Firms Dynamics and Business Cycle Effects of Policy Uncertainty Shocks

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Abstract

This paper provides evidence on firm dynamics in response to policy uncertainty shocks. Using the EPU and the MPU indices as measures of policy uncertainty and sectoral data on establishment births and deaths, it shows that the estimated conditional correlations of firms' entry and exit are negative for policy uncertainty shocks. In particular, decreasing firms' exit counteracts the negative effect of policy uncertainty on economic activity and contributes to speed the recovery. These results hold for the majority of the US industries. It emerges that while non-policy uncertainty shocks play a major role in explaining business cycle movements, the contribution of policy uncertainty is minor, in line with Born and Pfeiffer (2014). The paper claims that firms' exit can explain part of this minor role. To address the empirical evidence, the paper studies a DSGE model with heterogeneous firms and endogenous firm dynamics. It shows that the interaction between firms dynamics and financial markets is key to replicate the results found in the BVAR analysis.

KEYWORDS: firm dynamics, sectoral establishments births and deaths, banks, policy uncertainty shock, EPU, MPU, BVAR.

JEL codes: E32; E44; E52; E58

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1 Introduction

The contribution of this paper is twofold. First, it contributes to the literature of uncertainty shocks by showing that policy and non-policy uncertainty shocks imply different responses of firms' dynamics and consequently, different macroeconomic effects. Second, this paper contributes to the literature of firms dynamics building a New-Keynesian Dynamic Stochastic General Equilibrium model - henceforth, NK-DSGE model - with endogenous firms dynamics and inefficient banks by showing that the dynamics of firms interacting with imperfect financial markets is key to replicate the evidence found in the empirical analysis of the paper.

The first part of the paper follows the literature on uncertainty shocks and estimates a vector autoregressive (VAR) model through Bayesian techniques.[3] Several measures of uncertainty are considered. Together with proxies of uncertainty generally used to measure the volatility in the financial markets as the VXO index, and the volatility at the macroeconomic level as the Macroeconomic Uncertainty (MACRO) index by Jurado et al. (2015), proxies of policy-specific uncertainty as the Economic Policy Uncertainty (EPU) index and the Monetary Policy Uncertainty (MPU) index provided by Baker et al. (2016), are considered. A bunch of VAR specifications is estimated using both aggregate data and sectoral data on US establishments births and deaths. Looking at the impulse responses to policy related uncertainty shocks, the evidence suggests that, though they imply a relatively stronger fall of the Fed-fund rate and of the loan rate, the response of output is only mildly recessionary. Both births and deaths of establishments are decreasing in response to policy uncertainty shocks, thus being procyclical conditional to this shock. The negative response of firms' exit is particularly robust to the alternative VAR specifications we consider. First, it is robust to both EPU and MPU index. Second, and most importantly, this evidence is true not only at the aggregate level, but also for the majority of the US industry sectors considered. The response of firms' exit changes, when we investigate the dynamics to an increase of economic uncertainty in the same VAR specifications, but using non-policy uncertainty indicators, as the VXO index and the MACRO index. Remarkably, for all the sectors considered, establishments' death turns always increasing in response to a positive shock to non-policy uncertainty and the recession that follows

[3] Bloom (2009), Castelnuovo et al (2015), Leduc and Liu (2016) and Fernandez-Villaverde (2011) among many others.

is stronger and more prolonged than what implied by policy uncertainty shock. Further, conditional correlations to non-policy uncertainty shocks of establishments births and deaths with the real GDP growth are in line with the unconditional ones. This supports the preeminence of the non-policy uncertainty shocks with respect to the policy-uncertainty shocks as drivers of the business cycle fluctuations. This paper claims that one of the possible explanation of the minor role played by the policy uncertainty lies in the response of firm dynamics, and more specifically in the response of firms exit.

To corroborate the empirical analysis, the second part of the paper considers a NK-DSGE model characterized by firms' heterogeneity, firms' dynamics with endogenous entry and exit, and imperfect banking sector. Firms are heterogenous in terms of their specific productivity, so that firms' average productivity is endogenous in the model. Incumbent firms borrow from an inefficient banking sector. In particular, banks compete under monopolistic competition and cannot insure against the risk of firms' default. They can incur in balance-sheet losses every time a firm exits the market without repaying the loan. To preserve the profits banks endogenously increase the loan rate as the probability of firms default increases, making banks markups endogenous and countercyclical. Firms' entry and exit is modeled as in Rossi (2019). Firms decide to produce as long as their specific productivity is above a cut-off level, which is determined by the level of productivity that makes their profits equal to zero. Exiting firms do not repay their loan to banks. Under this framework, the paper studies the model response to policy and non-policy uncertainty shocks, which are represented by an increase to the volatility of the monetary policy shock in the former case, and an increase to the volatility of the aggregate total factor productivity and to the volatility of a preference shock in the latter case. The main results of the theoretical model can be summarized as follows. First, both policy and non-policy uncertainty shocks are recessionary, however the recession is more severe in response to non-policy uncertainty shocks. Second, in line with the VAR analysis, both policy and non-policy uncertainty shocks are followed by a decline in business creation, whereas the firm destruction only increases in response to the policy uncertainty shocks and decreases in response to the non-policy uncertainty shocks. Third, the higher firm default that follows a non-policy uncertainty shocks translates into an increase of the loan rate. Overall, whereas the lower firm exit ameliorates the implied recession in the case of policy-uncertainty shocks, the higher firm exit implies a stronger and more prolonged recession in response to non-policy uncertainty shocks. A key contribution in explaining the more severe recession comes from the financial intermediaries, that being inefficient cannot completely ensure against the risk of firm default and therefore, raise the loan rate once the firm exit increases. The interaction between firms dynamics and financial markets is therefore crucial to replicate the results found in the VAR analysis.

This paper is closely related to two strands of the literature. The literature on economic uncertainty and that of firms dynamics. Drawing on the availability of the measures of EPU, a growing research literature focuses on the consequences of policy uncertainty. At the macro level, prior studies find that policy uncertainty influences capital flows, the business cycle, and the speed of economic recovery (Bloom et al., 2012; Baker et al., 2016; Julio & Yook, 2016). Recently, Born and Pfeiffer (2014) claim that policy risk is unlikely to play a major role in business cycle fluctuations. In their work, they consider an estimated DSGE model in which output effects to policy uncertainty shocks are relatively small because these shocks are too small and not sufficiently amplified. With respect to them, this paper claims that firms dynamics can contribute to reduce the effects of policy uncertainty shocks on output. To the best of our knowledge none of the previous papers analyze the effects of policy and non-policy uncertainty on firms dynamics and their implications for the business cycle, particularly at industry level.

The impact of firm dynamics on business cycle has been studied in many papers. The seminal paper of Bilbiie, Ghironi and Melitz (2012) shows that endogenous entry generates a new and potentially important endogenous propagation mechanism for real business cycle models. In this respect, Etro and Colciago (2010) study a DSGE model with endogenous good market structure under Bertrand and Cournot competition and show that their model improves the ability of a flexible price model in matching impulse response functions and second moments for US data. Colciago and Rossi (2015) extend this model accounting for search and matching frictions in the labor market. Among others, Lewis and Poilly (2012), Jaimovich and Floetotto (2008), also provide evidence that the number of producers varies over the business cycle and that firms dynamics may play an important role in explaining business cycle statistics. Closer to our paper are Totzek (2009), Cesares and Poutineau (2014) and Hamano and Zanetti (2015), which however use different timing and a different exit condition. Moreover, they consider efficient financial markets and do not study the effects of an uncertainty shock. The theoretical framework of this paper is strongly related to Rossi (2019), who however studies the effects of first moment shocks to the productivity level. Instead, this paper investigates the effects of second moments shocks that, as many works have recently highlighted,[4] have played a relevant role in the Great Recession of 2008-2009 in worsening the recession and slowing the recovery. Brand et al (2018) sing study the effects of a technology uncertainty shock in a model with search and monitoring costs in the credit market and endogenous firm decisions on entry and exit. They estimate their structural model through Bayesian techniques and show that uncertainty in productivity turns out to be a major driver to both macro-financial aggregates and firm dynamics. This paper shares some results with Brand et al (2018), though their framework to model financial markets and firms dynamics is completely different. To the best of our knowledge this paper is moreover the first to investigate the differences between policy and non-policy uncertainty shocks focusing on the relationship with firm dynamics.

The remainder of the paper is organized as follows. Section 2 provides the empirical evidence by reporting the dynamic responses to different proxies of policy and non-policy uncertainty at aggregate and sectoral level. Section 3 spells out the model economy, while Section 4 contains the main results of the model. Technical details and robustness checks are left in the Technical Appendix.

