

# Monetary Policy and Corporate Default

By ABOLFAZL REZGHI\*

*This paper shows that a contractionary monetary shock would increase the number of defaults and the aggregate liability of defaulted firms in the economy. The adverse effect of firms' default on the balance sheet of banks lowers the supply of credit and forces the interest rate of loans to rise. As a result, the cost of production grows even further, and more firms decide to file for bankruptcy. Using a DSGE framework, I show that Monetary policy can dampen this amplification mechanism by considering financial variables in the policy rule.*

*JEL: E32,E44,E52*

*Keywords: Monetary shocks, Taylor Rule, Corporate default*

Central banks use Taylor rule to stabilize inflation at low levels and manage the economic fluctuations (Clarida, Galí and Gertler (2000)). The standard Taylor rule prescribes that interest rates should be adjusted more than one-for-one to an increase in inflation all the while considering real variables like output gap. During the financial crisis of 2008, Federal Reserve deviated from the standard rule by aggressively reducing federal fund rates even though inflation was on the rise and there was no sign of a decline in GDP (Cúrdia and Woodford (2010)). This deviation in practice occurred because the Fed was trying to deal with severe problems in the financial sector. Although this happened during a financial crisis, considering variables in the financial sector might be beneficial in the conduct of monetary policy as a general rule, especially when monetary policy shocks are the primary source of aggregate disturbances. The central objective of this paper is to see if paying attention to factors in the financial sector, such as aggregate credit, default rate, and credit spread, over applying the standard monetary policy rule would lead to a better response of the economy to monetary policy shocks.

In this paper, I consider the adverse effect of monetary shocks on firm default. I show that contractionary monetary shocks increase the number of firms that default and subsequently, the aggregate liability of defaulted firms. The initial effect of monetary shocks then can be reinforced via two different mechanisms and thus leads to a more substantial impact on the economy. One mechanism is the “bank lending channel”, and the other is the “competition channel.”

If a business fails and its debt becomes past due or nonperforming, the risk weight of the loan increases for the bank. Consequently, the bank has to raise its capital to abide by the capital requirement regulations. Also, the bank will incur a loss if the principal and interest of the loan are not going to be fully repaid. Both increasing the capital and not getting the loan back, raises the bank's cost

\* The University of Texas at Austin, Rezghi@utexas.edu

and lowers the supply of credit. As a result, banks would increase the interest rate on loans, which leads to a rise in the cost of production and forces more firms to fail. If the failed firm decides to cease its operation and leaves the market, the competition among firms will decline due to having a fewer number of firms. As a result, markups will rise, and aggregate output will decrease even further following a contractionary shock.<sup>1</sup>

Based on these two mechanisms, I claim that the financial sector has an essential role in the propagation and reinforcement of monetary shocks throughout the economy. Thus, incorporating an indicator from the financial sector such as aggregate credit, and considering the default rate into the policy rule might alleviate the overall impact of adverse monetary shocks. This Speculation will be investigated in the paper.

Depending on the nature of the shock, different studies suggest different modification of Taylor rule. Christiano, Motto and Rostagno (2006) answered this question in an environment with news shock on future productivity. They showed that a modified version of monetary policy that does not promote boom and bust is preferred to standard inflation targeting rule. Since credit growth is strongly procyclical in their model, they propose adding aggregate credit growth to the monetary rule to “lean against the wind.” Cúrdia and Woodford (2010) find that an adjusted Taylor rule, which includes the credit spread, can reduce the distortions caused by financial disturbances. However, a monetary rule that responds to changes in the aggregate credit is not as effective as a credit-spread-adjusted rule in their model. Cúrdia and Woodford (2016) propose implementing flexible inflation targeting by adjusting the standard Taylor rule for the changes in current and future expected credit spreads to improve the welfare.<sup>2</sup>

The closest paper to this project is Bhamra, Fisher and Kuehn (2011), where they compare two extreme cases of monetary policy: interest rate peg, and inflation targeting. In their model, passive interest rate peg policy generates procyclical inflation and increases the incentive for corporate default after a negative productivity shock hits. The other policy rule that they investigate is inflation targeting. An inflation targeting policy that eliminates procyclical inflation can dampen the amplification mechanism that causes more default. They show that full inflation targeting requires considering credit market conditions, like default rate, in their policy rule. They assume fixed-rate perpetual debt in their model without any other source of nominal rigidity. In contrast, I allow for short term one-period debt with price stickiness. Moreover, I incorporate the competition and bank lending channels in the model while they ignore.

<sup>1</sup>Contractionary shocks can also decrease the number of entry as documented by Bergin and Corsetti (2008), Lewis and Poilly (2012), and Uusküla (2016). This also leads to an increase in the markups, since Campbell and Hopenhayn (2005) document a negative correlation between markups and entry in many sectors of the US economy.

<sup>2</sup>Other studies propose a combination of credit-augmented Taylor rule with macroprudential policies to minimize the welfare losses. see, e.g., Kannan, Rabanal and Scott (2012), Angelini, Neri and Panetta (2014), Rubio and Carrasco-Gallego (2014), and Angeloni and Faia (2013).

Taylor and Zilberman (2016) also suggest a modification to the Taylor rule and find the optimum monetary policy for both cases of supply and credit shock. Their model prescribes that the central bank should reduce its inflation response in the Taylor rule, despite higher inflationary pressures.<sup>3</sup> While they try to answer a similar question, they do not investigate the optimum monetary policy in the presence of monetary shocks. Moreover, bankruptcy in their model does not result in exiting the market, and thus, they assume a fixed number of firms. The banking structure in their model is a competitive one, while I consider monopolistic banking that allows for having nominal rigidities in the financial sector.

The basis of the model is adopted from the seminal paper by Bilbiie, Ghironi and Melitz (2012) on business cycle with endogenous entry. Their framework replicates several features of the business cycle, and variants of it are widely used in the literature of endogenous entry and exit. Endogenous default is incorporated in the model by following Rossi (2019), and the monopolistic banking sector is based on Gerali, Neri and Sessa (2010). Using the model, I show that including aggregate credit and default rate in the monetary policy rule improves the response of the economy to shocks and brings more stability.

The remainder of the paper is structured as follows: In section I, I provide the empirical evidence on the effect of monetary shocks on corporate default and the liabilities of defaulted firms. Section II describes the model, section III discusses the results, and section IV concludes.

## I. Empirical Evidence

### A. Data

The data on *Business Failure* and *Liabilities* come from Dun & Bradstreet (D&B), a company that provides commercial data and analytics for businesses. The D&B dataset covers almost 90 percent of the enterprises in the economy (Uusküla (2016)). The monthly data series are available from 1953 to 1994 in the Survey of Current Business.

*Business Failure* statistics include businesses that ceased operation with losses to creditors after foreclosure or attachment; were involved in court actions such as receivership, reorganization or arrangement; or voluntarily compromised with creditors. It is worth to note that business failure is different from business discontinuance. According to this definition, businesses that discontinue operations and exit the market are not recorded as failures if creditors are paid in full. Also, not all of the business failures necessarily result in exiting the market.

*Liabilities* represents approximately current liabilities. Current liabilities include all accounts and notes payable and all obligations, whether in secured form or not. These liabilities are known to be held by banks, officers, affiliated compa-

<sup>3</sup> They find that countercyclical banking regulations like Basel III, is much more capable of stabilizing the economy following a credit shock.

nies, supplying companies, or the Government. They do not include long-term, publicly held obligations. Offsetting assets are also not taken into account.

