NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

*Mariia A. Elkina*

# FINANCIAL REPRESSION AND TRANSMISSION OF MACROECONOMIC SHOCKS IN A DSGE MODEL WITH FINANCIAL FRICTIONS

BASIC RESEARCH PROGRAM
WORKING PAPERS

SERIES: ECONOMICS
WP BRP 246/EC/2021

*SERIES:* *ECONOMICS*

*Mariia A. Elkina* [1]

# FINANCIAL REPRESSION AND TRANSMISSION OF MACROECONOMIC SHOCKS IN A DSGE MODEL WITH FINANCIAL FRICTIONS [2]

Financial repression (FR) allows the government to save on its interest rate payments. However, forcing financial intermediaries to increase the share of government debt in their portfolios can alter transmission of macroeconomic shocks. In this paper, we raise the question whether it is the case. Simulations of a DSGE model with financial frictions indicate that the presence of FR creates an additional link between changes in government fiscal position and dynamics of corporate credit terms. Holding regulatory environment constant, if government wishes to issue more debt, it has to offer higher return on its debt and reduce its FR revenues. Lower FR revenues translate into better borrowing terms for entrepreneurs and higher private investment. Hence, FR can either amplify or dampen output response to the shock, depending on whether this shock increases or decreases government financing needs.

JEL Classification: E32, E60, H60.

Keywords: financial repression, business cycle, government debt, general equilibrium, financial frictions.

[1] Financial Research Institute of the Ministry of Finance of the Russian Federation, Centre for Macroeconomic Research, Junior Research Fellow. National Research University Higher School of Economics, International Laboratory for Macroeconomic Analysis, Research Intern. E-mail: elkina@nifi.ru

[2] This Working Paper was prepared within the framework of the Basic Research Program at the National Research University Higher School of Economics (HSE)

# 1 Introduction

Financial repression (FR) allows government to reduce interest payments on its debt by imposing various constraints on financial sector. Well-known FR measures include interest rate caps, capital controls, etc. Currently FR policies tend to take less explicit forms. [Reinhart, 2012] describes recent examples of FR in advanced economies and emerging markets. Among other examples of FR she mentions redirecting domestic credit to the government via state-owned banks and pension funds which are characterized by a comparatively high share of government bonds in their portfolios.

Recent surge in government debt raised the question whether economic agents should expect tightening of FR policies. FR is indeed an efficient way to reduce the level of government debt. Empirical studies show that financial repression revenues can amount up to a few percentages of GDP per year (see [Reinhart and Sbrancia, 2015]; [Giovannini and de Melo, 1993]).

However, raising additional revenues comes at a cost. [Jafarov et al., 2019] document that the introduction of interest rate restrictions reduces economic growth by 0.4-0.7 p.p. [Fry, 1997] argues that a 1 p.p. deviation of interest rate from its equilibrium leads to a 0.5 p.p. decrease in economic growth. Further empirical evidence on the negative impact of financial repression on economic growth can be found in [Roubini and Sala-i Martin, 1992], [Haslag and Koo, 1999], [Lee and Shin, 2008], [Becker and Ivashina, 2017]. Accounting for this negative impact of FR on growth can reduce estimates of FR revenues (for example, see [Kriwoluzky et al., 2018], [Isakov and Pekarski, 2016]).

Another strand of literature is dedicated to the question when FR policies are optimal. In a recent study on this matter [Chari et al., 2020] show that if the government cannot commit to the absence of default, FR can be an efficient way to signal it. When banks involuntary hold substantial amounts of government debt, it is too costly for the government to default on it. Optimality of financial repression is also studied in [Bencivenga and Smith, 1992], [Bai et al., 2001], [Gupta, 2008], [Norkina and Pekarski, 2015], [Mamedli and Norkina, 2019].

However, there is one more aspect of FR effects on the economy, which is rarely studied in the literature. That is its impact on transmission of macroeconomic shocks. Financial repression constraints private sector's investment decisions. Consequently, it can either amplify or dampen the economy's response to various macroeconomic shocks. For example, it can alter transmission of monetary policy shocks or affect fiscal policy efficiency. The question is whether these FR effects are substantial and what is the mechanism behind them.

In this paper, we aim to study the impact of FR on transmission of macroeconomic shocks in a DSGE model. Using a structural microfounded model allows us to study the mechanisms behind FR effects. Studying these effects is important for several reasons. Firstly, if FR significantly amplifies or dampens the economy's response to various macroeconomic shocks, it affects households' welfare.