2 Empirical Evidence on Uncertainty Shocks

To provide evidence on the relevance of uncertainty shocks, we estimate a VAR model with Bayesian techniques on US data. We show the impulse responses to orthogonalized shocks to four measures of uncertainty. Whereas two of them are indices measuring policy uncertainty, the other two aim to quantify a broader kind of uncertainty in the economy, which is not necessarily related to policy issues.

In details, non-policy uncertainty measures are i) the CBOE S&P 100 Volatility Index (VXO) and ii) the Macroeconomic Uncertainty index (MACRO) built by Jurado et al (2015). The policy uncertainty series are measured by

[4] See for example, Bloom (2009 and 2014), Bloom et al (2012), Born and Pfeiffer (2014), Leduc and Liu (2016), Fernandez and Villaverde (2011 and 2015) and Castelnuovo et al (2014), among others.

i) the Economic Policy Uncertainty index (EPU) and ii) the Monetary Policy Uncertainty index (MPU), both built by Baker et al (2016).[5] Given the sample size of the series of establishment births and deaths we use,[6] we consider the time interval 1993Q3-2016Q3 for our estimates. Against the short sample background we choose to estimate the model with Bayesian techniques, this avoids sampling errors in estimating error bands for the impulse responses that may occur when estimating a highly over parameterized model (see Sims and Zha, 1998). The reduced-form of the VAR model we estimate is given by,

$$Y_t = B_0 + B_1 Y_{t-1} + ... + B_p Y_{t-p} + \varepsilon_t = X_t' \theta_t + \varepsilon_t \ , \tag{1}$$

for $t = 1, ..., T$. Y_t is a $n \times 1$ vector containing the endogenous variables. $X_t' \equiv I_n \otimes [1, Y_{t-1}', ..., Y_{t-p}']$ is a matrix collecting the first p lags of Y_t. $\theta_t \equiv vec\left(B_{0,t}, B_{1,t}, ..., B_{p,t}\right)$ is a vector stacking the $n \times 1$ vector B_0 and the $n \times n$ matrices $B_{s,t}$, with $s = 1, ..., p$; ε_t is a $n \times 1$ vector of reduced-form residuals, which are assumed independent and identical distributed, as $\varepsilon_t \sim N\left(0_{n\times 1}, \Omega\right)$, with Ω the positive definitive variance-covariance matrix. We consider $n = 7$ endogenous variables, namely uncertainty measure, confidence index, inflation, real GDP, real profits, establishment births, establishment deaths, federal fund rate. The frequency of the data is quarterly and, as standard in the related literature, the autoregressive order is set to 4, i.e. $p = 4$, but the results are robust to lower orders. For the prior distribution of the parameters we chose Minnesota priors and set to 0.8 the autoregressive coefficient of the first lag. The identification of the structural shocks of the VAR model is achieved through short-run restrictions. Equivalently, following Leduc and Liu (2016) among many others,[7] we choose the lower triangular Cholesky factorization of with Ω as identification strategy. By ordering the uncertainty measure as first in our VAR specification, we assume the uncertainty measure as the most exogenous variable such that

[5]The uncertainty indices are downloaded respectively, from FRED database for VXO index (https://fred.stlouisfed.org/series/VXOCLS), from Sydney C. Ludvigson's webpage (https://www.sydneyludvigson.com/data-and-appendixes) for MACRO index, from http://www.policyuncertainty.com/ for EPU and MPU index. The series used in the estimates are demeaned and normalized by the standard deviation.

[6]The data of establishment births and deaths both at aggregate and industry data are retrieved from the Business Employment Dynamics database provided by the Bereau of Labor Statistics (https://www.bls.gov/bdm/). The data we consider are quarterly and seasonally adjusted.

[7]This ordering has been largerly used in the literature (see for example., Bloom, 2009).

on impact, the structural shock to the uncertainty measure affect itself and the other variables, while structural shocks to the other variables do not affect the uncertainty measure. The uncertainty measure is affected by the other structural shocks starting from one-period lag. The rest of the ordering of endogenous variables can be explained as follows. We assume the confidence index as the most exogenous variable after the uncertainty. Confidence responds on impact to shocks that hit itself and uncertainty, but with one-period lag to others. With inflation and real GDP we control for two variables leading the nominal and real dynamics of the economy. We ordered profits before respectively, firms' birth and firm's exit, to follow our theoretical framework. In the DSGE model indeed, firm's decision about entry the market depends on the average profits it expects to gain. Similarly, the exit directly depends on profits, but the timing assumption of the model implies that entry decisions anticipates the one of exiting the market. Lastly, we considered the policy rate that reacts on impact to all structural shocks, while its shocks affect the other variables with one-period lag. In addition to the uncertainty measures listed above, the rest of the quarterly data is retrieved from the FRED database for series on consumer sentiment, inflation, GDP, profits and interest rate, and from the Business Employment Dynamics database by the Bureau of Labor Statistics for the series on establishments' births and deaths. Specifically, we take the Consumer Sentiment index by the University of Michigan (UMCSENT), the annualized rate of growth of the GDP deflator (GDPDEF), the logarithm of the real GDP in annual terms (GDPC1), the logarithm of the ratio between corporate profits after tax in annual terms (CP) and GDP deflator, the logarithm of the private sector establishment births and deaths, the minimum among the federal fund effective rate (FEDFUNDS) and the shadow rate by Wu and Xia (2016).[8]

[8] Data on inflation, GDP, profits, establishment births and deaths are seasonally adjusted. Benchmark VAR specification includes a constant and linear trend.

2.1 Evidence using Aggregate Data

Figure 1 shows the impulse responses to the four different proxies of the sources of policy and non-policy uncertainty shocks. The normalized median responses of the endogenous variables to one-standard-deviation increase in the innovations to uncertainty measures are depicted by solid lines, while shaded areas represent 68 percent credible intervals. Notice that, independently from the measure considered, uncertainty shocks are always recessionary. The consumer confidence, real profits and the policy rate decrease as well. The response of inflation looks generally negative, although in the case of the MACRO uncertainty shock it raises on impact and then turns negative. By looking at these variables policy and non-policy uncertainty shocks are observational equivalent. The resulting dynamics changes once we take into account the flows of firms entry and exit. In particular, the response of firms exit comes out to be strongly dependent on the source of uncertainty. In response to non-policy uncertainty shocks firms' creation decreases, whereas firms destruction increases. In response to policy uncertainty shocks firms creation decreases as well, but firms destruction reduces and remains below zero for several periods before reverting to its steady state. It is worth to notice that when the positive response of exit is particularly strong on impact, as in response to a MACRO uncertainty shock, the decline of output is heavier than in response to all the other shocks. This suggests a possible cause of the stronger decline in output in response to non-policy uncertainty shocks. The decision of firms to shut down more their activity significantly worsens the economic scenario. The effects of firms' decisions are furthermore long-lasting. About six periods later the shock to MACRO uncertainty, firms' exit indeed undershoots its long run value and remains negative for several periods before reverting to its steady state value. Lastly, although the response of the interest rate is always negative, with respect to the dynamics of output and inflation this response is relatively lower, implying that policy-uncertainty shocks are characterized by relatively lower rates.

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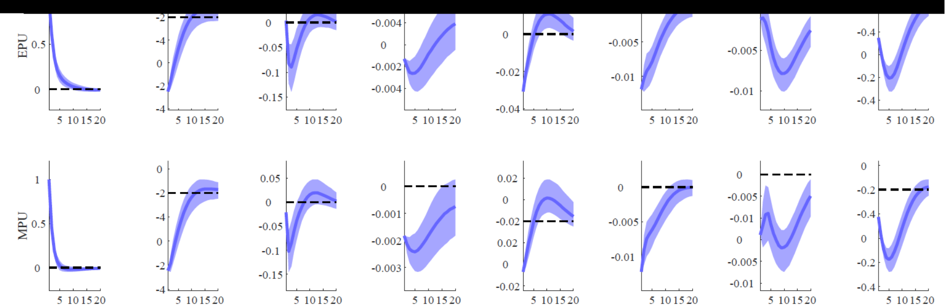

Figure 1: IRFs to VXO, MACRO, EPU and MPU with Total private Establishment Births and Deaths.

2.2 Evidence using Sectoral Data

Figure 3 and 4 show the estimated responses coming from the same VAR specifications of Section 2.1 but using sectoral data on establishments births and deaths. We first consider the two main macro sectors, that is: 1) good-producing (GP) and 2) services-providing (SP). Then, we will investigate the responses of the sub-sectors belonging to GP and SP. Table 1 indicates all the sectors an the sub-sectors considered. It also reports the correlations of sectoral births and deaths with the real GDP growth rate and their relative standard deviations.