Since the D&B dataset does not cover the universe of the firms, data on the business bankruptcy filing is also used as a robustness check. This dataset which is provided by the US bankruptcy court includes all business bankruptcy filing under chapter 7 and 11 of US bankruptcy code and runs from 1960Q3 to 2011Q2.

In Appendix B, I also use the data on establishment exit from *Business Employment Dynamic* dataset to measure the impact of monetary shocks on total exit. All data are seasonally adjusted.

### B. Empirical Framework

In order to investigate the effect of Romer and Romer (2004) (R&R) monetary policy shocks, I use the Jordà's (2005) local projection method. Local projection allows us to estimate the IRFs to externally-identified shocks. I use the monetary shocks generated in R&R and the updated R&R shock, which is extended to 2008 by Coibion et al. (2012). R&R identify monetary policy shocks as changes to the intended Federal Funds rate that is not predictable by the economic information in the Federal Reserves Greenbook forecasts. The local projection method also allows for non-linearities and sign-dependence. In the baseline model, I assume both linearity and symmetry. In appendix A, these two assumptions are relaxed and tested as a robustness check.

The effect of 1 unit monetary policy shock, which corresponds to 1 percent R&R monetary shock, on the variable of interest  $y_t$ ,  $h$  period after shock  $s_t$  hits can be estimated using the following regression:

$$(1) \quad y_{t+h} - y_t = \beta'_h \mathbf{X}_t + \gamma_h s_t + \epsilon_{t,h}$$

$\mathbf{X}_t$  is the vector of controls that might affect the variation in the dependent variable. The control variables are one year of lags for the shocks and the dependent variable, a constant and a time trend. According to Jordà (2005), the impulse response of  $y_t$  to the shock  $s_t$  after  $h$  period is given by  $\gamma_h$ . The standard error of the estimate is the standard error of  $\gamma_h$  itself.

### C. Results

Since D&B broadened the scope of businesses that included in their dataset after 1984, the total number of failures before and after this period are not directly comparable. Also, there is a steep increase in the number of business failures after 1980, which can affect the trend term in equation 1. Here I use the data from 1966M1-1979M12 to estimate the IRFs.<sup>4</sup>

<sup>4</sup>There are other ways to exploit the data after 1980s which I discussed in the first draft of the paper.

Figure 1 and 2 show the impulse response function of business failure and total liability to 1 percent R&R contractionary monetary shock. The number of business failure rises by more than 18 percent almost two years after the shock hits. This result is qualitatively in line with Uusküla (2016) in which the monetary shocks are identified by using a VAR model. The total liability of defaulted firms also increases with approximately the same magnitude. The data on liability is highly noisy, even after seasonally adjusting. Thus the IRF of liability is not as smooth as the IRF of business failure.<sup>5</sup> The shaded area represents the 90 percent confidence interval. The confidence interval is calculated by using the standard deviation of  $\gamma_h$  in the equation 1, which is adjusted as in Newey and West (1987) to deal with serial correlation.

US court data on the business bankruptcy filing, which reports total bankruptcies in each quarter from 1960 to 2011, enables us to use the updated R&R shocks. Figure 3 shows the IRF of the bankruptcy filing to one percent R&R contractionary monetary shock. The effect of monetary shocks on the bankruptcy filing provided by US court is qualitatively the same as its effect on business failure data by D&B. These results recommend that monetary policy shocks lead to disturbances in the financial sector through their impact on business failure and the aggregate liabilities of defaulted firms.

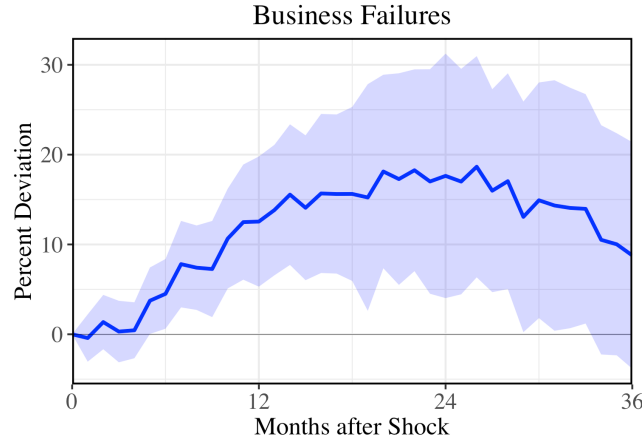


Figure 1. : IRF of business failure to 1 percent contractionary monetary policy shock. The shaded area represents 90 percent confidence interval.

<sup>5</sup>Appendix A shows that the assumptions of symmetry and linearity in shocks can be rejected at 90 percent confidence interval for total liabilities.

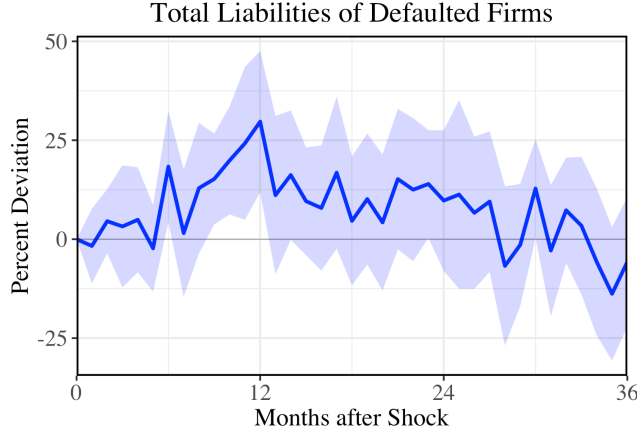


Figure 2. : IRF of aggregate liabilities of defaulted firms to 1 percent contractionary monetary policy shock. The shaded area represents 90 percent confidence interval.

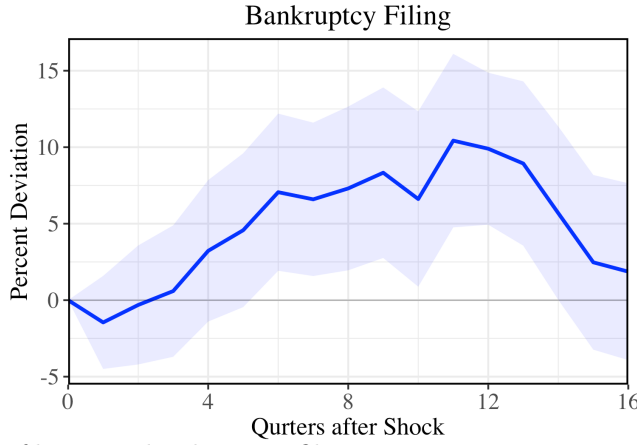


Figure 3. : IRF of business bankruptcy filing to 1 percent contractionary monetary policy shock. The shaded area represents 90 percent confidence interval.

## II. The Model

In the previous section, I showed that monetary shocks could cause disturbances in the financial sector through impacting bankruptcy and liabilities of defaulted firms. These disturbances propagate throughout the economy due to the tight relationship between businesses and the financial sector. This observation leads us to question the effectiveness of standard Taylor rule, which ignores the financial sector, in stabilizing the economy following a monetary shock.

In this section, I present a model with endogenous default and see if incorporating variables from the financial sector like aggregate credit in the monetary

rule results in a better response of the economy to monetary shocks. The basis of the model is adopted from Melitz and Ghironi (2005) and Bilbiie, Ghironi and Melitz (2012). Endogenous default is incorporated in the model by following Rossi (2019), and the monopolistic banking sector is based on Gerali, Neri and Sessa (2010). There are four types of agents in the model that I explain in following sections: firms, households, banks, and central bank.

