. Therefore, a third-order approximation of the policy functions is required, as it allows for volatility (second-order moments) shocks to have an independent role in the approximated policy functions. Following the literature, we define an uncertainty shock a one-standard deviation increase in the level shock's volatility.

4.1 Calibrated parameters

Due to the scale of our model, not all parameters can be parametrized with a moment-matching procedure. Therefore, we partition the parameters into two subsets. A first subset contains parameters which are calibrated on a quarterly basis either based on values commonly used in the literature or by matching empirical targets in the steady-state. They are summarized in Table 2. The subjective discount factor, β, is set to 0.99, implying a steady-state annual real interest rate of approximately 4 percent. When it comes to preferences, the intertemporal elasticity of substitution is set to 1.13 and the Frisch elasticity of labor supply is $1/\left(\omega_w - 1\right) = 4$, a relatively high value in line with the macroeconomic literature, in line with King and Rebelo (1999) among others. The scale parameter υ is chosen to ensure that household's labor in the steady state, ℓ^h, equals to 1/3. Further, the Cobb-Douglas parameter associated with capital, α, is set to 0.36, the depreciation rate is $\delta = 0.02$ and we assume a markup of 10 percent in the intermediate sector ($\theta_p = 11$).

Due to the lack of empirical evidence regarding the portfolio sector, we mostly follow Bernanke et al. (1999). We impose $R^p/R = 1.02^{0.25}$, corresponding to an annual risk spread of 200 basis-points for the portfolio. The deterministic steady state of the model requires that $R^k = R^b = R^p$. In addition, the steady-state portfolio-to-net-worth ratio x, is calibrated to 2, the annual business failure rate is set to $F(\bar{\varepsilon}) = 3\%$, and the idiosyncratic productivity shock, ε_t, is distributed as a log-normal with an unconditional expectation of 1 and a standard deviation σ_ε. Altogether, these targeted moments imply that $\gamma = 0.98$, $\mu = 0.12$, $\sigma_\varepsilon = 0.28$ and $\bar{\varepsilon} = 0.50$. Finally, the entrepreneurial labor-income share is set to 0.01, implying a value of $\Omega = 0.9846$ and the transfers from defaulted investors to households ensures model's stability $(1 - \varrho = 0.999)$.

We now turn to the calibrated values of fiscal policy parameters. Based on our dataset used in Section 2, the steady-state level of public spending to output, g/y, is set to 0.194. In addition, in line with Euro Area data, we assume an average maturity of government bonds of 7 years, *i.e.* $\mathcal{M} = 28$ in our quarterly setup. The parameters of the tax feedback rule are $\phi_b = 3$ and $\phi_y = 0.34$ to ensure equilibrium determinacy. The Taylor rule is calibrated with a high degree of interest rate persistence reflecting the ECB inertia ($\rho_R = 0.95$) and a standard sensitivity to inflation ($\phi_\pi = 1.4$). Finally, we calibrate the public spending shocks in level following the baseline estimates obtained in Table 1 with $\rho_g = 0.98$, $\rho_{gy} = -0.03$ and $\sigma^g = -6.949$.

Table 2. Calibrated parameters

β	Discount factor	0.99
$1/(\omega_w - 1)$	Frisch elasticity related parameter	4
σ	Intertemporal elasticity of substitution	1.13
ℓ^h	Household's labor steady state	0.33
α	Cobb-Douglas parameter for capital	0.36
δ	Capital depreciation rate	0.02
θ_p	Elasticity of substitution of goods	11.00
R^p/R	Steady-state portfolio spread	$1.02^{0.25}$
x	Steady-state ratio of capital to net worth	2
γ	Survival rate of portfolio investors	0.9834
μ	Monitoring cost	0.1175
σ_ε	Standard error of idiosyncratic shock	0.2764
$\bar{\varepsilon}$	Threshold value of idiosyncratic shock	0.4982
Ω	Proportion of household labor in aggr. labor	0.9846
$1 - \varrho$	Transfers from failed investors to households	0.9999
g/y	Share of government expenditure in output	0.194
$\mathcal{M}$	Average maturity of the bond	28
ϕ_b	Tax rule feedback parameter wrt debt	3
ϕ_y	Tax rule feedback parameter wrt output	0.34
ρ_R	Interest rate inertia	0.95
ϕ_π	Taylor rule parameter wrt inflation	1.40
ρ_g	Persistence of the spending share process	0.98
ρ_{gy}	Sensitivity of the spending share to the output gap	-0.03
σ^g	Log of the average variance of the spending share	-6.95

4.2 Estimated parameters

We are left with eight parameters to estimate, namely parameters related to government spending uncertainty shock $\{\rho_{\sigma^g}, \eta_{\sigma^g}, \}$, parameters governing TFP level shocks $\left\{\rho_{\mathcal{Z}}, \sigma^{\mathcal{Z}}\right\}$, the preference parameter driving the wealth effect of labor supply σ_X, the Rotemberg parameter κ_p that governs the extent of price stickiness, the investment adjustment cost parameter $\varkappa$, and the portfolio adjustment cost parameter ϖ. Let us write

$$\psi_i = \left\{\rho_{\sigma^g},\ \eta_{\sigma^g},\ \rho_{\mathcal{Z}},\ \sigma^{\mathcal{Z}},\ \sigma_X,\ \kappa_p,\ \varkappa,\ \varpi\right\}, \tag{33}$$