Figure 3 and 4 show the IRFs for GP and SP births and that together with the other macroeconomic variable we consider. First of all, notice that the results found for total private data are robust for both GP and SP data. Firm exit reduces when the economy is hit by policy-uncertainty shocks, while it increases when the economy is hit by non-policy uncertainty shocks. In both cases firm entry reduces on impact and remains persistently below zero before reverting to its steady state value. The Appendix reports the same IRFs for the sub-sector belonging to GP and SP. Remarkably, our results holds also at sub-sectoral level.

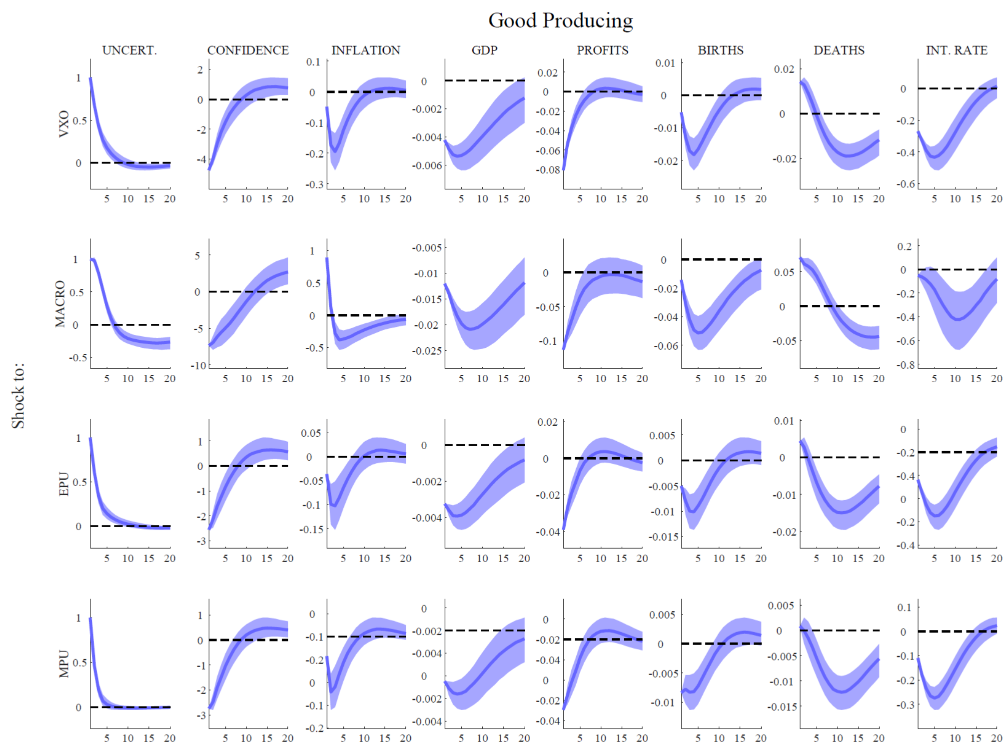

Figure 2: IRFs to VXO, MACRO, EPU and MPU with Good-Producing Establishment Births and Deaths.

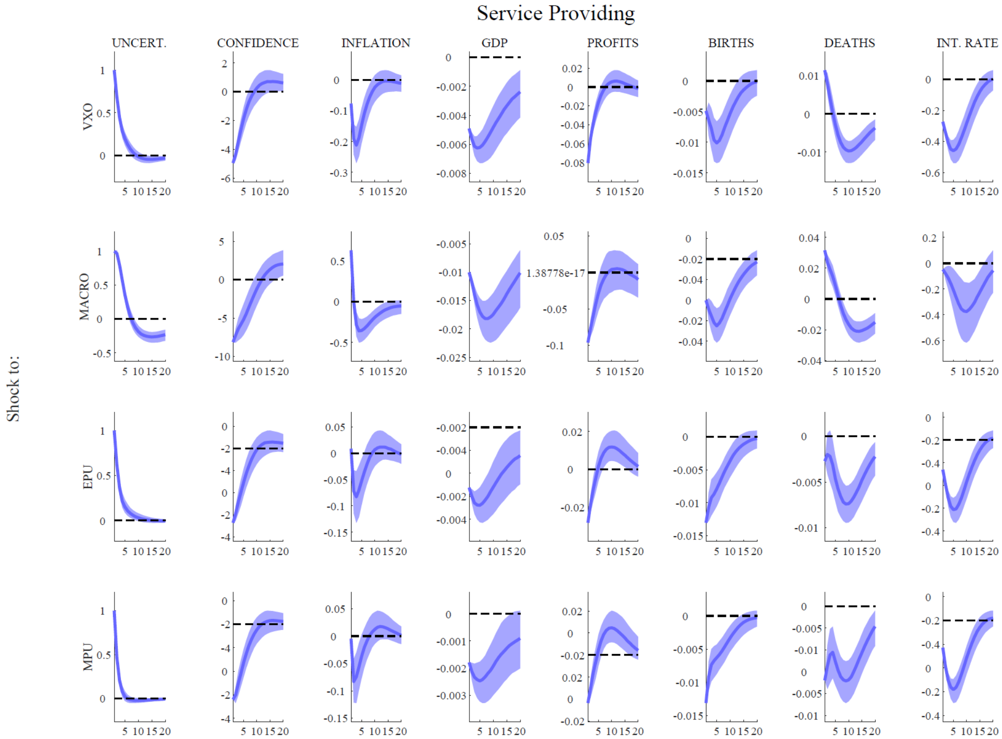

Figure 3: IRFs to VXO, MACRO, EPU and MPU with Service-Providing Establishment Births and Deaths.

To address this evidence in the next section we build-up a model with heterogeneous firms where both firms' creation and firms' destruction are endogenous and financial market are inefficient. New entrants cannot borrow from the banking system, while incumbent firms are financed by monopolistic competitive banks. Defaulting firms, exit the market and do not repay loans. We show that the interactions between firms and financial markets are key to replicate the results found in the VAR analysis.

3 The Model

The model considered is borrowed from Rossi (2019). Thus, we now present a brief description of her model, underlying the main differences and the way in which uncertainty shocks are introduced into the model. The list of all the equations characterizing the model are in the Appendix, while a complete description of the model can be found in Rossi (2019).

The model consists of a closed economy composed by four agents: households, firms, banks and the monetary authority which is responsible for setting the policy interest rate. Below a brief description of the behavior of the four agents.

Households

Households consume a basket of differentiated retailer-goods. Further, differently Rossi (2019) their consumption (C_t) is characterized by external habits. They supply their labor (L_t) to intermediate-good producing firms, they save in the form of deposits (D_t) to the banking sector and invest in a mutual fund of firms given by the sum of the already existing firms (N_{t-1}) and the new entrants at time t, (N_t^E). Households first order conditions can be summarized as follows:

$$w_t = \lambda_t L_t^{\phi}, \tag{2}$$

$$E_t \beta \varepsilon_{P_t} \left\{ \left(\frac{\lambda_{t+1}}{\lambda_t} \right) \right\} = \frac{\pi_{t+1}}{\left(1 + r_t^d\right)}, \tag{3}$$

$$\widetilde{v}_t = E_t \beta \varepsilon_{P_t} \left\{ \left(\frac{\lambda_{t+1}}{\lambda_t} \right) \left(1 - \eta_{t+1}\right) \left[\widetilde{v}_{t+1} + \widetilde{j}_t \right] \right\}, \tag{4}$$

with

$$\lambda_t = \lambda_t = (C_t - hC_{t-1})^{-\sigma} \tag{5}$$

which are respectively the households' labor supply, the Euler equation for consumption and the Euler equation for share holding. ε_{P_t} is an exogenous AR(1) preference shock. Households decide how much to invest in new firms, so that the following entry condition holds:

$$\tilde{v}_t = f^E + ec_t \tag{6}$$

where f^E is a fixed sunk cost of entry and where $\tilde{v}_t$ is the average firms value, given by the sum of current average profits, $\widetilde{j}_t$, and the next period discounted average value of firms, i.e. $\beta E_t \left(1 - \eta_{t+1}\right) \tilde{v}_{t+1}$. Differently from Rossi (2019) we assume that entry costs are subject to congestion externalities, given by the following convex function:

$$ec_t = \Psi \left(\frac{N_{t+1}^E}{N_t} \right)^{\gamma} \tag{7}$$

Firms

The supply side of the economy is then composed by N_t intermediate good-producing firms and by a retailer sector. Each firm in the intermediate sector produces a differentiated good under monopolistic competition and flexible prices. Firms are heterogeneous in terms of their specific productivity, which is drawn from a Pareto distribution. In this context, the production function of firm i is,

$$y_{i,t} = A_t z_{i,t} l_{i,t} \tag{8}$$

where $l_{i,t}$ is the amount of labor hours employed by firm i, while $z_{i,t}$ is a firm specific productivity, which is assumed to be Pareto distributed across firms, as in Ghironi and Melitz (2005). The variable A_t is instead an aggregate AR(1) productivity shock, characterized by a time-varying stochastic volatility, that will be described below.