Secondly, if FR substantially affects transmission of macroeconomic shocks, it should be considered when analyzing drivers of the business cycle in practice.

That said, among all macroeconomic shocks a special attention is always paid to monetary policy and fiscal policy shocks. Existing literature provides a lot of evidence on their transmission mechanisms and factors which affect the efficiency of these policies. For example, [Christensen and Dib, 2008] document that the presence of financial frictions in the form of financial accelerator amplifies monetary policy shocks in a DSGE model. [Iacoviello and Neri, 2010] show that adding a housing market with collateral constraints to the model increases the sensitivity of consumption to a monetary policy shock but investment's response is not affected significantly. [Castelnuovo and Pellegrino, 2018] conclude that a higher level of uncertainty in the economy leads to its milder response to monetary policy shocks.

As for fiscal policy transmission mechanism, existing literature demonstrates that it might be important to allow for non-Ricardian households and complementarity between private consumption and government spending to capture fiscal policy effects (for example, see [Galí et al., 2007], [Bouakez and Rebei, 2007]). Otherwise, a positive government spending shock leads to a significant crowding-out of private consumption which is not supported by empirical literature. [Leeper et al., 2017] demonstrate that assumptions about the degree of nominal rigidities and monetary policy regime have a sizeable impact on the sensitivity of output to fiscal policy shocks.

Still, little is known about the impact of FR on the transmission of monetary policy and fiscal policy shocks. One of a few papers, which study the impact of FR on transmission mechanisms of macroeconomic shocks, is [Isakov and Pekarski, 2017]. Using a DSGE model with FR, authors conclude that increasing the share of government debt in private sector's portfolio lowers fiscal multipliers while increasing the difference between the return on government debt and the return on comparable assets raises fiscal multipliers. However, only fiscal policy shocks are studied in this paper. In addition, authors choose to model the return on government debt as an exogenous variable (i.e., FR allows the government to independently choose the share of government debt in total assets of the economy and the return on government debt). At the same time, it is important to explore the case when the return on government debt is determined endogenously (i.e., the government only controls the share of its debt in total assets).

Another interesting paper is [Funke et al., 2015]. Authors study the transmission of monetary policy in the presence of shadow banking and interest rate controls. They conclude that interest rate controls decrease the sensitivity of output and its components to monetary policy shocks. However, [Funke et al., 2015] do not consider other FR instruments which operate through forcing financial sector to increase its holdings of government debt.

This paper aims to fill the gap in the literature identified above. To achieve this goal, we use a DSGE model with financial frictions which builds on [Elkina and Pekarski, 2020]. Adding financial frictions to the model is justified by their importance in explaining business cycle fluctuations (for example, see [Doojav and Kalirajan, 2020]). We compare transmission of main macroeconomic shocks in two versions of the model: the one with FR and the one without it. We model FR as a constraint which forces banks to increase the share of government debt in their portfolios.

We conclude that FR indeed alters the transmission mechanisms of macroeconomic shocks. The difference between models with and without FR can be quite sizeable.

FR creates a link between the impact of macroeconomic shocks on the government budget and the dynamics of private investment. Suppose that some shock leads to accumulation of government debt because of a higher budget deficit. Then financially repressed private sector is eager to provide additional funds to the government only if the government offers a higher return on its debt (i.e. lowers FR revenue). Smaller difference between the return on government debt and the return on comparable assets stimulates private investment. The reason is that banks now face lower FR costs and can provide better borrowing terms to entrepreneurs.

Hence, depending on the direction of the impact of the shock on government debt, the presence of FR can either amplify or dampen the economy's response. In particular, FR dampens output response to monetary policy shocks. An increase in interest rates leads to a rise in government debt. In the presence of FR it is accompanied by an increase in private investment. A positive response of investment to a contractionary monetary policy shock is different from the prediction of a standard New Keynesian model. However, some empirical evidence suggests that initial response of private investment to a contractionary monetary policy shock can be positive (for example, see [Tenreyro and Thwaites, 2016]).

In addition, FR increases the sensitivity of output to fiscal policy shocks. A positive government spending shock leads to an increase in private investment in the presence of FR, not a decline. Hence, the overall positive output response is higher. Indeed, some empirical studies document crowding-in of private investment which is observed in the model with FR (see [Burriel et al., 2010], [Iwata, 2013]).