as the vector of parameters to estimate. We match both (i) conditional moments (IRFs) which provides information regarding the transmission of fiscal uncertainty shocks, and (ii) unconditional moments so as to produce reasonable business cycle moments. Real output, consumption, investment, and inflation are incorporated in the set of empirical variables. We abstract from the response of long-term spread in the VAR model because our model is too stylized to replicate the right magnitude. However, we show in Section 6 (Figure 4) that our model generates a response of this variable to the uncertainty shock of the right sign and not too far in magnitude. We consider both second-order moments of the above variables, as well as their empirical IRF to a government spending uncertainty shock. The vector of empirical IRFs is denoted by $\hat{\Phi}$ and extracted from the SVAR in Figure 2. The set of corresponding model-based IRFs, which we denote as $\Phi^m(\psi_i)$, is computed as the deviation from the *ergodic mean* of each variable after a government spending uncertainty shock. When it comes to the set of business cycle moments, we compute the variance of the variables as well as their covariance with real output, all preliminarily one-sided HP filtered both in the model and in the data. Let $\hat{M}$ denote the vector of empirical unconditional moments to be matched and define $M^m(\psi_i)$ as their model-based counterpart. Notice that the vector $M^m(\psi_i)$ is built by simulating the third-order approximated model, and that both conditional and unconditional moments are used simultaneously in our estimation procedure. Then, the set of estimated parameters $\hat{\psi}_i$ is computed so as to minimize the following Euclidean distance

$$\mathcal{J}(\psi_i) = \underbrace{[\Phi^m(\psi_i) - \hat{\Phi}]'\hat{W}^{\Phi}[\Phi^m(\psi_i) - \hat{\Phi}]}_{MDE} + \Lambda\underbrace{[M^m(\psi_i) - \hat{M}]'\hat{W}^{M}[M^m(\psi_i) - \hat{M}]}_{SMM}, \tag{34}$$

and where $\hat{W}^{\Phi}$ and $\hat{W}^{M}$ are diagonal matrices with the inverse of the asymptotic variances of each element of $\hat{\Phi}$ and $\hat{M}$ respectively along the diagonals. Parameter Λ governs the relative importance of the second-order moments in the $\mathcal{J}$-stat. Prior to the estimation, it is set so that both types of moments account for an equal fraction of the total distance.

5 Estimation results

We now discuss the estimation results and the overall goodness-of-fit of the model.

5.1 Parameter Estimates

We start by analyzing the estimation results of the baseline model, as reported in the first column of Table 3. The magnitude and the persistence of the public uncertainty shock ($\eta_{\sigma^g} = 0.20$ and $\rho_{\sigma^g} = 0.60$, respectively) are estimated to simply reproduce the response of σ_t^g to its own shock (see Figure 3).[13] Parameters related to the TFP shock are identified through the unconditional moments and we obtain $\sigma^{\mathcal{Z}} = 0.002$ and $\rho_{\mathcal{Z}} = 0.86$. The estimation of the remaining parameters provides some insights regarding the transmission channels of public spending uncertainty. It is quite standard in the literature to remove the wealth effect on labor supply, *i.e.* to impose $\sigma_X = 0$, to shut down the precautionary labor supply effect and therefore magnify the response of output to uncertainty shocks (see Basu and Budnick, 2017). We let the data speak regarding the strength of the wealth effect on the labor supply, and obtain $\sigma_X = 0.35$. This suggests that our model is able to generate a recession as large as documented by the SVAR analysis even with a partially active wealth effect on labor supply. We believe it is due to the presence of additional interacting amplification mechanisms, that make the model less dependent on the absence of a wealth effect to amplify the recession. In particular, the joint estimated values of the investment cost parameter $\varkappa = 0.73$ and the portfolio parameter $\varpi = 1.27$ allow our model to match the variance and the response of investment to the fiscal uncertainty shock. While $\varkappa = 0.73$ is lower than usually estimated in New-Keynesian models, our estimation of $\varpi = 1.27$ implies important restrictions in the substitutability between assets (equity and government bonds) for portfolio investors. On top of that, this parameter interacts with the standard financial accelerator mechanism that affect the dynamics of investment to magnify its effects as shown in Section 6.1. Finally, the large estimated value of the Rotemberg parameter $\kappa_p = 587$ confirms that nominal rigidities matter in the transmission of uncertainty shocks (see Basu and Budnick, 2017). Our model is fully non-linear implying that the NKPC under Calvo price setting is not observationally equivalent to the NKPC obtained with Rotemberg adjustment costs. However, abstracting from the second order terms, the estimated value $\kappa_p = 587$ corresponds to an average frequency of price adjustment of two years (eight quarters), lining up well enough with available empirical evidence.

[13] Notice that the estimates of η_{σ^g} and ρ_{σ^g} differ from Section 2 because we use alternative methods. In particular, the mix of SMM and MDE is a multivariate method based on simulations while the simpler method used in Section 2 to estimate these parameters is univariate.