This sector is characterized by endogenous firms dynamics. Specifically, the timing characterizing the dynamics of firms is the following. At the beginning of the period new firms enter the market until the entry condition is satisfied, that is until the average firms' value equals the entry cost, equation (6). Then, to become operating both new entrants and incumbents firms borrow from the banking sector to pay the fixed operating cost f^F. Only after they draw their firms specific productivity from a Pareto distribution. The cumulative distribution function (CDF) of the Pareto implied for productivity $z_{i,t}$ is $G(z_{i,t}) = 1 - \left(\frac{z_{\min}}{z_{i,t}}\right)^{\xi}$, $z_{\min}$ and $\xi > \theta - 1$ are scaling parameters of the Pareto distribution.[9] Firms observe the aggregate shock and decide whether to produce or exit the market. Exiting firms do not repay their loan to the banking sector.

Using this timing assumption, the decision of new entrants to exit the market is identical to the decision of incumbent firms. In particular, both new entrants and incumbent firms decide to produce as long as their specific productivity $z_{i,t}$ is above a cutoff level $\overline{z}_t$. The latter value is the level of productivity that makes the sum of current and discounted future profits (i.e. the firms value) equal to zero. Otherwise, firms will exit the market before producing. The cut off level of productivity, $\overline{z}_t$, is therefore determined by

[9] They represents respectively the lower bound and the shape parameter, which indexes the dispersion of productivity draws. As ξ increases dispersion decreases and firm productivity levels are increasingly concentrated towards their lower bound $z_{\min}$. Subsequently, the aggregate shocks arrives.

the following exit condition:

$$v_t(\bar{z}_t) = j_{\bar{z},t}(\bar{z}_t) + \beta E_t \left\{ \left(1 - \eta_{t+1}\right) v_{t+1}(\bar{z}_{t+1}) \right\} = 0, \tag{9}$$

with

$$j_t(\bar{z}_t) = y_t(\bar{z}_t) - w_t l_{\bar{z},t} - \left(1 + r_t^b\right) f^F, \tag{10}$$

where $j_t(\bar{z}_t)$ are current profits of the firm with a productivity $z_{i,t} = \overline{z}_t$. The exit probability $\eta_{t+1} = 1 - \left(\frac{z_{\min}}{\bar{z}_{t+1}}\right)^{\xi}$ is thus endogenously determined. As in Ghironi and Melitz (2005), the lower bound productivity $z_{\min}$ is low enough relative to the production costs so that $\overline{z}_t$ is above $z_{\min}$. In each period, this ensures the existence of an endogenously determined number of exiting firms: the number of firms with productivity levels between $z_{\min}$ and the cutoff level $\overline{z}_t$ are separated and exit the market without producing. Under these assumptions the number of firms in the economy at period t is given by:

$$N_t = (1 - \eta_t)\left(N_{t-1} + N_t^E\right). \tag{11}$$

Retailers bundles the goods produced by the intermediate firms using a CES technology, under monopolistic competition and Rotemberg (1982) price adjustment costs. The optimal price decision rule of retailer implies the following standard NKPC:

$$\theta - 1 = \theta \rho_t^I - \tau(\pi_t - 1)\pi_t + (\theta - 1)\frac{\tau}{2}(\pi_t - 1)^2 + E_t\left\{\Lambda_{t,t+1}\tau(\pi_{t+1} - 1)\pi_{t+1}\frac{Y_{t+1}}{Y_t}\right\} \tag{12}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate and where the stochastic discount factor, $\Lambda_{t,t+1} = \beta E_t\left\{\left(\frac{C_{t+1}}{C_t}\right)^{-1}\right\}$.

Banks

The structure of the banking sector is a simplified version of Gerali et al. (2010). It is composed by two branches: the loan branch and the deposit branch. Both are monopolistic competitive, so that deposits from households and loans to entrepreneurs are a composite CES basket of a continuum of slightly differentiated products. The amount of loans issued by the loan branch are financed through the amount of deposits, D_t, collected from households from the deposit branch or through bank capital (net-worth), denoted by K_t^b, which is accumulated out of retained earnings. Thus, the bank sector obey a balance sheet constraint,

$$B_t = D_t + K_t^b, \tag{13}$$

with the low of motion of the aggregate banking capital given by:

$$\pi_t K_t^b = (1-\delta^b) K_{t-1}^b + j_t^b, \tag{14}$$

where δ^b represents resources used in managing bank capital, while j_t^b are overall profits made by the retail branches of the bank, which are the distributed to households.

Banks play a key role in determining the conditions of credit supply. Assuming monopolistic competition, banks enjoy market power in setting the interest rates on deposits and loans. This leads to explicit monopolistic markups and markdowns on these rates. The loan branch differentiates the loans at no cost and resell them to the firms applying a markup over the policy rate. As in Curdia and Woodford (2009) banks are unable to distinguish the borrowers who will default from those who will repay, and so must offer loans to both on the same terms. The equation for the optimal interest rate:

$$r_t^b = \left(\frac{\varepsilon^b}{\left(\varepsilon_t^b - 1\right)(1-\eta_t)} \right) (r_t + \eta_t), \tag{15}$$

where $\mu_t^{Lb} = \frac{\varepsilon^b}{\left(\varepsilon^b - 1\right)(1-\eta_t)}$ is the bank markup and $r_t + \eta_t$ is its marginal cost.[10] ε^b is the loan elasticity of substitution. The bank marginal cost is the sum of two components: i) r_t, i.e. the net interest rate that the bank has to pay to the deposit branch for each loan.[11] This is the only effective cost per loan in the case the bank is able to have back the notional value of the loan from defaulting firms. ii) η_t represents instead the additional cost per loan faced by the bank due to firms defaulting and not repaying the loan.

Notice that $\frac{d\left(\mu_t^{Lb}\right)}{d\eta_t} = \frac{1}{\varepsilon^b - 1} \frac{\varepsilon^b + 1}{(\eta_t - 1)^2} > 0$, implying a positive relationship between firms' exit and the value of the bank markup. Indeed, as the expected probability of exit increases, retail banks increase their markup and

[10] Indeed, in the symmetric equilibrium total costs are given by $CT_t^b = r_t b_t + b_t \eta_t$. Thus bank's marginal costs are $MC_t^b = \frac{dCT_t^b}{db_t} = r_t + \eta_t$.

[11] We assume that banks have access to unlimited finance at the policy rate, sot that r_t is also the interest rate set by the monetary authority.

set higher interest rate. The intuition is straightforward. An increase in the firms' exit probability imply that the probability that a firm do not repay the loan increases. As a consequence the bank that has issued that loan faces lower expected profits. To restore its profits the bank is forced to increase the interest rate on loan.

The deposit branch collects deposits from households and gives them to the loans unit, which pays r_t. The optimal interest rate for deposits,

$$r_t^d = \frac{\varepsilon^d}{\varepsilon^d - 1} r_t \tag{16}$$

$\frac{d\left(\frac{\varepsilon}{\varepsilon-1}\right)}{d\varepsilon} = -\frac{1}{(\varepsilon-1)^2} < 0$, i.e. the interest rate on deposits is markdown over the policy rate r_t.

Aggregate bank profits are the sum of the profits of the branches of the bank. Thus, they are also affected by the firms' exit probability and given by:

$$j_t^b = r_t^b B_t (1 - \eta_t) - r_t^d D_t - B_t \eta_t. \tag{17}$$

where $B_t \eta_t$ is the total amount of the loans not repaid to the banks.

Monetary Authority

To close the model we specify an equation for the Central Bank behavior. We simply assume that the monetary authority set the nominal interest rate r_t following a standard Taylor-type rule given by

$$\ln\left(\frac{1+r_t}{1+r}\right) = \phi_R \ln\left(\frac{1+r_{t-1}}{1+r}\right) + (1-\phi_R)\left[\phi_\pi \ln\left(\frac{\pi_t}{\pi}\right) + \phi_y \ln\left(\frac{Y_t}{Y}\right)\right] + \sigma_{R,t}\varepsilon_{m,t}, \tag{18}$$

where $\ln\left(\frac{\pi_t}{\pi}\right)$ and $\ln\left(\frac{Y_t}{Y}\right)$ are respectively the deviations of inflation and output from their steady state values, ϕ_π and ϕ_y being the elasticities of the nominal interest rate with respect to these deviations. The parameter ϕ_r is the interest rate smoothing parameter.