#### A. Firms

Firms in the economy produce three types of goods: final good, industry good, and intermediate good.

##### FINAL GOOD

The final good producer bundles the differentiated industry goods  $Y_t^I(i)$ , taking as given their price  $P_t^I(i)$  and sells the output  $Y_t$  at the competitive price  $P_t$ . The final good firm's optimization problem is:

$$(2) \quad \max_{Y_t^I(i)} \left\{ P_t Y_t - \int_0^1 Y_t^I(i) P_t^I(i) di \right\}$$

Subject to the CES production function:

$$(3) \quad Y_t = \left( \int_0^1 Y_t^I(i)^{\frac{\theta_i-1}{\theta_i}} di \right)^{\frac{\theta_i}{\theta_i-1}}$$

Where  $\theta_i$  is the elasticity of substitution between industry goods. The first order conditions give the demand functions for industry goods:

$$(4) \quad Y_t^I(i) = \left( \frac{P_t^I(i)}{P_t} \right)^{-\theta_i} Y_t$$

And the aggregate price in terms of industry good prices will be:

$$(5) \quad P_t = \left( \int_0^1 P_t^I(i)^{1-\theta_i} di \right)^{\frac{1}{1-\theta_i}}$$

Solving the model for symmetric equilibrium results in  $Y_t^I(i) = Y_t$  and  $P_t^I(i) = P_t$  for all sectors  $i$ .

##### INDUSTRY GOODS

Industry good producers buy the intermediate goods from the firms, bundle them and sell them to the final good producer. The Industry good producers

compete against each other in a monopolistic way and set the price in a Calvo (1983) fashion. The only reason for introducing the industry good producer in the model is to have nominal rigidities while the intermediate goods producers are setting price flexibly. The optimization problem of the firms consists of two stages. First, they minimize their expenditures on intermediate goods:

$$(6) \quad \min_{y_t(\omega)} \int_{\omega \in \Omega_t} p_t(\omega) y_t(\omega) d\omega$$

s.t.

$$(7) \quad Y_t^I = \left( \int_{\omega \in \Omega_t} y_t(\omega)^{\frac{\theta_f - 1}{\theta_f}} d\omega \right)^{\frac{\theta_f}{\theta_f - 1}}$$

Where  $\Omega$  is the set of operating firms and  $\theta_f$  is the elasticity of substitution between intermediate goods. Solving this problem results in:

$$(8) \quad \int_{\omega \in \Omega_t} p_t(\omega) y_t(\omega) d\omega = \lambda_t Y_t^I$$

and

$$(9) \quad y_t(\omega) = \left( \frac{p_t(\omega)}{\lambda_t} \right)^{-\theta_f} Y_t^I$$

Where

$$(10) \quad \lambda_t = \left( \int_{\omega \in \Omega_t} p_t(\omega)^{1 - \theta_f} d\omega \right)^{\frac{1}{1 - \theta_f}}$$

In the second stage, industry good firms set the price  $P_t^I$  to maximize their sum of discounted expected profit:

$$(11) \quad \max_{P_t^I} E_t \sum_{i=0}^{\infty} \xi^i \Lambda_{t,t+i} \left( \frac{P_t^I}{P_{t+i}} - \frac{\lambda_{t+i}}{P_{t+i}} \right) \left( \frac{P_t^I}{P_{t+i}} \right)^{-\theta_i} Y_{t+i}$$

Where  $\xi$  is the probability of having the chance to set the price.  $\Lambda_{t,t+i}$  is the stochastic discount factor that comes from the household side in the general equilibrium. The FOC results in:

$$(12) \quad E_t \sum_{i=0}^{\infty} \Lambda_{t,t+i} \xi^i \left[ (1 - \theta_i) \frac{P_t^{*I}}{P_{t+i}} + \theta_i \frac{\lambda_{t+i}}{P_{t+i}} \right] \frac{1}{P_t^{*I}} \left( \frac{P_t^{*I}}{P_{t+i}} \right)^{-\theta_i} Y_{t+i} = 0$$

Where the  $P_t^{*I}$  is the optimal price that firm can set.

Since I assume that the sectors are symmetric in equilibrium, the following



equation will be the law of motion for the aggregate price in the economy:

$$(13) \quad P_t^{1-\theta_i} = (1-\xi)(P_t^{*I})^{1-\theta_i} + \xi P_{t-1}^{1-\theta_i}$$

#### INTERMEDIATE GOODS

The model is populated by unit mass of sectors. In each sector, there are  $N_t$  measure of firms, indexed by  $i$ , which are competing against each other in a monopolistic way. Firms have a linear production function and only use labor  $l_{it}$  as their input:  $y_{it} = z_{it}l_{it}$ .  $z_{it}$  is the productivity of firm  $i$  that will be drawn from a Pareto distribution in each period. The CDF of the distribution is given by  $G(z_t) = 1 - (\frac{zm}{z_t})^\alpha$ .

Following Rossi (2019), I assume that each firm has to pay a fixed production cost of  $f^F$  in terms of final good in each period. This fixed cost needs to be financed at the beginning of each period by borrowing  $b_{it}$  from the financial sector prior to drawing the productivity. Firms have to pay the loan back at the end of the same period. Therefore, the real profit  $d_{it}$  of firm  $i$  in time  $t$  can be written as:

$$(14) \quad d_{it} = \frac{p_{it}}{P_t} y_{it} - w_t l_{it} - f^F + b_{it} - b_{it}(1 + r_t^b)$$

$p_{it}$  is the price of the intermediate good,  $P_t$  is the price of final good,  $w_t$  is the real wage, and  $r_t^b$  is the interest rate.

A firm given staying in the market will solve the following static problem:

$$(15) \quad \max_{p_{it}} \left( \frac{p_{it}}{P_t} - \frac{w_t}{z_{it}} \right) y_{it} - f^F (1 + r_t^b)$$

s.t.

$$(16) \quad y_{it} = \left( \frac{p_{it}}{\lambda_t} \right)^{-\theta_f} Y_t^I$$

The FOC results in<sup>6</sup>:

$$(17) \quad p_{it} = \frac{\theta_f}{\theta_f - 1} \frac{w_t}{z_{it}} P_t$$

$\tilde{v}_t$ , the value of the entrants and incumbents after production, will be equal to the present value of the expected stream of the average real profit  $\tilde{d}_t$ :

$$(18) \quad \tilde{v}_t = E_t \sum_{i=1}^{\infty} \Lambda_{t,t+i} \tilde{d}_{t+i}$$

<sup>6</sup>Here is where the competition channel can be embedded in the model. Due to time constraint, I ignored this channel for now.

## ENTRY AND DEFAULT DECISIONS

In each period and for each sector, there is an unbounded measure of prospective firms which consider entering the market. Prior to entry, firms are identical and face an exogenous sunk entry cost of  $f^E$  in terms of final good (as in Bergin and Corsetti (2008)). The number of entrants  $N_t^E$  will be pinned down by free entry condition:  $\tilde{v}_t = f^E$ . The prospective firms that pay the sunk entry cost, will enter the market in the next period.<sup>7</sup>

After borrowing from the banks, incumbent and entrant firms draw their productivity from a Pareto distribution. Then they calculate their expected present value of the flow of their profit and decide if it is profitable to operate in the economy or default on the loan. Defaulting on the loan results in leaving the market. In this framework, the firms that have a productivity higher than  $\underline{z}_t$  will stay in the market and firms with  $\underline{z}_t$  earns zero net present profit:

$$(19) \quad d_t(\underline{z}_t) + \tilde{v}_t = 0$$

By having the number of entrants and incumbents and the probability of default, the law of motion of the number of operating firms will be:

$$(20) \quad N_t = \eta_t(N_{t-1} + N_{t-1}^E)$$

Where  $1 - \eta_t$ , the probability of default, is equal to  $1 - (\frac{z_m}{\underline{z}_t})^\alpha$ .