Table 3. Estimation results

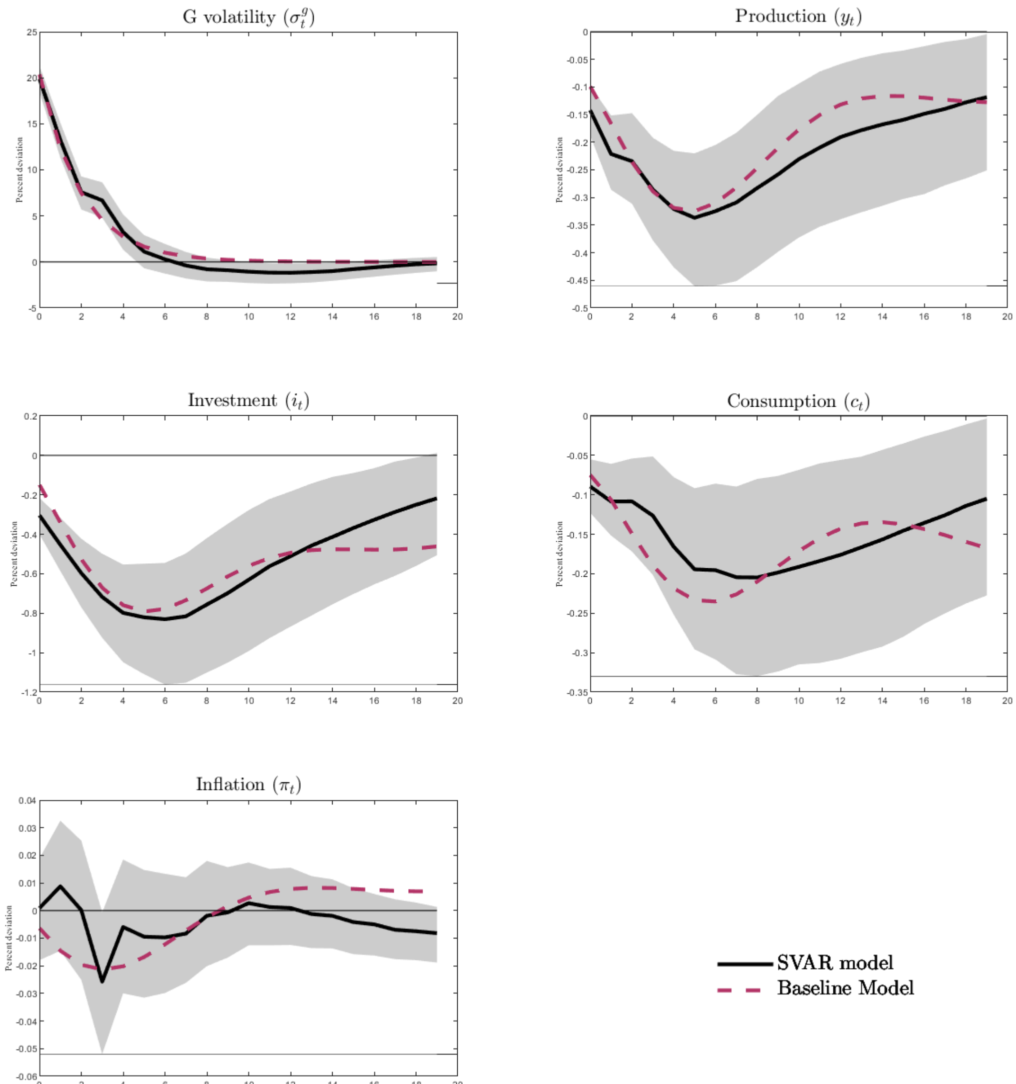
		Baseline	Fin. acc.
η_{σ^g}	Impact effect spending uncertainty shocks	0.20 [0.203, 0.204]	0.20 [0.203,0.204]
ρ_{σ^g}	Persistence of spending uncertainty shocks	0.60 [0.602, 0.609]	0.60 [0.602, 0.609]
$\sigma^{\mathcal{Z}}$	Log of the average variance of (level) TFP shocks	0.002 [0.002, 0.003]	0.004 [0.003, 0.005]
$\rho_{\mathcal{Z}}$	Persistence of (level) TFP shocks	0.86 [0.665, 1.052]	0.97 [0.944, 0.988]
σ_X	Strength of the wealth effect on labor supply	0.35 [0.339, 0.359]	0.43 [0.424, 0.441]
ϖ	Portfolio adjustment cost parameter	1.27 [1.110, 1.434]	–
$\varkappa$	Investment adjustment cost parameter	0.73 [0.706, 0.750]	0.41 [0.399, 0.431]
κ_p	Rotemberg price adjustment parameter	587 [575, 599]	634 [595, 673]

Note: Following Christiano et al. (2005), the standard errors of the estimated parameters are computed using the asymptotic delta function method. The Baseline column corresponds to the estimation of the full model. The Fin. acc. column corresponds to the estimation of a model without portfolio structure.

5.2 Unconditional Moments

The second column of Table 4 shows that the baseline model reproduces observed second-order moments (first column of Table 4) relatively well. In particular, it does a good job in reproducing the volatility of real variables since the simulated variance of output, consumption and investment ($\sigma_y = 1.87$, $\sigma_c = 0.79$ and $\sigma_i = 8.28$) align quite well with their empirical counterparts ($\sigma_y = 1.45$, $\sigma_c = 1.02$ and $\sigma_i = 9.31$). The volatility of inflation is lower in the model $\sigma_\pi = 0.03$ than in the data $\sigma_\pi = 0.08$ reflecting a high degree of nominal rigidities, as shown above. The latter is particularly required to fit the conditional moments of the model, *i.e.* the empirical IRFs to a government spending uncertainty shock. Finally, the theoretical model replicates covariance patterns well: the covariance of output with consumption (1.02 and 0.98 in the data and in the model respectively), of output with investment (3.39 in the data and 3.55 in the model respectively) and of output with inflation (0.12 in the data and 0.17 in the model respectively) are all closely matched.

Figure 3: Empirical and model-implied IRFs to a government spending uncertainty shock.



Note: Red dashed lines are model-implied IRFs; blue dotted lines are empirical IRFs. Grey areas are the 14th and 86th percentiles. Horizontal axes indicate quarters. All responses are in percent.

Table 4. Simulated unconditional moments (×100).

Variance of:		Data	Baseline	Fin. acc.
	y_t	1.45	1.81	1.82
	c_t	1.02	0.79	0.85
	i_t	9.31	8.28	7.88
	π_t	0.08	0.03	0.03
Cov. of y_t with:				
	c_t	1.02	0.98	1.06
	i_t	3.39	3.55	3.35
	π_t	0.12	0.17	0.18

Note: All moments are computed from one-sided HP filtered data. The Baseline column corresponds to the estimation of the full model. The Fin. acc. column corresponds to the estimation of a model without portfolio structure.

5.3 Transmission Channels of Fiscal Uncertainty Shocks

Figure 3 displays the SVAR-based (solid lines) as well as the model-based IRFs (dashed lines) of key variables to the government spending uncertainty shock. Overall, the model generates theoretical responses that are large enough to match their empirical counterparts, and all variables exhibit hump-shaped responses, as in the data. In particular, the model generates the negative effect of the government spending uncertainty shock on real output as well as consumption and investment. Also, higher government spending uncertainty looks like a demand shock as it generates a recession along with a drop in inflation.

One explanation of the satisfying goodness-of-fit of the model is the high estimated degree of price stickiness ($\kappa_p = 587$), which gives rise to the demand channel of the propagation of uncertainty. Indeed, firms decrease their demand for production inputs in response to the lower demand implied by the shock. The marginal product of capital falls, which leads to a fall in aggregate investment. If capital is predetermined, labor is the only input to production that can change. As prices adjust slowly, firms' markups do not fall as much as marginal costs. The wedge between marginal costs and markups thus increases.