3.1 Uncertainty Shocks

We consider two types of uncertainty shocks: non-policy and policy uncertainty shocks. We model these shocks by using the stochastic volatility approach as proposed by Fernandez-Villaverde et al. (2011), i.e. assuming time varying volatility of the innovation of level shocks. In details, non-policy uncertainty shocks enter into the economy through: i) the time-varying stochastic volatility of the preference shock $\varepsilon_{p,t}$; ii) the time-varying stochastic volatility of the aggregate productivity shock A_t. The level and volatility shocks preference shock are of the form:

$$\varepsilon_{p,t} = \rho_{p,t}\varepsilon_{p,t-1} + \sigma_{p,t}u_{\varepsilon p,t} \tag{19}$$

and $\sigma_{p,t}$, that is the time-varying volatility of preference shock, which follows the following AR(1) stationary process:

$$\ln\left(\sigma_{p,t}/\sigma_p\right) = \left(1-\rho_p\right)\ln\left(\sigma_{p,t-1}/\sigma_p\right) + \eta_{\sigma_p}u_{\sigma_{p,t}} \tag{20}$$

where the innovation $u_{\sigma_{p,t}}$ is a standard normal process and η_{σ_p} is the (constant) standard deviation of the uncertainty shock. This shock affects the volatility of average value of firms. It can then be interpreted as a proxy of the volatility of the stock market, and thus directly comparable with the VXO.

Analogously, the aggregate productivity follows a process of the form:

$$\ln\left(A_t/A\right) = \rho_a \ln\left(A_{t-1}/A\right) + \sigma_{a,t}u_t^a, \tag{21}$$

where A is the steady state value of A_t and where the innovation u_t^a is a standard normal process. The time-varying standard deviation of the innovations, $\sigma_{a,t}$, that is the uncertainty shock, follows this stationary process:

$$\ln\left(\sigma_{a,t}/\sigma_a\right) = \rho_a \ln\left(\sigma_{a,t-1}/\sigma_a\right) + \eta_{\sigma_a}u_{\sigma_a,t}, \tag{22}$$

where the innovation $u_{\sigma_a,t}$ is a standard normal process and η_{σ_a} is the (constant) standard deviation of the uncertainty shock.

Finally, a policy uncertainty shock enters into the economy through the monetary shock in the Taylor rule, $\varepsilon_{m,t}$. Specifically,

$$\varepsilon_{m,t} = \rho_{m,t}\varepsilon_{m,t-1} + u_{\varepsilon m,t} \tag{23}$$

with

$$\ln\left(\sigma_{R,t}/\sigma_R\right) = \left(1-\rho_R\right)\ln\left(\sigma_{R,t-1}/\sigma_R\right) + \sigma_{\sigma_R}u_{\sigma_{R,t}} \tag{24}$$

where the innovation $u_{\sigma_{R,t}}$ is a standard normal process and σ_{σ_R} is the (constant) standard deviation of the uncertainty shock.

3.2 Calibration and Model Dynamics

Calibration is set on a quarterly basis. The discount factor, β, is set at 0.99. The inverse of Frisch elasticity of labor supply is $\phi = 4$. As in BGM (2012), we set the steady state value of the exit probability η to be 0.025, this needs that ξ is set equal to 7.76. A value of $\eta = 0.025$ matches the U.S. empirical evidence of 10% of firms destruction per year. The elasticity of substitution among intermediate goods, θ, is set equal to 3.8, a value which is in line with Ghironi and Melitz (2005) and BGM (2012). It also ensures that the condition for the shape parameter $\xi > \theta - 1$ is satisfied in the model with endogenous exit. The lower bound of productivity distribution, $z_{\min}$, is equal to 1. Further, as in BGM (2012), Etro and Colciago (2010) and Colciago and Rossi (2012), we set the entry cost $f^E = 1$. The fixed costs f^F is set such that in all the economies considered they correspond to 5% of total output produced. We translate the Rotemberg cost of adjusting prices, τ, into an equivalent Calvo probability that firms do not adjusted prices equal to 0.67, a value close to the ones obtained in the empirical literature (see for example Christiano et al 2005, among others).

We calibrate the banking parameters as in Gerali et al. (2010). For the deposit rate, we calibrate $\varepsilon^d = -1.46$. Similarly, for loan rates we calibrate $\varepsilon^b = 3.12$. The steady-state ratio of bank capital to total loans, i.e. the capital-to-asset ratio, is set at 0.09. As done for the computation of the correlation with real GDP. When we run the shock to the level of the productivity, we set the parameters as follows: the steady state of productivity A is equal to 1, its standard deviation is 0.0035, while its persistence is set to 0.94, as found by Smets and Wouters (2007), for the labor productivity.

The parameter of the uncertainty shock are calibrated as in the VAR and follows Leduc and Liu (2016) strategy. A one standard deviation shock to uncertainty raises the measure of uncertainty, i.e. the VXO, by 5.63 units relative to the sample mean of 20.6. Thus, the shock is equivalent to a 27.2 percent increase in the level of uncertainty relative to its mean (5.63/20.6 = 0.392). Since we calibrate the mean standard deviation in our model to 1 percent, we set the standard deviation of the uncertainty shock to 0.392 in line with the VAR evidence. Our VAR evidence also suggest that the effects of the uncertainty shock on measured uncertainty is persistent, so that in a period of 4 quarters, the VXO falls gradually to about 45.7 percent of its peak. This observation suggests that, if the shock is approximated by an AR(1) process, as in our model, then the persistence parameter should be about 0.822 at quarterly frequencies. Thus, we set $\rho_\sigma = 0.822$.

Finally, we consider a Taylor rule, with $\phi_R = 0.75$, $\phi_\pi = 2.15$ and $\phi_y = 0.125$. This rule guarantees the uniqueness of the equilibrium. Further, these parameters are in the range of the values estimated for the US economy.[12]

3.2.1 IRFs to Policy and Non-policy Uncertainty Shocks

We now show the IRFs to a TFP uncertainty shock, which is a shock to the volatility of the aggregate productivity and the IRFs to a nominal interest rate uncertainty shock. To examine the dynamic effects of the two uncertainty shocks, we solve the model using third-order approximations to the equilibrium conditions around the steady state. We follow the procedure suggested by Fernandez-Villaverde et al. (2011) to compute the impulse responses.[13] .

Figure 5 and 6 compares the performance of our baseline model (as before labeled as *Endogenous exit MB*) with the endogenous exit model with efficient banks (labeled as *Endogenous Exit EB).*

Figure 5 shows that in both models a TFP uncertainty shock is followed by an increase in firms exit and a decrease in firms entry, together with a reduction in output. The recessionary effects are stronger in the model with monopolistic banks (black solid lines) than in the model with efficient banks (blue dotted lines). The intuition is simple. In both models the increase in uncertainty reduces firms' expected average profits. The number of defaulting firms increases and new entrants decrease. Since exiting firms do not repay the loans, the number of non-performing loans increases and banks face balance-sheet losses, so that they increase their interest rate on loan to restore their profits. The banks' markup increases, making the cost of loans higher and further reducing firms expected average profits. As a consequence, both firms' exit and the fall in business creation is higher with

[12] See for example Smets and Wouters (2007). The qualitative results and the comparison with the exogenous exit model and with the model with efficient banks are not qualitatively altered by the choice of the Taylor rule.

[13] In particular, using Dynare, we first simulate the model (using a third-order approximations to the decision rules) for 2,096 periods, starting from the deterministic steady state. We the drop the first 2,000 periods to avoid dependence on initial conditions and we use the remaining 96 periods to compute the ergodic mean of each variable. Then, starting from the ergodic means, we run two different simulations of 20 periods each, one with an uncertainty shock (i.e. a one-standard-deviation increase in uncertainty in the first period) and the other with no shocks. Finally, we compute the IRFs as the percentage differences between these two simulations.

respect to the model with efficient banks, where the banks markup remains unchanged. This result in a more severe recession.

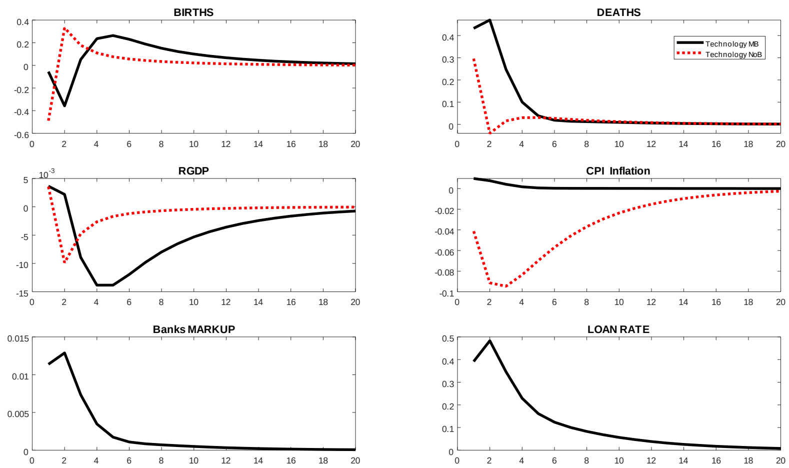

Figure 5. IRFs to a Technology Uncertainty shock. Benchmark model (black solid line), No Banks model (red dotted line).