## B. Households

The representative household lives forever, consumes final good  $C_t$ , supplies labor  $L_t$ , and maximizes the sum of expected discounted utility given the budget constraint that faces in each period. Household deposits  $D_t^h$  in banks and earns interest with the rate  $r_t^d$ . Also, she invests in the stock of mutual fund of firms by buying share  $s_{t+1}$  of the fund.

$$(21) \quad \max_{C_t, L_t, D_t^h, s_t} E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\phi}}{1+\phi} \right)$$

Subject to:

$$(22) \quad C_t + D_t^h + (N_t + N_t^E)\tilde{v}_t s_{t+1} = w_t L_t + (1 + r_{t-1}^d) \frac{D_{t-1}^h}{\pi_t} + N_t(\tilde{d}_t + \tilde{v}_t)s_t + N_t f^F$$

Where  $\pi_t = \frac{P_t}{P_{t-1}}$ . FOCs imply that:

<sup>7</sup>This one period lag is a way to consider the time-to-build period as in BGM (2012).

$$(23) \quad C_t^\sigma L_t^\phi = w_t$$

$$(24) \quad 1 = \beta(1 + r_t^d) \mathbb{E}_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{1}{\pi_{t+1}} \right]$$

$$(25) \quad \tilde{v}_t = \beta \mathbb{E}_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \eta_{t+1} (\tilde{d}_{t+1} + \tilde{v}_{t+1}) \right]$$

Forward iteration of the FOC for share holdings and the absence of speculative bubbles yield the asset price given in equation 18, And the stochastic discount factor:

$$(26) \quad \Lambda_{t,t+i} = \beta^i \left( \frac{C_{t+i}}{C_t} \right)^{-\sigma} \prod_{s=1}^i \eta_{t+s}$$

### C. The Banking Sector

The structure of banking sector is adopted from Gerali, Neri and Sessa (2010). Each bank has three different branches, two retail branches and one wholesale branch. The retail branches are responsible for raising differentiated deposits and giving out differentiated loans. The wholesale unit manages the capital position of the group. Retail branches in this framework can have monopolistic power and set the rates for loans and deposits, while the wholesale branches compete in a competitive market.

#### WHOLESALE BRANCH

Wholesale branch combines bank capital  $K_t$  and wholesale deposits  $D_t$  and issue wholesale loans  $B_t$ . The balance sheet identity has to hold for the banks. The total amount of loans equals the sum of deposits and banks' capital :

$$(27) \quad B_t = D_t + K_t$$

The bank capital adjusts slowly through accumulation of banks earnings:

$$(28) \quad \pi_t K_t = (1 - \delta) K_{t-1} + J_{t-1}$$

$J_t$  is overall real profits made by three branches of each bank and  $\delta$  measures resources used up in managing bank capital.

Also banks have to abide by banking regulations on capital requirements. I assume that banks target an exogenous capital adequacy ratio  $\nu$ , which is set by

policy maker. Deviation from this target is costly. Banks use the risk weights that are also determined by the regulator to calculate the capital adequacy ratio<sup>8</sup>. In order to see the effect of this regulation in this framework I make another simplifying assumption. In periods that more default occurs, the risk-weighted asset of a bank is larger. I define  $B_t^W = \zeta B_t + (1 - \zeta)w^b B_t$  as the risk weighted asset of a bank in time  $t$ .  $\zeta$  is the share of the loans that firms do not default on, and  $w^b$  is the risk weight associated with defaulted loans.

I assume that banks have access to unlimited finance at the policy rate  $r_t$ . The optimization problem of wholesale branch is to choose loans and deposits so to maximize the discounted sum of real cash flows:

$$(29) \quad \max_{B_t, D_t} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ (1 + R_t^b) B_t - B_{t+1} \pi_{t+1} + D_{t+1} \pi_{t+1} - (1 + r_t) D_t + \right. \\ \left. (K_{t+1} \pi_{t+1} - K_t) - \frac{\kappa}{2} \left( \frac{K_t}{B_t^W} - \nu \right)^2 K_t \right]$$

Subject to balance sheet constraint. The FOC results in:

$$(30) \quad R_t^b = r_t - \kappa \left( \frac{K_t}{B_t^W} - \nu \right) \left( \frac{K_t}{B_t^W} \right)^2$$

#### RETAIL BANKING: LOAN BRANCH

I assume that households offer a basket of differentiated deposits that is bundled using a CES aggregator. Likewise, each firm demands a basket of differentiated loan bundled using a CES aggregator.

Retail loan branch  $j$  borrows  $B_t(j)$  from the wholesale branch and sells them to the firms charging a markup. Since firms borrow before drawing their productivity, bank  $j$  charges all of them with the same rate  $r_{jt}^b$ . Each firm demands a CES bundle of loans from all banks and the banks compete in a monopolistic way to supply the loans. Given the demand of a firm for the bundle of loans  $b_t$ , the demand for loans of bank  $j$  will be:

$$(31) \quad b_{jt} = \left( \frac{r_{jt}^b}{r_t^b} \right)^{-\epsilon^b} b_t$$

Where  $\epsilon^b$  is the elasticity of substitution between banks, and  $r_t^b = \left( \int_0^1 r_{jt}^b {}^{1-\epsilon^b} dj \right)^{\frac{1}{1-\epsilon^b}}$ .

The profit maximization problem of the retail loan branch  $j$ , assuming flexible

<sup>8</sup>According to Basel III guidelines, risk weight of a loan changes from 100 percent to 150 percent if the loans becomes past due. In contrast, Risk weight of a loan generally does not change if the loan becomes past due according to Basel I, except for certain residential mortgage loans.

rates, is:

$$(32) \quad \max_{r_{jt}^b} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ \eta_t r_{jt}^b b_{jt} - R_t^b B_{jt} - \gamma(1 - \eta_t) b_{jt} \right]$$

subject to  $B_{jt} = b_{jt}$  and 31.

Assuming symmetric equilibrium results in  $b_{jt} = b_t$ , and  $B_{jt} = B_t$ . From the FOC and imposing symmetry the rate of loans will be:

$$(33) \quad r_t^b = \frac{\epsilon_b}{(\epsilon_b - 1)\eta_t} (R_t^b + \gamma(1 - \eta_t))$$

Where  $\gamma$  is the ratio of loans of defaulted firms that are not going to be repaid to the bank.

#### RETAIL BANKING: DEPOSIT BRANCH

The retail deposit branch  $j$  collects the deposit from households and passes the raised funds  $D_{jt}$  to the wholesale branch and earn interest with rate of  $r_t$ . Household offers a CES bundle of deposits to all retail banks, seeking to maximize his revenue from total saving. The retail deposit banks compete with each other on rates that they offer to the household. Given the total unit of bundled deposit  $D_t^h$  that a household wants to save, bank  $j$ 's demand of deposit  $d_{jt}$  from the household will be:

$$(34) \quad d_{jt} = \left( \frac{r_{jt}^d}{r_t^d} \right)^{-\epsilon^d} D_t^h$$

Where  $\epsilon^d$  is the elasticity of substitution between banks and  $r_t^d = \left( \int_0^1 r_{jt}^d 1 - \epsilon^d dj \right)^{\frac{1}{1 - \epsilon^d}}$ .