From the perspective of the representative household, the real wage drops and this income risk increases precautionary savings, leading consumption to decrease and savings (deposits) to rise. On the one hand, the fall in the real wage pushes labor supply down and the reduction in consumption boosts labor supply through the wealth effect. Hence, depending on the strength of the latter, the recession can be larger or smaller, as already highlighted by Basu and Budnick (2017). Given the form of our utility function, the wealth effect is maximal in the case of King et al. (1988) household preferences ($\sigma_X = 1$), which would then offset the drop in labor demand and mitigate the recession. Our estimate for $\sigma_X = 0.35$ rather suggests a quite weak wealth effect on labor supply, which implies a large reduction in labor and ultimately drives output down.

Further, Fernandez-Villaverde et al. (2011) argue that uncertainty shocks generate a rise in inflation because the "upward pricing bias channel" (which pushes firms to set prices too high compared to their competitors) dominates the precautionary saving channel which generates a reduction in aggregate demand.[14] Our model imbeds additional transmission mechanisms – interacting financial frictions – and offers estimated parameters that allow us to replicate the observed fall in inflation, consistently with the view that government spending uncertainty shocks look like a negative demand shock. In addition, the drop in inflation leads the central bank to lower its risk-free rate.[15]

The above analysis suggests that the recession induced by the government spending uncertainty shock can be explained by the precautionary saving motive combined with price stickiness, which has been already identified in the literature (see Basu and Budnick, 2017 for instance).[16] On top of that, in line with Cesa-Bianchi and Fernandez-Corugedo (2017), the effects of a government spending uncertainty shock are amplified by the presence of financial frictions. However, these three channels (precautionary savings, price stickiness and financial frictions) are not enough to provide the explanation for the recession caused by the government spending uncertainty shock. We complement previous results in the next section, and argue that the portfolio channel acts as an important additional transmission channel of the government spending uncertainty shock.

[14]The "upward pricing bias channel" results from the presence of sticky prices. As the profit function is asymmetric, firms have incentive to set prices too high, rather than too low, in order to prevent themselves against any price adjustment they would need to make in the future. This channel drives inflation upward and leads to the counter-intuitive result that uncertainty shocks behave like supply shocks.

[15]As show in the online Appendix on Figure 3, a SVAR that includes the risk-free rate point to a reduction of the latter in the medium run after a government spending uncertainty shock, as predicted by our model.

[16]Section 3 in the online appendix provides a complete sensitivity analysis with respect to parameters that affect the strength of these transmission channels: the Frisch elasticity of labor supply, the strength of the wealth effect on labor supply, the response of the central bank to inflation, the use of Calvo contracts instead of Rotemberg adjustment costs, the degree of price stickiness and the use of capital adjustment cost. In Section 3.7, we provide a model extension by introducing distortionary labor tax. Unsurprisingly, having stabilizing taxes helps attenuate the fall in the value of portfolio and output (Figure 12 of the online appendix).

6 A Closer Look at the Portfolio Channel

One originality of our model is that financial frictions distort the allocation of *both* firms' equity – capital – and public bonds and both assets are imperfect substitutes, due to the portfolio adjustment cost. In this section, we highlight the role of these features on the transmission channels of fiscal uncertainty shocks.

6.1 Dissecting the Portfolio Channel

In this paper, we argue that linking equity and public bonds in the frictional financial market generates an additional amplification mechanism of government spending uncertainty shocks. To illustrate this point, we focus on the dynamics of equity – capital – and link them to the traditional financial accelerator model. Consider Equations (13), (15) and (16), that respectively give the dynamics of the portfolio risk premium, R^p_{t+1}/R_t, as well as their tie to the bond and capital returns, R^b_{t+1} and R^k_{t+1}. Combining these equations and abstracting from (higher order) non-linear terms to highlight the main intuitions, we obtain the following expression of the portfolio risk premium

$$\mathrm{E}_t\{\hat{R}^p_{t+1}\} - \hat{R}_t = \mathrm{E}_t\{\hat{R}^k_{t+1}\} - \hat{R}_t + (\chi + \vartheta)\,\hat{\omega}_t, \tag{35}$$

where hatted variables denote log-deviations from the steady state, and where

$$\mathrm{E}_t\{\hat{R}^k_{t+1}\} - \hat{R}_t = \chi\left(\hat{q}_t + \hat{k}_t - \hat{n}_t\right) + \vartheta\hat{\omega}_t, \tag{36}$$

with $\hat{\omega}_t = (1-\omega)\left[(\hat{q}_t + \hat{k}_t) - (\hat{q}^c_t + \hat{b}_t)\right]$, χ the elasticity of the risk premium (R^p_{t+1}/R_t) to the leverage ratio and $\vartheta \equiv \varpi\beta/\check{r}\omega\,(1-\omega) - \chi > 0$ the elasticity of the equity risk premium to $\hat{\omega}_t$.[17] Notice that $\hat{\omega}_t$, the share of equity in the portfolio, can be expressed as the difference between the value of capital ($\hat{q}_t + \hat{k}_t$) and value of sovereign debt ($\hat{q}^c_t + \hat{b}_t$).

The typical financial accelerator model is nested by Equations (35) and (36). Indeed, if public bonds are removed from the portfolio ($\omega = 1$), then $\hat{\omega}_t = 0$, such that the two last terms in Equations (35) and (36) disappear. In that case, the portfolio premium simply equals the equity risk premium $(\hat{R}^p_t - \hat{R}_t) = (\hat{R}^k_t - \hat{R}_t)$ and Equation (36) corresponds to the typical expression for the equity risk premium

$$\mathrm{E}_t\{\hat{R}^k_{t+1}\} - \hat{R}_t = \chi(\hat{q}_t + \hat{k}_t - \hat{n}_t). \tag{37}$$

[17] Details of the computations are provided in Section 1.8 of the online Appendix. According to our calibration, $\chi = 0.04$, $\varpi = 1.27$, $\beta = 0.99$. Further $\check{r} > 0$ and $\omega > 0$, which implies $\vartheta > 0$.