The rest of the paper is organized as follows. Section 2 describes the model and Section 3 reports on the calibration of the model. Section 4 studies the differences between specifications with and without FR. Conclusion summarizes the results of the analysis.

# 2 The model

The analysis presented in this paper bases on a New Keynesian DSGE model with financial frictions. The model is inspired by the model with financial frictions used in [Christiano et al., 2011], however, we make a number of adjustments justified by the goals of our paper. In particular, households' utility function is taken from [Smets and Wouters, 2007] because it might result in a more realistic description of the economy's response to monetary policy shocks. Since we are interested in examining fiscal policy effects too, we model fiscal side of the economy in a greater detail. We assume existence of distortionary taxes, government purchases and transfers to households. Fiscal rules which govern the dynamics of government purchases and transfers ensure stabilization of government debt. A certain fraction of households are non-Ricardian households, so that crowding-out effects of a government spending shock are mitigated. In addition, we abstract from open economy effects to focus on the impact of the introduction of FR in a simpler environment.

Economic agents who populate the economy include Ricardian and non-Ricardian households, entrepreneurs, banks, output producers and capital-producing firms. The government conducts fiscal policy by setting tax rates on consumption, labour and capital and choosing the level of government purchases and the level of transfers to households. Central bank sets short-term interest rate.

As was mentioned in the Introduction, we are going to compare two types of model: the one with FR and the one without it. FR is modelled as a regulatory constraint imposed on banks. This constraint forces banks to increase the share of government bonds in their portfolios. Firstly, we are going to describe the model with FR. Then we will comment on how to simplify the model to get the one without FR.

## 2.1 Households

The economy is populated by a continuum of households indexed by $i \in (0;1)$. Fraction $n$ of them are Ricardian households who solve the usual intertemporal utility maximization problem. Others are non-Ricardian households who do not have access to the financial market. Hence, their problem is static.

Ricardian household $i$ maximizes its utility (1) subject to the budget constraint (2) and the demand for its differentiated labour services (3):

$$\max_{C^i_{R,t}, L^i_{R,t}, W^i_t, D^i_{R,t}} \mathbb{E}_t \sum_{s=o}^{\infty} \beta^s e^{\eta^\beta_{t+s}} \left[ \frac{1}{1-\Omega^C} \left( \frac{C^i_{R,t+s} - he^{\bar{z}} C^a_{R,t+s-1}}{Z_{t+s}} \right)^{1-\Omega^C} - \frac{\chi}{1+\Omega^L} \left( L^i_{R,t+s} \right)^{1+\Omega^L} \right] \tag{1}$$

$$s.t. (1+\tau^C_t) P_t C^i_{R,t} + D^i_{R,t} = (1-\tau^W_t) W^i_t L^i_{R,t} - \Psi^W \left( \frac{W^i_t}{W^i_{t-1}} \right) W_t L_t + Tr^i_{R,t} + Div^i_{R,t} + H^i_{R,t} + R_{D,t-1} D^i_{R,t-1} \tag{2}$$

$$L^i_{R,t} = \left( \frac{W^i_t}{W_t} \right)^{-\zeta^L_t} L_t. \tag{3}$$

We assume existence of habit formation, so the household's utility depends on the difference between its current consumption $C^i_{R,t}$ and the average consumption of Ricardian households in the previous period $C^a_{R,t-1}$. Note that consumption is non-stationary and always grows in line with technological progress. Technological progress is described by the variable $Z_t$:

$$Z_t = Z_{t-1} e^{z_t} = Z_{t-1} e^{\rho^z z_{t-1} + (1-\rho^z)\bar{z} + \varepsilon^z_t}, \ \varepsilon^z_t \sim N\left(0, \sigma^2_z\right). \tag{4}$$

Hence, the dynamics of the Ricardian household's consumption can be divided into two components: stationary component $c^i_{R,t}$ (which describes fluctuations due to business cycle factors) and non-stationary component $Z_t$:

$$C^i_{R,t} = c^i_{R,t} Z_t. \tag{5}$$

The same is true for most of other variables in our model.