The optimization problem of retail deposit branch  $j$  will be:

$$(35) \quad \max_{r_{jt}^d} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ r_t D_{jt} - r_{jt}^d d_{jt} \right]$$

Subject to 34 and  $D_{jt} = d_{jt}$ . From the FOC and imposing symmetry condition the interest rate on deposits will be:

$$(36) \quad r_t^d = \frac{\epsilon^d}{\epsilon^d - 1} r_t$$

The aggregate profit of the branch is sum of the profit of these three branches.

Deleting intragroup transaction yields:

$$(37) \quad J_t = \eta_t r_t^b b_t - r_t^d D_t - \frac{\kappa}{2} \left( \frac{K_t}{B_t} - \nu \right)^2 K_t - \gamma(1 - \eta_t) b_t$$

#### D. Market Clearing

The equilibrium is symmetric across industries. In the equilibrium, all markets should clear. The clearing condition for the deposit market is  $D_t^h = D_t$ , for the loan market is  $b_t = B_t = N_t f^F$ , and for the labor market is  $\int_{\omega \in \Omega} l_t(\omega) d\omega = L_t$ .

The final good will be consumed by consumers and accumulated as bank capital. Firms use final good to pay for the sunk entry costs and the fixed cost of production. Also, banks use it to pay their adjustment costs. The market clearing condition for final good is:

$$(38) \quad Y_t = C_t + J_t + \frac{\kappa}{2} \left( \frac{K_t}{B_t^w} - \nu \right)^2 K_t + N_t^E f^E$$

Since I assume that the fixed cost of production will be paid to the households, it does not enter the market clearing equation of final good.

#### E. Central Bank

To close the model, I assume that central bank follows an adjusted Taylor rule:

$$(39) \quad \ln\left(\frac{1+r_t}{1+r}\right) = \phi_r \ln\left(\frac{1+r_{t-1}}{1+r}\right) + (1 - \phi_r) \left( \phi_\pi \ln\left(\frac{\pi_t}{\pi}\right) + \phi_x \ln\left(\frac{x_t}{x}\right) \right) + \epsilon_t$$

$x_t$  is a variable from the financial sector like aggregate credit or default rate, and  $x$  is its steady state value.  $r$  and  $\pi$  are the steady state values for interest rate and inflation.  $\phi_\pi$  and  $\phi_x$  are the elasticity of the nominal interest rate with respect to the deviation of inflation and credit variable from their steady states.  $\phi_r$  is the degree of persistence in the interest rate rule. Following Tayler and Zilberman (2016), I did not include output in the policy rule, since a response to output in the Taylor rule results in negligible welfare gains (see also Schmitt-Grohé and Uribe (2007)).  $\epsilon_t$  is an AR(1) monetary policy shock with persistence  $\rho_\epsilon$  and standard error  $\sigma_\epsilon$ .

#### F. Calibration

I set  $\beta = 0.99$  and  $\sigma = 2$  which are standard choices for quarterly business cycle models. Following Gerali, Neri and Sessa (2010), I choose  $\epsilon_d = -1.46$  and  $\epsilon_b = 3.12$ . The Frisch elasticity of labor supply  $\phi$  is set at 4 as in Bilbiie, Ghironi and Melitz (2012). The bank capital adequacy ratio  $\nu$  is set at 0.08, which represents a floor value under Basel III. Risk weight of past due loans  $\omega^b$

is set at 1.5, according to Basel III.  $\eta = 0.9707$  as in Rossi (2019). I set  $\gamma = 0.16$  which results in 13 percent annual rate for bank loans. I assume  $\theta_i = \theta_f = \theta$  and use Bernard, Eaton, Jensen, and Kortum (2003) to set  $\theta = 3.8$ , which was calibrated to fit U.S. plant and macro trade data.

Following Melitz and Ghironi (2005),  $Z_m$  and  $F_E$  are normalized to one and  $\alpha = 3.4$ .  $\delta$  is set at 0.20 which ensures that the ratio of bank capital to risk weighted loans is 0.08.  $\zeta$ , the parameter that governs price rigidity is set at 0.86. I set  $\rho_\epsilon = 0.82$  and  $\phi_r = 0.18$ , values that are used in Lewis and Poilly (2012).

### III. Impulse Response Functions<sup>9</sup>

In this section, I compare three different monetary policy rules. The benchmark policy rule (Policy I) only considers the inflation rate and ignores other variables. For this policy, I set  $\phi_\pi = 2$  and  $\phi_x = 0$  in equation 39. The other policy (Policy II) includes aggregate credit  $B_t$  in the rule. While fixing the  $\phi_\pi = 2$ ,  $\phi_x = 0.08$  gives the best response of output to the shock by minimizing the deviation of output from the steady-state. Likewise, the other policy rule (Policy III) considers the default rate by including  $\eta_t$  and setting  $\phi_x = 0.10$  to obtain the least deviation of output from steady-state.

Figure 4 presents the IRFs of several variables of the model to 1 percent contractionary monetary shock. Both alternative policies result in lower deviation of output and inflation from their steady-state values. The model, however, cannot replicate the effect of monetary shock on default rate correctly. As figure 4 shows,  $\eta$  increases after the contractionary shock hits, which means that the default rate falls. Lack of rigidity in wages might be one of the possible reasons. When the shock hits, the real wage drops a lot so that the production cost of firms decreases and fewer firms have an incentive to default. Incorporating wage rigidity might resolve this issue.

The other problematic observation is that the number of entry  $N_E$  responds drastically to the shock. In general, the number of firms in the models of endogenous entry and exit plays the role of capital in standard business cycle models. In these models, the change in the number of firms is equivalent to the investment. Introducing some types of adjustment cost of entry, similar to the capital adjustment costs in the business cycle models would dampen the extreme response of entry to the shocks.

<sup>9</sup>In order to compare different monetary policies, I need to define an objective function for the central bank and then find the optimal monetary policy by maximizing this objective function. Due to time constraint, I provide a naive approach of comparison and will complete this section in the future.