Consequently, simplifying the portfolio structure implies that the equity risk premium increases with the leverage ratio, the elasticity being given by χ, as in Bernanke et al. (1999).

Including public bonds into the portfolio (ω_t endogenous) adds a new transmission channel to the financial accelerator mechanism that we call the portfolio channel, characterized by the relationship between between the portfolio risk premium and $\hat{\omega}_t$ in Equations (35) and (36). The intuition of the portfolio channel is based on the fact that, if an asset features a higher return, the portfolio investor shifts the composition towards this asset, which in turn makes his portfolio more profitable but also riskier (see Equations (15) and (16)). In addition, Equations (20) and (21) show that the returns of assets are negatively related to their prices. Therefore, considering a shock that lowers the price of equity relative to the price of public bonds, equity becomes relatively more valuable than bonds as its relative return increases. Said differently, $(\hat{q}_t + \hat{k}_t)$ falls less than $(\hat{q}_t^c + \hat{b}_t)$, which expands the equity share in the portfolio $\hat{\omega}_t$. This portfolio rebalancing towards the riskier asset – *i.e.* equity – makes the portfolio more likely to default, which therefore increases the portfolio risk premium. This is what we call the "portfolio channel".

Further, the portfolio channel is illustrated in Equations (35) and (36) through two effects. First, the last term in Equation (35) means that a portfolio rebalancing behavior towards equity (because it features a higher relative return) makes the portfolio riskier. Indeed, $(\chi + \vartheta) > 0$ in our calibration. Second, the portfolio risk premium also increases through the rise in the equity risk premium (see Equation (36)). Further, the strength of the portfolio channel depends on the size of the portfolio adjustment cost, ϖ. As discussed in Section 3.2, when the two assets are perfectly substitutable ($\varpi = 0$), the composition of the portfolio does not matter, and the portfolio channel only works through the direct effect in Equation (35), which almost mutes the channel. On the contrary, when bonds and equity are not fully substitutable ($\varpi > 0$), the portfolio channel is active since $\vartheta > 0$, exacerbating the effects of potential shocks through an amplification of the portfolio risk premium. We will further analyze these two cases in the following section.

6.2 Impulse Response Functions Analysis

In this section we highlight the respective quantitative roles of the portfolio channel and of the portfolio adjustment cost. To do this, we report and analyze the theoretical IRFs under two different specifications: one that completely shuts down the portfolio channel by abstracting from public bonds in the portfolio ($\omega_t = 1$), and one in which we consider alternative degrees of substitutability between the two assets by varying the portfolio adjustment cost ϖ.

Shutting down the Portfolio Channel Figure 4 complements Figure 3 and displays model-based IRFs to a one standard deviation increase in public spending uncertainty shock, $\varepsilon_t^{\sigma^g}$. The solid lines correspond to the baseline model. The dashed lines depict the IRFs of the typical financial accelerator model (FA model) that abstracts from public bonds in the portfolio ($\omega_t = 1$, *i.e.* $\mathcal{P}_t = Q_t k_t$). In that case, the portfolio premium is given by Equation (37), and government bonds are bought directly by the representative household.