Notice that while the shock is deflationary in the model with efficient banks, the response of inflation is positive and close to zero in our benchmark model. Even though, a positive response of inflation is commonly find in the theoretical literature on uncertainty shocks,[14] this contrasts with the response of inflation found in the VAR.

Finally, Figure 6 shows that in both models a nominal interest rate uncertainty shock is followed by a reduction in firms exit and a decrease in firms entry, together with a reduction in output. The recessionary effects are less severe in the model with monopolistic banks (black solid lines) than in the model with efficient banks (blue dotted lines). The intuition is simple. In both models the increase in uncertainty reduces firms' expected average profits. The number of defaulting firms decreases and new entrants decrease as well. Since the loan rate reduces in the model with monopolistic banks, firms profits increases, non-performing loans reduces and banks face lower balance-sheet losses. As a consequence, firms' exit reduces. At the same time since the decision to entry is not directly affected by the loan rate, firm entry decreases because of the recessionary effect of the shock. The

[14] See for example, Fernandez-Villaverde at al (2015), Born and Pfeiffer (2014), Bonciani and van Roje (2016) and Fasani Rossi (2017).

different response of the loan rate together with that of firms destruction is responsible for the lower decrease in output.

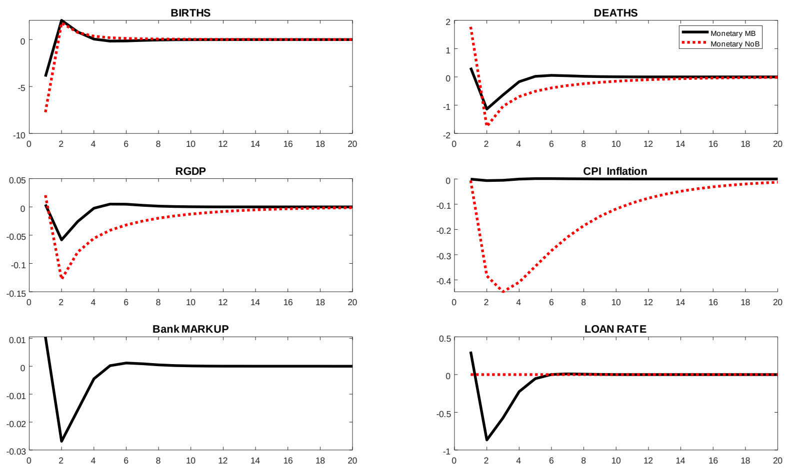

Figure 5. IRFs to a Nominal Uncertainty shock. Benchmark model (black solid line), No Banks model (red dotted line

4 Conclusion

This paper provides evidence on the responses of firms dynamics to policy and non-policy uncertainty shocks, using aggregate and sectoral data on establishments' births and deaths. of monetary policy and TFP uncertainty. It shows that both shocks contribute to the US recession, however the response of firms exit is strongly dependent on the source of uncertainty. In response to non-policy uncertainty shock firms' creation decreases, whereas firms destruction increases. In response to an increase in policy uncertainty firms creation decreases, however firms destruction reduces and remains below zero for several periods before reverting to its steady state, contributing to stabilize the recession and to faster the recovery.

Finally the paper shows that a model with heterogeneous firms where both firms' creation and firms' destruction are endogenous and financial market are inefficient is able to replicate the empirical evidence. It shows that the interaction between firms dynamics and the banking sector is key to replicate the results found in the BVAR analysis.

This paper is only a first attempt to understand the interactions between firms dynamics and uncertainty shocks. Further investigation on empirical side is needed to better understand the links between policy uncertainty and firm dynamics together with their business cycle consequences. This of our research agenda.

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5 Appendix

5.1 Business Cycle Statistics

Table 1 reports the acronym and the names of the industry sectors considered for BLS establishments births and deaths. Table 2 shows the business cycle statistics: correlation of establishments births and deaths with real GDP, mean, absolute standard deviations, relative standard deviations with respect to the standard deviation of the real GDP and autocorrelations.

Table 1	Industry Sectors - BLS database
TP	Total private
GP	Goods-producing
SP	Service-providing
MA	Manufacturing
NRM	Natural resources and mining
CO	Construction
WH	Wholesale trade
RE	Retail trade
TR	Transportation and warehousing
INF	Information
FIN	Financial activities
PB	Professional and business services
EH	Education and health services
LH	Leisure and hospitality
OS	Other services (except Pub. Admin.)

Table 2 - BUSINESS CYCLE STATISTICS

Establishments Births Rates 1993q2-2017q4

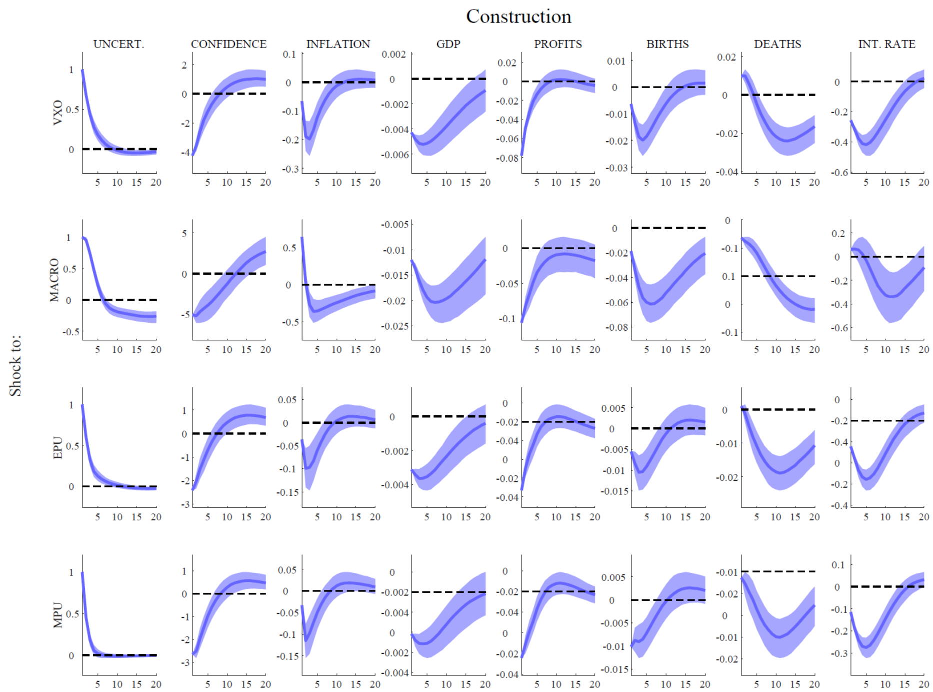
STATISTICS	RGDP	TP	Total Private		Good Producing			Services Providing								
	Y/X	GP+SP	GP	SP	MA	NRM	CO	WH	RE	TR	INF	FIN	PB	EH	LE	OS
Corr(Y,X)	1,00	0,37	0,40	0,31	0,37	0,17	0,42	0,21	0,31	0,32	0,27	0,30	0,30	0,04	0,28	0,32
Mean(X)	2,50	12,80	12,26	12,88	7,28	11,33	15,16	11,65	8,66	13,75	15,18	11,34	15,85	13,69	11,70	9,68
SD(X)	0,59	0,24	0,43	0,22	0,27	0,39	0,63	0,42	0,33	0,55	0,77	0,43	0,40	0,54	0,43	0,26
RelSD(X/Y)	1,00	0,41	0,72	0,37	0,45	0,65	1,06	0,71	0,56	0,92	1,29	0,72	0,67	0,91	0,73	0,43
Autocorr(X,X(-1))	0,38	0,86	0,91	0,83	0,85	0,48	0,92	0,92	0,94	0,88	0,84	0,88	0,89	0,33	0,92	0,84