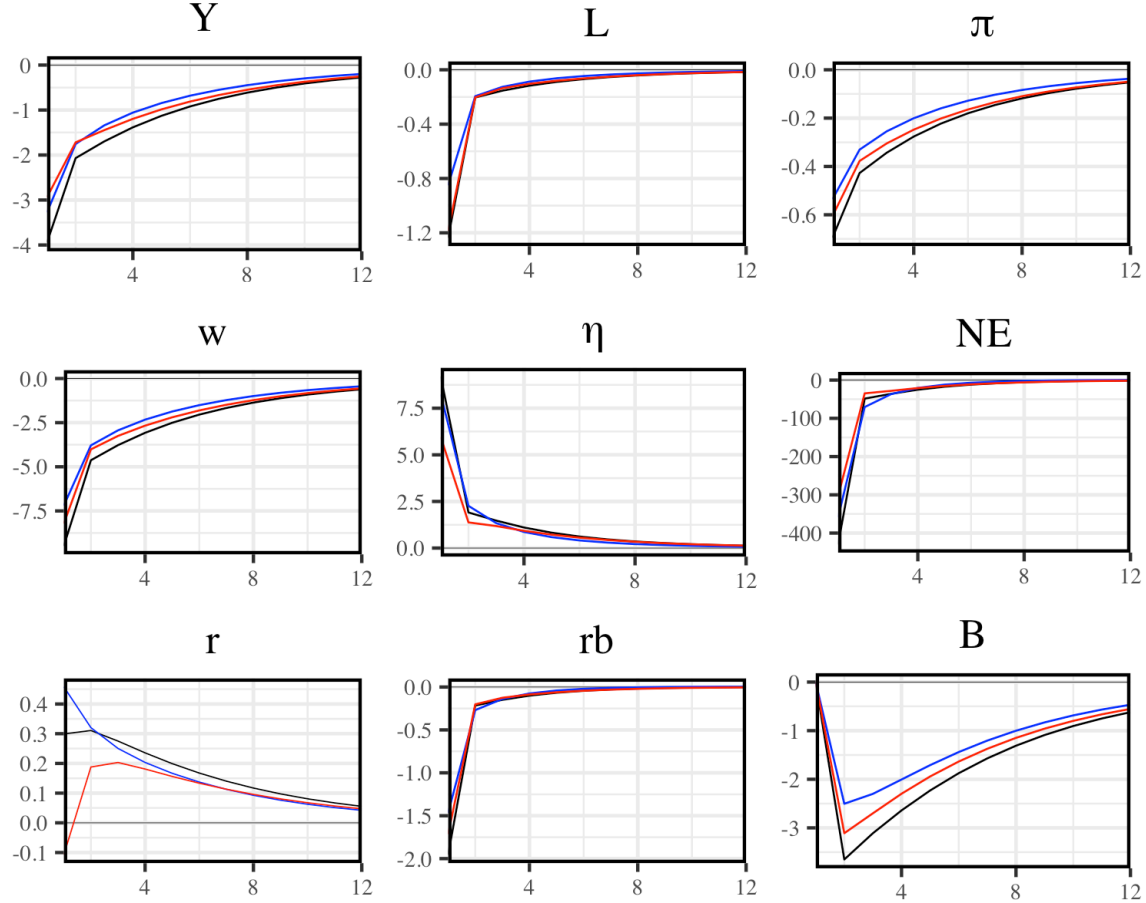


Figure 4. : Impulse response functions to 1 percent contractionary monetary shock under three different monetary rules: policy I, II, and III. The y-axis represents the percent deviation from the steady state.

#### IV. Conclusion

In this paper, I showed that contractionary monetary shocks increase the number of defaults. Also, the aggregate liability of defaulted firms rises following the shock. I provided a model with endogenous default and investigated the propagation mechanisms of monetary shocks. Based on the model, I compared different monetary policies and their effectiveness in response to monetary shocks.

The paper, in its current version, suffers from several shortcomings. In the empirical section, other methods of shock identification and estimating the IRFs



has to be added. The theoretical model also needs improvement in several dimensions. First, it has to be modified so that it becomes capable of replicating the empirical facts regarding entry and bankruptcy. Adding wage rigidity and adjustment cost for entry might help resolve this issue. Second, the competition channel is currently ignored in the model and also needs to be added. Third, different monetary policies should be compared after finding the optimal monetary policy by introducing an objective function for the central bank. Fourth, there are assumptions in the model that makes it less credible and thus need to be relaxed. For instance, the productivity of a firm is independently drawn in each period and does not depend on its previous values. Also, Firms are identical at the time of borrowing and do not face any collateral constraint.

### Appendix A: Testing Symmetry and Linearity

One of the assumptions behind the equation 1 is that responses to positive and negative shocks are identical except for their sign. In other words, positive and negative shocks affect  $y_t$  in a symmetric way. We can test the assumption of symmetry using the following specification, as used in Tenreyro and Thwaites (2016) and Wong (2015). This specification allows for responses to differ condition on the sign of shocks:

$$(40) \quad y_{t+h} - y_t = \beta'_h \mathbf{X}_t + \gamma_h^+ s_t^+ + \gamma_h^- s_t^- + \epsilon_{t,h}$$

Where  $s_t^+ = \max\{0, s_t\}$  and  $s_t^- = \min\{0, s_t\}$ .  $s_t^+$  represents the contractionary shocks and  $s_t^-$  the expansionary ones. Then we can simply test the null hypothesis of  $H_0 : \gamma_h^+ = \gamma_h^-$  for all  $h : 1, 2, \dots, T$ . This time  $\mathbf{X}_t$  includes lags of both positive and negative shocks, as well as lags of  $y_t$ , a trend term and a constant.

We can also incorporate a quadratic form in the regression to see if this kind of non-linearity can have any explanatory power. Since the added term is always positive for positive and negative shocks, it generates another form of non-symmetry in our specification:

$$(41) \quad y_{t+h} - y_t = \beta'_h \mathbf{X}_t + \gamma_h s_t + \delta_h s_t^2 + \epsilon_{t,h}$$

In order to test the quadratic form against the linear one, the null hypothesis will be  $H_0 : \delta_h = 0$  for all  $h : 1, 2, \dots, T$ .

Figure 5 and figure 7 show the IRF of business failure to monetary shocks. Figure 5 tests the null hypothesis of symmetry of shock and figure 7 tests the null hypothesis of linearity of shocks. As we see, the null hypothesis cannot be rejected using 90 percent confidence interval.

Figure 6 and figure 8 repeats the same exercises for the total liability. We can reject the null hypothesis of symmetry for some periods and the null hypothesis of linearity for most of the periods.

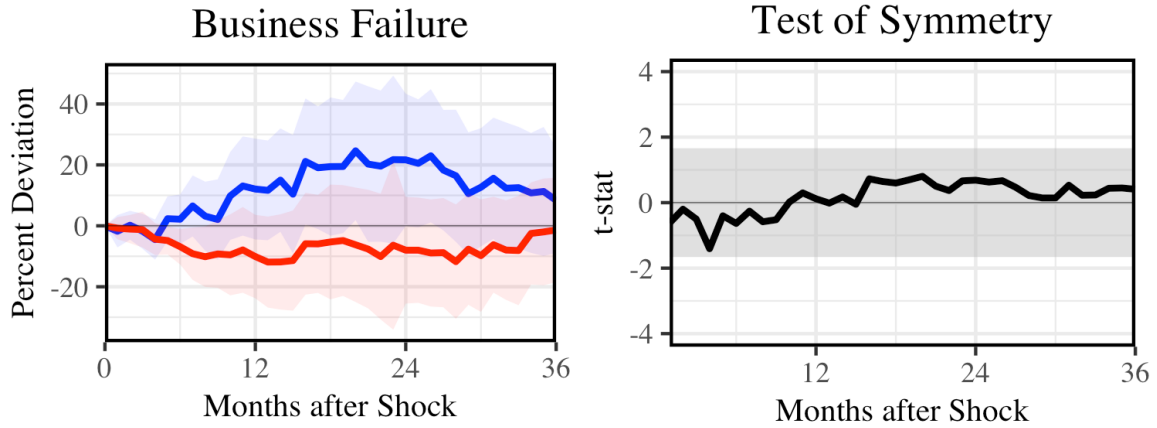


Figure 5. : *Left*: IRF of business failure to 1 percent contractionary (blue) and expansionary (red) monetary policy shock, using equation 40. *Right*: Testing the null hypothesis of having symmetry respect to negative and positive shocks. 6 lags of both positive and negative shocks have been used as control. The shaded areas represent 90 percent confidence interval.