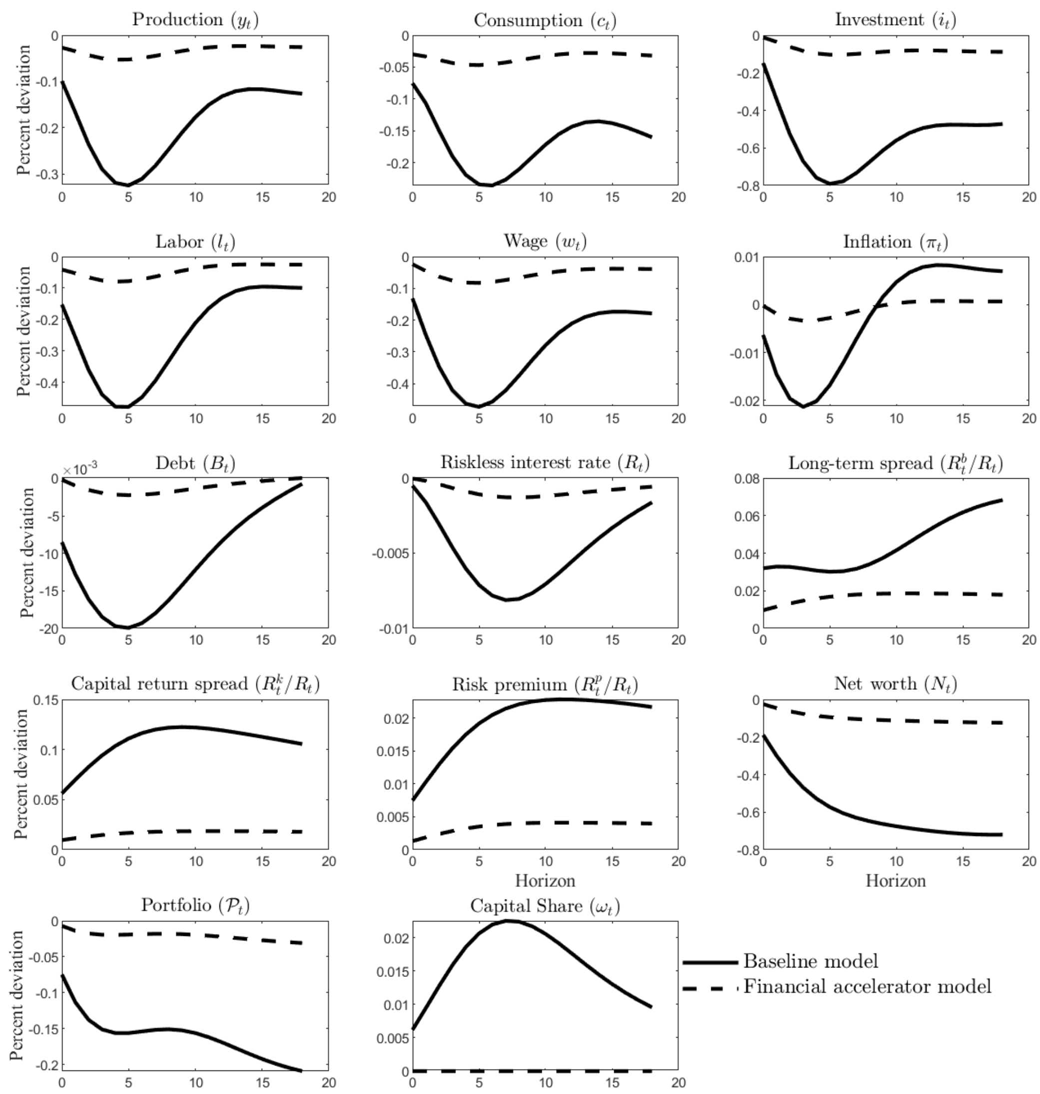
One striking result is that extending financial frictions to public bonds substantially amplifies the reduction in investment in response to government spending uncertainty shocks. The recession generated by higher uncertainty (as explained above) leads to a reduction in net worth through a deterioration of portfolios' balance sheet. Also, notice that the Fisher effect plays an additional driver of balance sheet deterioration. Indeed, as financial contracts are written in nominal terms, the reduction in inflation increases the value of debt hold by portfolio investors which generates an additional reduction in investment (see Fernandez-Villaverde et al., 2011).[18] In the typical FA model that abstracts from public bonds, the reduction in net worth is only driven by the drop in capital demand and a subsequent reduction in the price of capital. Enriching the model with a portfolio structure of both equity and public bonds leads to a reduction in the price of both assets because of the balance sheet deterioration. The portfolio channel then is at work to amplify the effects of financial frictions. Indeed, remember that the level of public spending, g_t, is defined as $g_t = \tilde{g}_t \times y_t$. Therefore, a rise in the uncertainty of public spending, σ_t^g, increases the share of public spending on output ($\tilde{g}_t$) but this effect is not large enough to compensate the effect of the recession (y_t) on the dynamics of g_t. As a result, it turns out that public spending (g_t) is *pro-cyclical* conditional on a government spending uncertainty shock.[19] The cut in public spending in turn lowers the issuance of public bonds, which reduces their price by less than the price of private capital. Consequently, the return of capital falls less than the return of bonds, leading portfolio investors to rebalance portfolios towards equity. The share of capital $\hat{\omega}_t$ increases, which in turn magnifies the financial accelerator mechanism, as shown by Equations (35)-(36) above.[20] The combination of a rising risk premium on the portfolio $E_t \left\{ R_{t+1}^p / R_t \right\}$ – portfolio investors are more likely to default – and fall in net worth

[18]As we show in Figure 9 in the online appendix, this effect is magnified when the coefficient attached to inflation in the Taylor rule is low as inflation reacts more to the uncertainty shock.

[19]In Figure 3 in the online Appendix, we confirm this intuition by running a SVAR expanded with a series of public expenditure: in line with our model's predictions, public spending *in level* decreases in response to higher fiscal uncertainty.

[20]In the online Appendix, we build a measure of the share of capital in the portfolio based on public debt and private equity using the aggregate balance sheet of non-financial institution available from the ECB. We show that the capital share also increases in response to higher public spending uncertainty in the data (see Figure 5 of the online Appendix).

Figure 4: IRFs to a government spending uncertainty shock.



Note: IRFs to a government spending uncertainty shock. The solid lines correspond to the baseline model. The dashed lines correspond to the typical financial accelerator model. Horizontal axes indicate quarters. All responses are in percent.

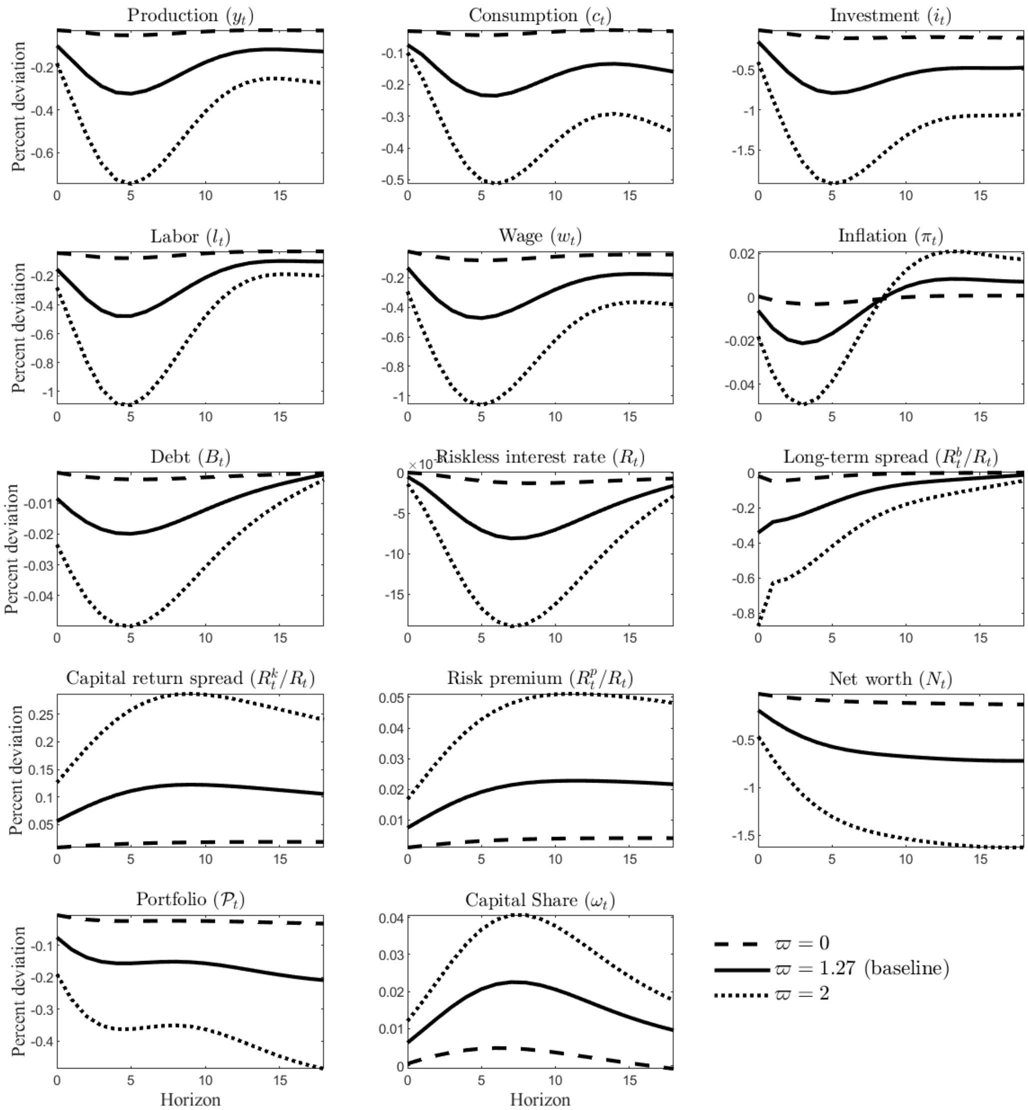
(and portfolio size) are thus observed and typical in FA models, but both are substantially amplified in a setup in which financial frictions apply to a portfolio combining public and private assets.