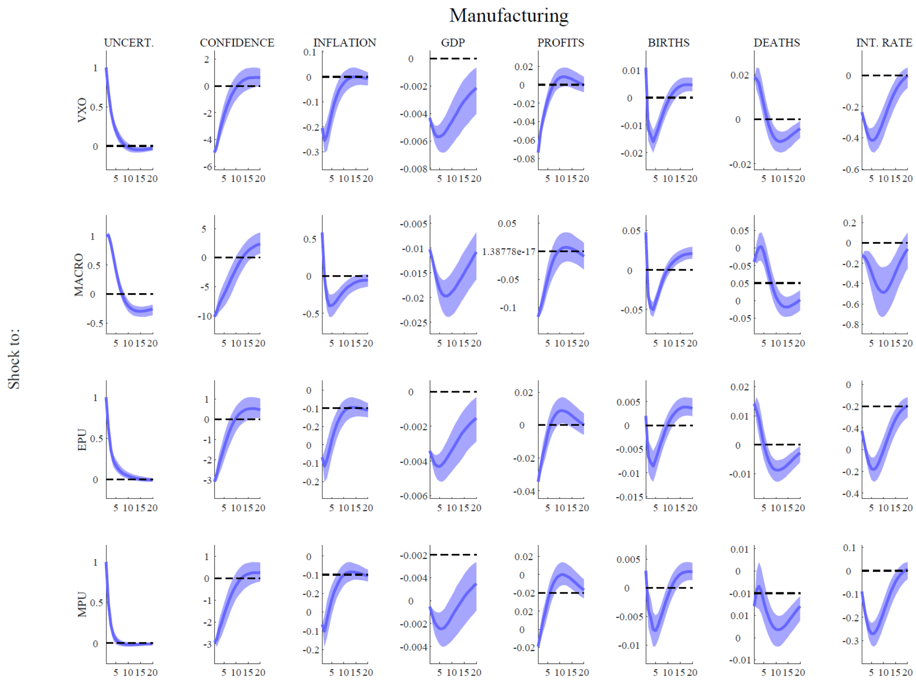
Establishments Deaths Rate 1992q3-2017q1

STATISTICS	RGDP	TP	Total Private		Good Producing			Services Providing								
	Y	GP+SP	GP	SP	MA	NRM	CO	WH	RE	TR	INF	FIN	PB	EH	LE	OS
Corr(Y,X)	1,00	-0,29	-0,38	0,31	-0,08	0,06	-0,37	-0,25	0,07	-0,13	-0,13	-0,36	-0,40	-0,01	0,15	-0,13
Mean(X)	2,51	11,65	12,38	12,88	8,30	11,02	14,85	11,59	9,37	13,19	14,55	10,88	13,66	10,55	10,79	9,42
SD(X)	0,60	0,21	0,40	0,22	0,22	0,42	0,59	0,26	0,29	0,36	0,59	0,34	0,25	0,29	0,32	0,16
RelSD(X/Y)	1,00	0,35	0,67	0,37	0,37	0,70	0,99	0,43	0,48	0,60	0,99	0,57	0,42	0,48	0,53	0,27
Autocorr(X,X(-1))	0,37	0,78	0,90	0,83	0,68	0,51	0,92	0,77	0,90	0,75	0,77	0,86	0,73	0,14	0,85	0,64

5.2 BVAR Analysis with data on GP and SP sectors of Establishments Births and Deaths

The implied IRFs of the BVAR estimated using data of Establishments Births and Deaths of GP and SP sectors are reported below.




Manufacturing
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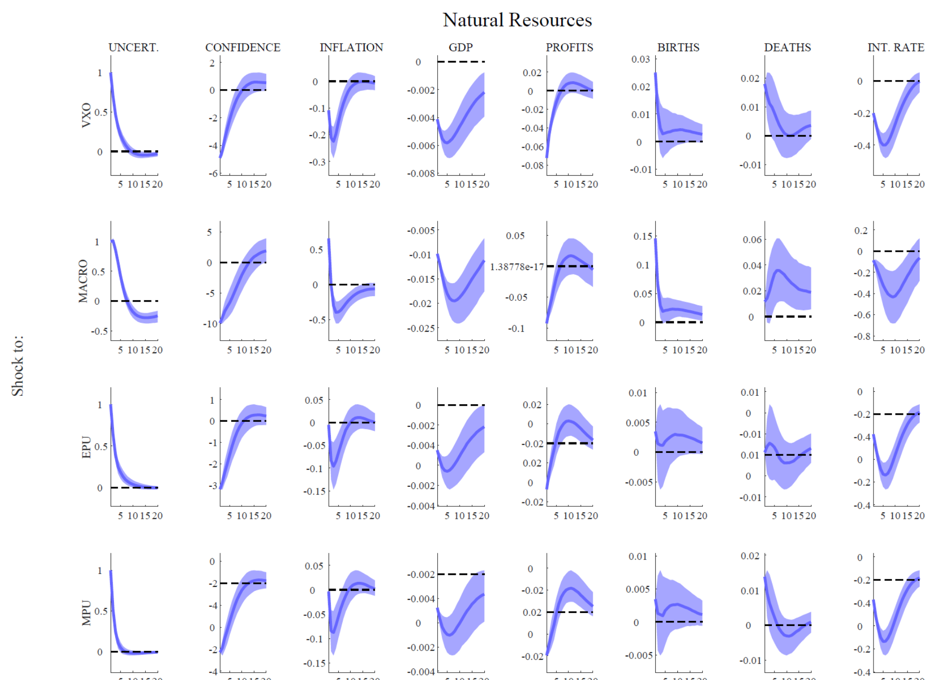
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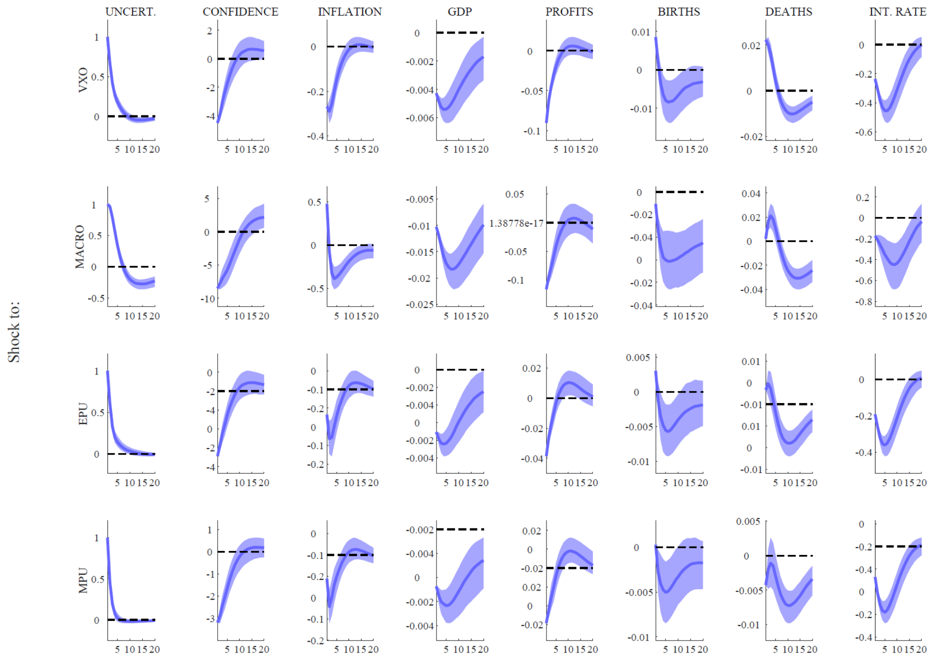
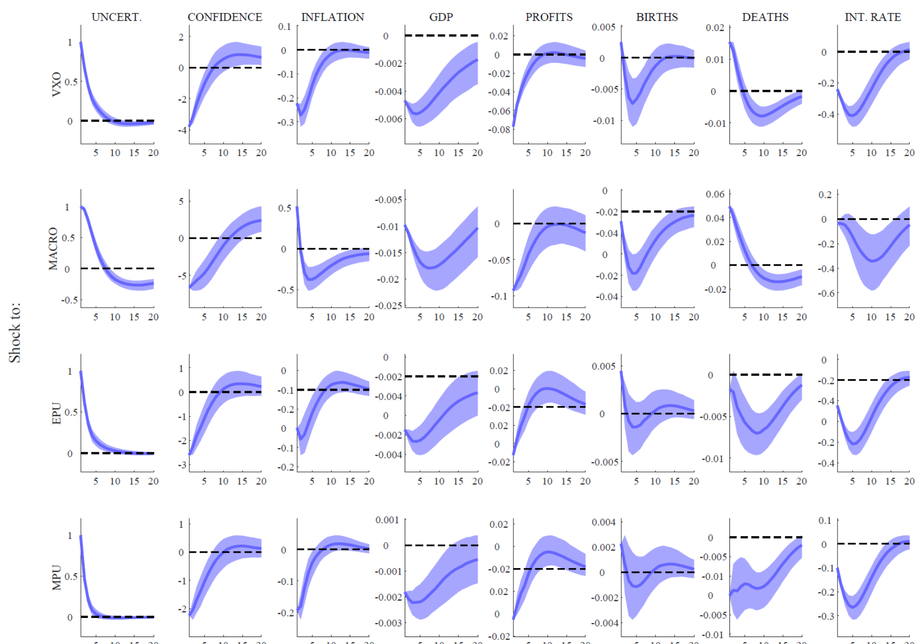
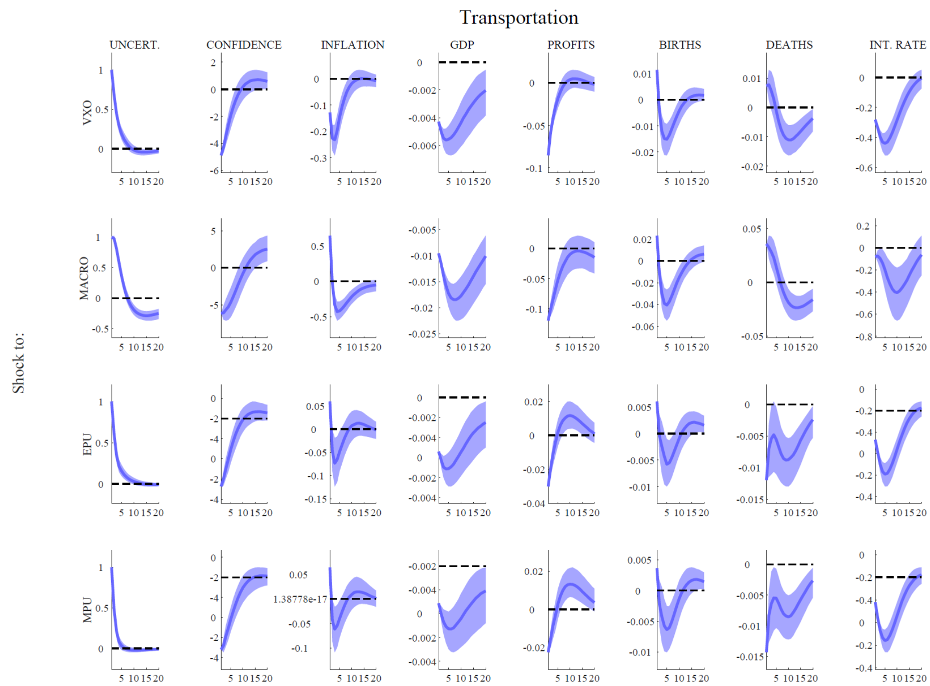
Wholesale