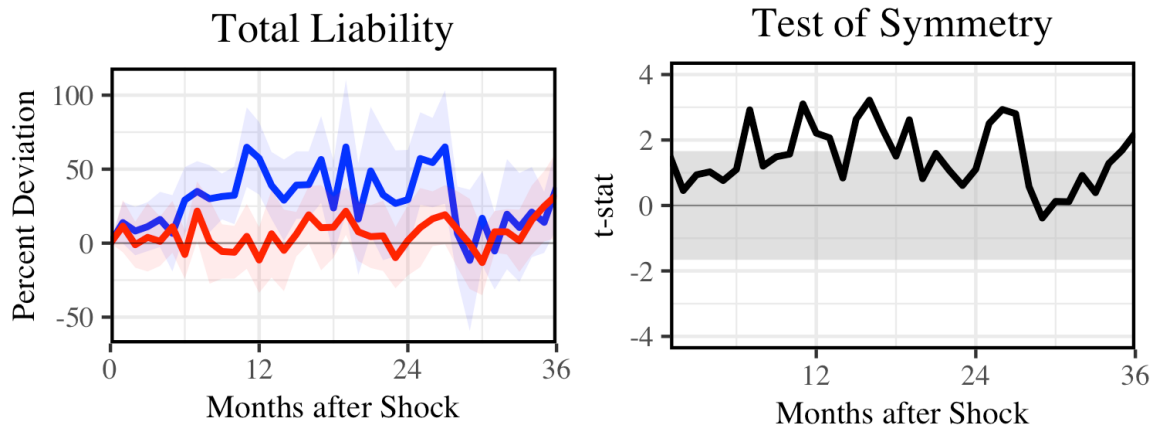


Figure 6. : *Left*: IRF of total liability of defaulted firms to 1 percent contractionary (blue) and expansionary (red) monetary policy shock, using equation 40. *Right*: Testing the null hypothesis of having symmetry respect to negative and positive shocks. The shaded areas represent 90 percent confidence interval.

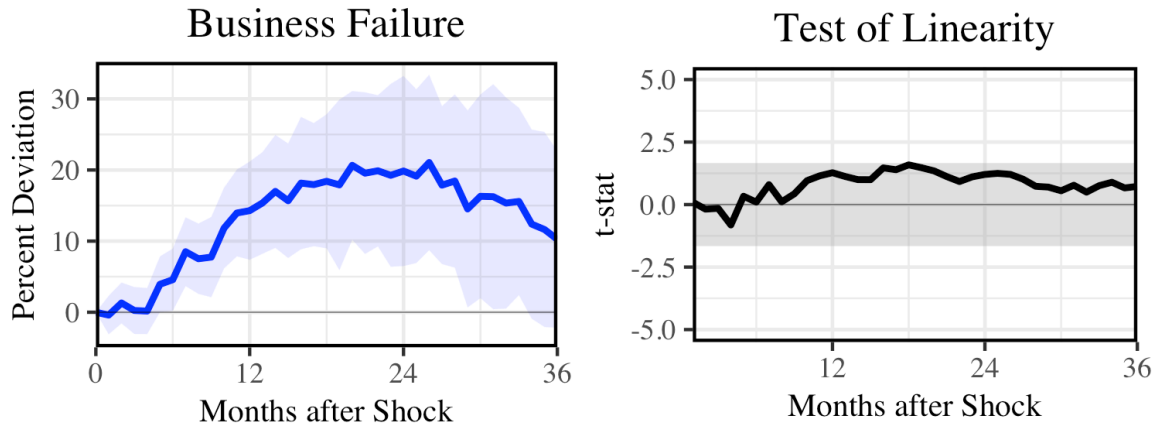


Figure 7. : IRF of business failure to 1 percent contractionary monetary shock, using equation 41. *Right:* Testing the null hypothesis of having linear specification respect to shocks. The shaded area represents 90 percent confidence interval.

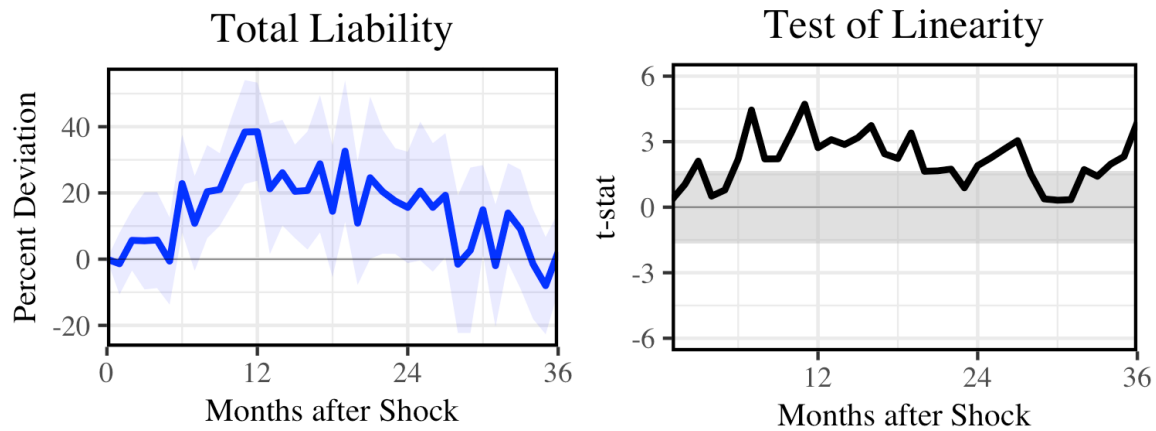


Figure 8. : *Left:* IRF of total liabilities of defaulted firms to 1 percent contractionary monetary shock, using equation 41. *Right:* Testing the null hypothesis of having linear specification respect to shocks. The shaded area represents 90 percent confidence interval.

## Appendix B: VAR Evidence

Since not all of the business failures result in exiting the market, here I provide additional evidence on the effect of monetary shock on exit. The data on the number of establishment exit comes from BED. It has universal coverage and extends from 1992Q3-2018Q3. Since R&R monetary shocks are not available after 2008Q4, utilizing R&R shocks for estimating IRFs results in losing almost half of the observations from 2008Q4-2018Q3. Therefore, I follow Uskula (2016) and estimate the impulse response function by using a VAR model.

The variables that are included in the model are Real GDP, GDP deflator, Establishment exit<sup>10</sup>, and federal fund rates. I use the shadow interest rate of Wu and Xia (2015) for periods from 2009Q3-2015Q3, to account for the unconventional measures.

Monetary policy shocks are identified by using the recursive approach, which is popular in the empirical literature. This approach assumes that the monetary shocks cannot have a contemporaneous impact on the variables that are inside the information set of the central bank. In the VAR model, I assume that all variables are inside the policymaker's information set. Thus, the federal fund rate is placed at the end.

Figure 9 presents the IRFs of variables of the model to one standard deviation contractionary monetary shock. The interest rate rises by around 0.3 percent after the shock hits. The number of establishment exit increases following the contractionary shock by 1 percent, and the effect is statistically significant. The results of real GDP and inflation are similar to other VAR models such as Altig et al. (2011). The inflation rate rises for a couple of periods and then falls. Real GDP also falls following the shock.

<sup>10</sup>Uskula (2016) uses establishment death, a subset of establishment exit, instead of the overall number of establishment exit in his VAR model. Other than this difference, this section follows Uskula (2016) closely.