Imperfect asset substitutability The above discussion highlights the importance of the portfolio channel in the transmission of a public spending uncertainty shock. We now investigate the strength of the portfolio channel by looking at the responses of the macroeconomic variables under different values of the portfolio adjustment cost ϖ. Figure 5 displays the IRFs in the baseline model for our benchmark parametrization ($\varpi = 1.27$, solid line), when the portfolio adjustment channel is shut down ($\varpi = 0$, dashed line) and when this channel is made stronger than estimated in the data ($\varpi = 2$, dotted line).

Figure 5 confirms that the strength of the portfolio channel depends on the size of the portfolio adjustment cost, which in turn critically affects the transmission channels of the uncertainty shock to investment and on output. Abstracting from portfolio adjustment costs ($\varpi = 0$) implies that capital assets and public bonds are perfect substitutes. Hence, both assets provide the same expected returns because of no-arbitrage in this case (see Equation (16)). As such, risk diversification is perfect and private and public spreads only rise because the recession implies a higher external risk premium, materializing the higher probability of default of portfolio investors. Notice that the model with $\varpi = 0$ generates responses that are almost identical to those of the typical FA model displayed in Figure 4. However, as seen in Equation (36), imposing $\varpi = 0$ does not completely shut down the portfolio channel as the term $\vartheta\hat{\omega}_t$ (which is negligible due to our calibration of ϑ) does not disappear. Said differently, having both public bonds and capital assets in a portfolio that is subject to financial frictions is not enough to generate a full amplification mechanism, but instead requires positive portfolio adjustment costs $\varpi > 0$.

To understand the role played by these costs, we now consider the IRFs in the baseline model ($\varpi = 1.27$) and with larger adjustment costs $\varpi = 2$. Larger adjustment costs both amplify the rise in the spread of each asset, and increase the difference in expected returns between assets. The portfolio rebalancing toward private capital is thus much larger, amplifying the rise in the external risk premium $\mathrm{E}_t \left\{ R^p_{t+1}/R_t \right\}$ – consistent with Equations (35)-(36). As a result, the size of the recession is much larger because the portfolio transmission channel is stronger, but also because this channel interacts with all the other transmission channels of the model (nominal rigidities, precautionary savings, labor supply).

Figure 5: IRFs to a government spending uncertainty shock for alternative values of the portfolio adjustment cost.



Note: The solid line always depicts the response under the benchmark parametrization. Horizontal axes indicate quarters. All responses are in percent.

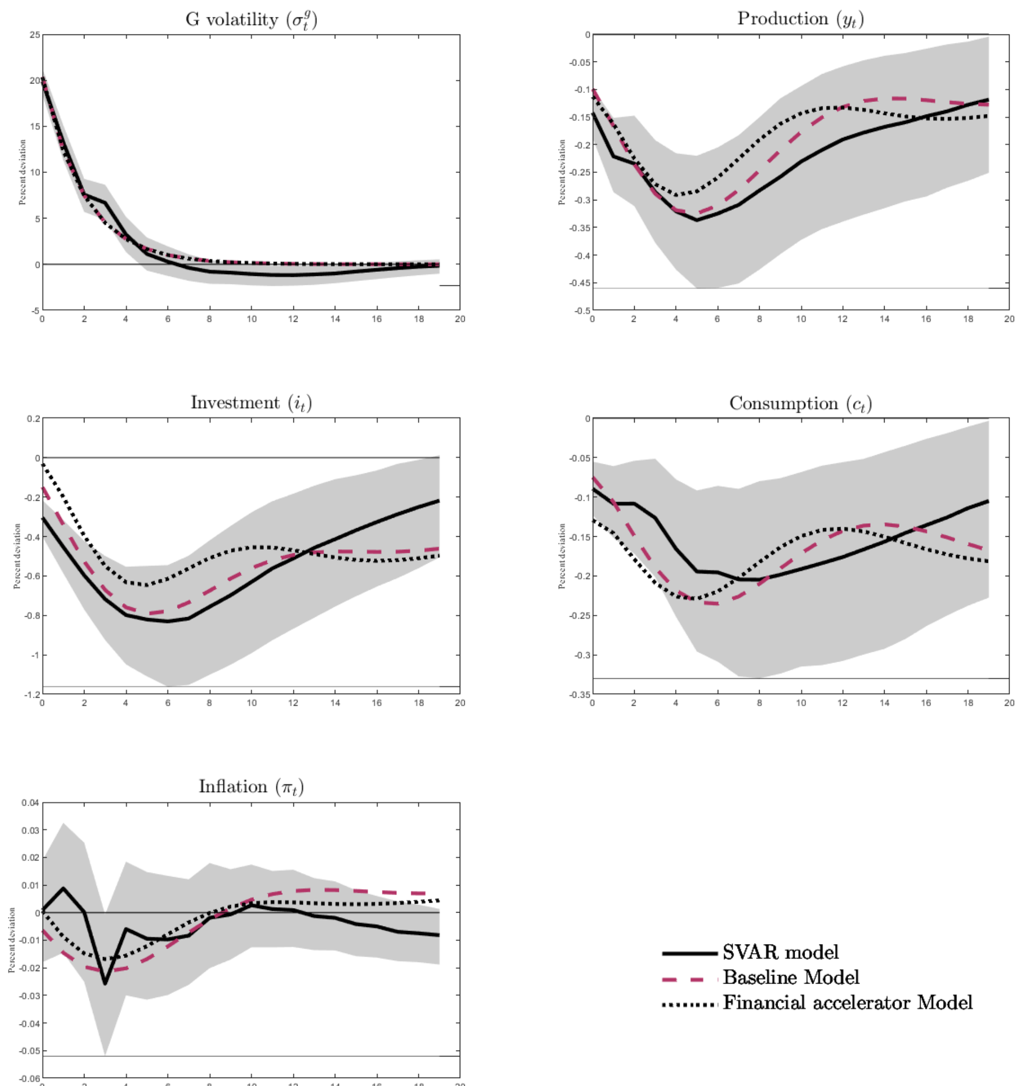
6.3 Estimating a Model without Portfolio