Retail




Transportation
UNCERT.
CONFIDENCE
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Shock to:
VXO
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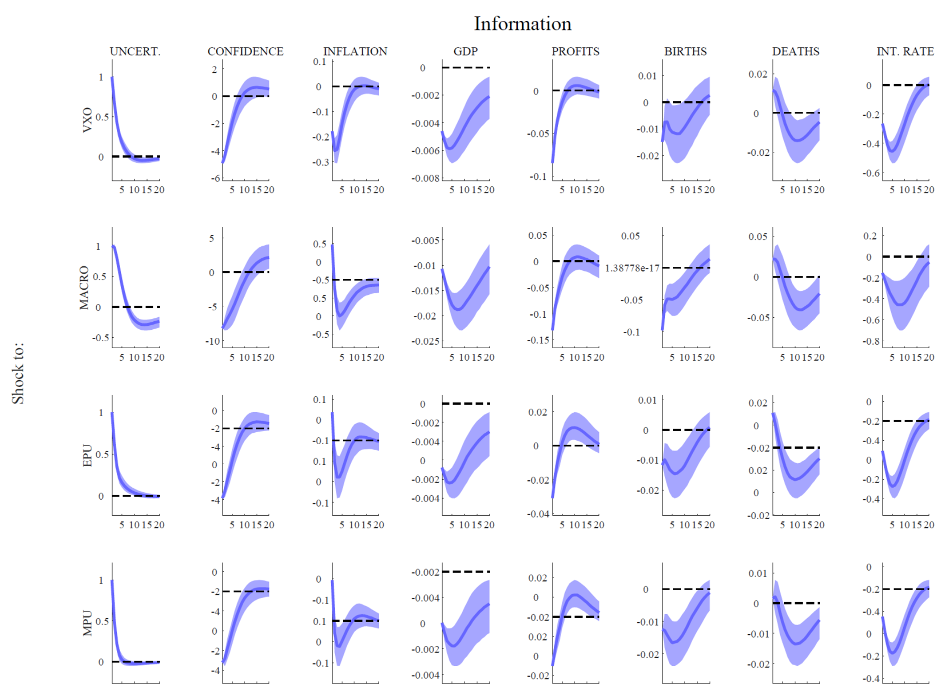
Information
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CONFIDENCE
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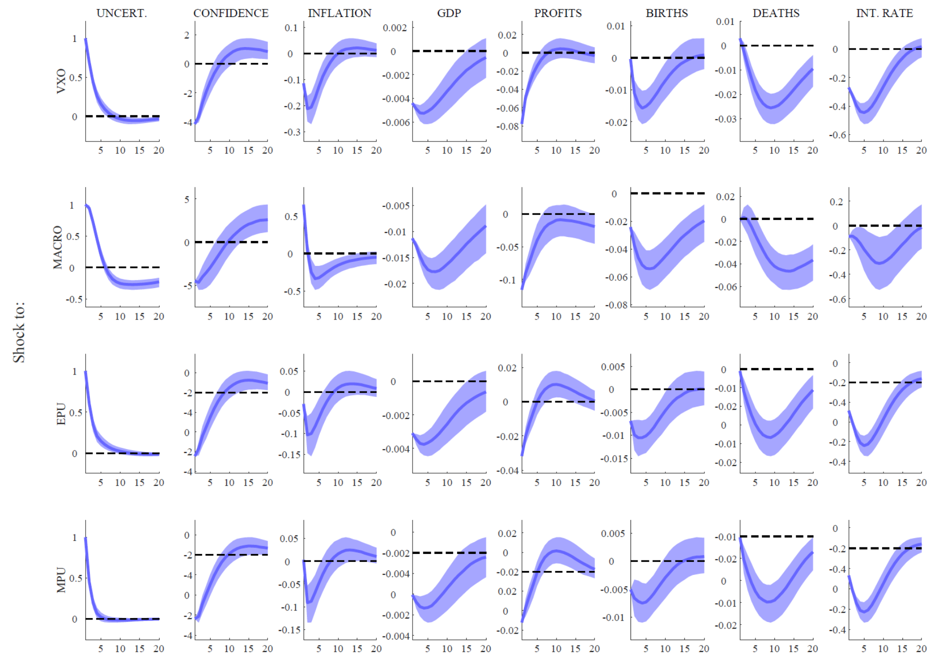
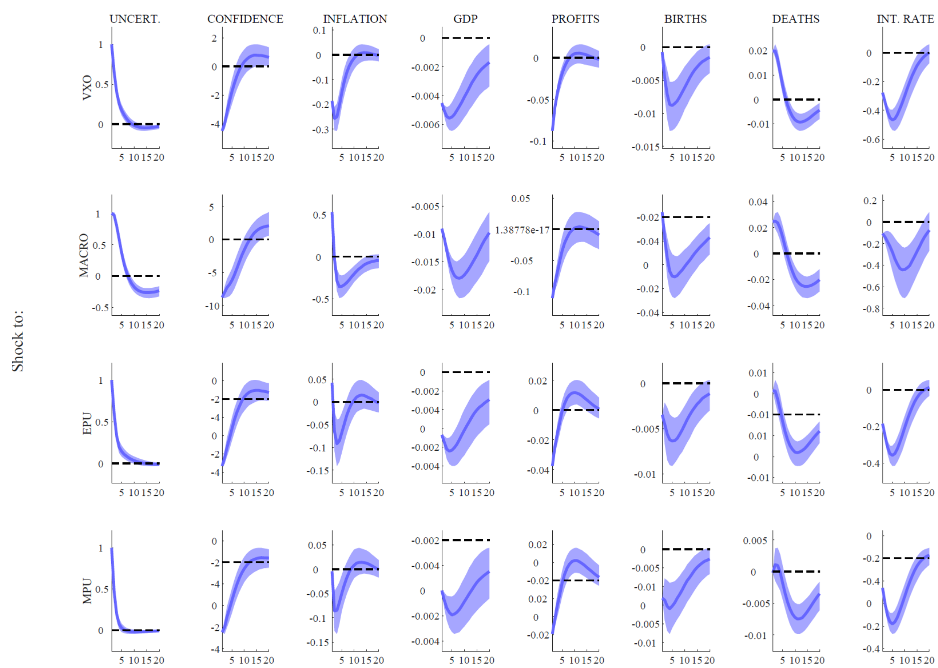
BIRTHS
DEATHS
INT. RATE
Shock to:
VXO
MACRO
EPU
MPU

Financial services



Professional and Business services



Education and health services