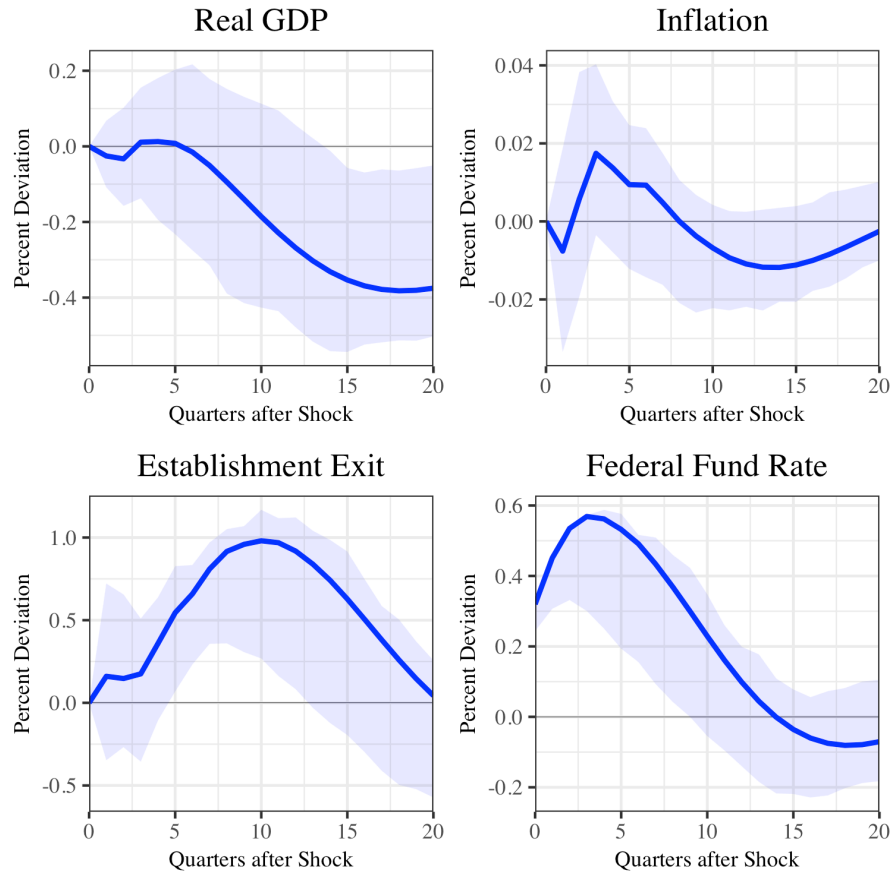


Figure 9. : *IRFs of variables in the VAR model to one standard deviation contractionary monetary shock. Shaded area represents the 90 percent confidence interval.*

## REFERENCES

- Altig, David, Lawrence J. Christiano, Martin Eichenbaum, and Jesper Lindé.** 2011. "Firm-specific capital, nominal rigidities and the business cycle." *Review of Economic Dynamics*, 14(2): 225–247.
- Angelini, Paolo, Stefano Neri, and Fabio Panetta.** 2014. "The Interaction between Capital Requirements and Monetary Policy." *Journal of Money, Credit and Banking*, 46(6): 1073–1112.
- Angeloni, Ignazio, and Ester Faia.** 2013. "Capital regulation and monetary policy with fragile banks." *Journal of Monetary Economics*, 60(3): 311–324.
- Bergin, Paul R., and Giancarlo Corsetti.** 2008. "The extensive margin and monetary policy ." *Journal of Monetary Economics*.
- Bhamra, Harjoat S., Adlai J. Fisher, and Lars Alexander Kuehn.** 2011. "Monetary policy and corporate default." *Journal of Monetary Economics*, 58(5): 480–494.
- Bilbiie, Florin O, Fabio Ghironi, and Marc J Melitz.** 2012. "Endogenous Entry, Product Variety, and Business Cycles." *Journal of Political Economy*, 120(2): 304–345.
- Campbell, Jeffrey R., and Hugo A. Hopenhayn.** 2005. "Market size matters." *Journal of Industrial Economics*, 53(1): 1–25.
- Christiano, Lawrence, Roberto Motto, and Massimo Rostagno.** 2006. "Monetary Policy and Stock Market Boom-Bust Cycles."
- Clarida, Richard, Jordi Galí, and Mark Gertler.** 2000. "Monetary policy rules and macroeconomic stability: Evidence and some theory." *Quarterly Journal of Economics*, 115(1): 147–180.
- Coibion, Olivier, Yuriy Gorodnichenko, Lorenz Kueng, and John Silvia.** 2012. "Innocent Bystanders? Monetary Policy and Inequality in the U.S.; by Olivier Coibion, Yuriy Gorodnichenko, Lorenz Kueng, and John Silvia; IMF Working Paper 12/199; August 1, 2012."
- Cúrdia, Vasco, and Michael Woodford.** 2010. "Credit Spreads and Monetary Policy." *Source: Journal of Money, Credit and Banking*, 42(15289): 3–35.
- Cúrdia, Vasco, and Michael Woodford.** 2016. "Credit Frictions and Optimal Monetary Policy." *Journal of Monetary Economics*, 84: 30–65.
- Gerali, Andrea, Stefano Neri, and Luca Sessa.** 2010. "Credit and Banking in a DSGE Model of the Euro Area." *Journal of Money, Credit and Banking*, 42(6).
- Jordà, scar.** 2005. "Estimation and inference of impulse responses by local projections." *American Economic Review*, 95(1): 161–182.
- Kannan, Prakash, Pau Rabanal, and Alasdair M Scott.** 2012. "Monetary and Macroprudential Policy Rules in a Model with House Price Booms." *Journal of Macroeconomics Contributions*, 12(1): 16.

- Lewis, Vivien, and Cline Poilly.** 2012. "Firm entry, markups and the monetary transmission mechanism." *Journal of Monetary Economics*, 59(7): 670–685.
- Melitz, Marc J, and Fabio Ghironi.** 2005. "International trade and macroeconomic dynamics with heterogeneous firms." *Quarterly Journal of Economics*, , (August).
- Newey, Whitney K, and Kenneth D West.** 1987. "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Author(s): Whitney K. Newey and Kenneth D. West Source:." *Econometrica*, 55(3): 703–708.
- Romer, Christina D, and David H Romer.** 2004. "A New Measure of Monetary Shocks: Derivation and Implications." *American Economic Review*, 94(4): 1055–1084.
- Rossi, Lorenza.** 2019. "The overshooting of firms destruction, banks and productivity shocks." *European Economic Review*, 113(612796): 136–155.
- Rubio, Margarita, and Jos A. Carrasco-Gallego.** 2014. "Macroprudential and monetary policies: Implications for financial stability and welfare." *Journal of Banking and Finance*, 49: 326–336.
- Schmitt-Grohé, Stephanie, and Martn Uribe.** 2007. "Optimal simple and implementable monetary and fiscal rules." *Journal of Monetary Economics*, 54(6): 1702–1725.
- Taylor, William J., and Roy Zilberman.** 2016. "Macroprudential regulation, credit spreads and the role of monetary policy." *Journal of Financial Stability*, 26: 144–158.
- Tenreyro, Silvana, and Gregory Thwaites.** 2016. "Pushing on a string: Us monetary policy is less powerful in recessions." *American Economic Journal: Macroeconomics*, 8(4): 43–74.
- The Dun & Bradstreet business failure record.** 1980. "The Dun & Bradstreet business failure record." Business Economics Division, Dun & Bradstreet,, New York.
- Uusküla, Lenno.** 2016. "Monetary transmission mechanism with firm turnover." *Journal of Macroeconomics*.
- Wong, Arlene.** 2015. "Population Aging and the Transmission of Monetary Policy to Consumption." 2015: 1–78.
- Wu, Jing Cynthia, and Fan Dora Xia.** 2015. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound Fan Dora Xia Working Paper No . 13-77 Measuring the Macroeconomic." 48(2).