In the previous analysis, we conduct counterfactual exercises and compare the transmission channels of fiscal uncertainty shocks in models with a portfolio structure ($\omega_t < 1$) and without it ($\omega_t = 1$). However, we shut down the portfolio channel *for a given set* of estimated or calibrated parameters. We now estimate the typical FA model – without any portfolio structure – using the exact same set of empirical IRFs and unconditional moments, to get a sense of how well a plain vanilla FA model does in matching them. This specification of the FA model is the one where only private capital enters in the composition of the "portfolio" of investors, while public bonds are held directly by the representative household ($\omega_t = 1$, *i.e.* $\mathcal{P}_t = Q_t k_t$). As shown by Equation (37), the portfolio adjustment parameter is irrelevant in this case.

The second column of Table 3 reports the estimated parameters for the typical FA model, where financial frictions pertain to capital only. Comparing with the estimates obtained from the baseline model, the magnitude and persistence of the public uncertainty shock are basically the same. The FA model copes with the identification of unconditional moments by imposing substantially more volatile and persistent TFP level shocks. Regarding the matching of IRFs after a government spending uncertainty shock, the FA model tries to replicate them with a mix of larger Rotemberg price adjustment costs ($\kappa_p = 634$ in the FA model against $\kappa_p = 587$ in the baseline) to magnify the transmission mechanism going through nominal rigidities, lower investment costs ($\varkappa = 0.41$ against $\varkappa = 0.73$) to obtain a large response of investment, and a larger wealth effect on labor supply ($\sigma_X = 0.43$ against $\sigma_X = 0.35$), to mitigate the effects of the above parameters on inflation dynamics. These parameter estimates suggest that the FA model relies more on alternative transmission mechanisms other than financial frictions to match the IRFs. Table 4 also reports the unconditional moments deriving from the estimated parameters of the FA model, and suggests that the fit is not too bad along this dimension, maybe except for the volatility of investment. Finally, Figure 6 shows the match of IRFs to a government spending uncertainty shock when the a model without the portfolio structure is estimated (dotted lines). For the sake of comparison, it also reports the IRFs from the benchmark model (dashed lines), as in Figure 3.

Figure 6 shows that the fit of the empirical IRFs is better for the baseline model (see Figure 3) than for the FA model. In particular, even though the response of output is only marginally better matched in the baseline model, the estimated FA model undershoots the response of aggregate investment – especially on impact – and overshoots the response of aggregate consumption – especially on impact. It is worth noticing that the estimated standard New

Figure 6: Empirical and model-implied IRFs to a government spending uncertainty shock in a financial accelerator model without any portfolio structure.



Note: Red dashed lines are model-implied IRFs; blue dotted lines are empirical IRFs. Grey areas are the 14th and 86th percentiles. Horizontal axes indicate quarters. All responses are in percent.

Keynesian model (without financial frictions) fails to replicate the empirical IRFs.[21] This result confirms that the financial accelerator mechanism is essential for generating the realistic drop in investment and more generally a better match of key variables in response to higher uncertainty. However, the portfolio channel plays an crucial role in the transmission of public spending uncertainty shocks as it magnifies the effectiveness of financial frictions, which in turn results in a better fit with the data.

7 Conclusion

In this paper we showed that government spending uncertainty depresses the economy, lowering output, investment and consumption. Public spending uncertainty shocks act as negative demand shocks, lower inflation and induce a fall in the short-term interest rate. On the empirical side, these results were obtained by extracting a series of time-varying uncertainty from the government spending to GDP ratio of the Euro Area, and by putting it in a structural VAR of the Euro Area. Our results were robust to various alternative specifications (lags, variables, ordering of the uncertainty measure). On the theoretical side, we matched these contractionary effects using a New-Keynesian model where financial frictions apply to a portfolio of equity and public bonds, where both assets are imperfect substitutes. We showed the critical importance of the portfolio channel and its interactions with the other traditional transmission channels of uncertainty shocks (nominal rigidities, precautionary savings, labor supply) in accounting for the effects of government spending uncertainty. In particular, a typical financial accelerator model that abstracts from government bonds in the portfolio of investors, whether calibrated or estimated, was shown to be outperformed by our baseline model.

[21]Results for the estimation of the simple New Keynesian model are available upon request as the model fails to replicate the data.

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