Budget constraint (2) states that the Ricardian household's income can either be consumed or saved in bank deposits $D^i_{R,t}$. When a household purchases consumption goods at price $P_t$, it also pays consumption tax at rate $\tau^C_t$. Note that one of the main sources of household's income is labour income $(1-\tau^W_t)W^i_t L^i_{R,t}$, where $W^i_t$ is the wage rate, $\tau^W_t$ is the labour tax rate, $L^i_{R,t}$ is the amount of labour services supplied by the Ricardian household $i$. Ricardian households act as wage-setters and choose optimal wages. However, changing the wage is subject to adjustment costs à la Rotemberg:

$$\Psi^W\left(\frac{W^i_t}{W^i_{t-1}}\right)=\frac{\psi^W}{2}\left(\frac{W^i_t}{e^{\bar{z}}W^i_{t-1}\left(1+\pi_{t-1}\right)^{\gamma^W}\left(1+\pi\right)^{1-\gamma^W}}-1\right)^2, \tag{6}$$

where $\pi_t$ is inflation rate at time $t$ and $\pi$ is steady state inflation rate.

Other sources of household's income are transfers from government $Tr^i_{R,t}$, dividends from firms $Div^i_{R_t}$, net receipts from entrepreneurs $H^i_{R,t}$ and repayment of previously made bank deposits at the gross interest rate $R_{D,t-1}$. Net receipts from entrepreneurs are determined in the following way. Each period a fraction of entrepreneurs $1-\gamma^E$ stop being entrepreneurs and become members of Ricardian households. Hence, they transfer all of their funds to Ricardian households. At the same time, each period a certain fraction of Ricardians become entrepreneurs so that the ratio of members of Ricadian households to entrepreneurs remains constant. Entrepreneurs who only started their businesses need start-up capital. It is provided by Ricardian households. Consequently, net receipts from entrepreneurs $H^i_{R,t}$ are the difference between gross receipts from entrepreneurs exiting the business and start-up capital provided to entrepreneurs who only started their businesses.

Equation (3) states that the demand for labour services provided by the household $i$ inversely depends on the ratio of the wage of household $i$ to the average wage in the economy $W_t$. Another factor which determines the demand for labour services provided by the household $i$ is the overall demand for labour $L_t$.

Note that Ricardian households are subject to several stochastic shocks. Firstly, their preferences are affected by shocks to intertemporal substitution (preference shocks):

$$\eta^\beta_t=\rho^\beta\eta^\beta_{t-1}+\varepsilon^\beta_t,\ \varepsilon^\beta_t\sim N\left(0,\sigma^2_\beta\right). \tag{7}$$

Secondly, the elasticity of the demand for labour is also subject to stochastic shocks (wage mark-up shocks):

$$\zeta^L_t=\zeta^L e^{\eta^L_t},\ \eta^L_t=\rho^L\eta^L_{t-1}+\varepsilon^L_t,\ \varepsilon^L_t\sim N\left(0,\sigma^2_L\right). \tag{8}$$

First order conditions of the Ricardian household's problem describe its optimal behaviour. These equations are not presented here, but they are available from the author upon request. Note that since all Ricardian households are identical, we can drop superscript $i$ in these first order conditions.

As mentioned above, the problem of non-Ricardian households is static: each period they consume all of their income. We adopt approach suggested by [Leeper et al., 2017] and assume that non-Ricardian households mirror behaviour of Ricardian households when it comes to choosing optimal wage and working hours $L^i_{NR,t}$. Hence, the non-Ricardian household's consumption $C^i_{NR,t}$ is determined by its budget constraint:

$$(1+\tau^C_t)P_tC^i_{NR,t} = (1-\tau^W_t)W_tL^i_{NR,t} + Tr^i_{NR,t}, \tag{9}$$

where $Tr^i_{NR,t}$ are government transfers received by the non-Ricardian household $i$.

## 2.2 Entrepreneurs and banks

Following [Bernanke et al., 1999], we assume that there is a continuum of entrepreneurs indexed by $j \in (0;1)$. An entrepreneur $j$ buys capital $K^j_t$ from capital-producing firms at price $Q_t$. At the time of the purchase the entrepreneur does not know the quality of the capital purchased. Next period the entrepreneur experiences idiosyncratic shock $\omega^j_{t+1}$ and effective amount of capital changes to $\omega^j_{t+1}K^j_t$. Here $\omega^j_{t+1}$ is i.i.d. lognormal random variable with parameters $(m, \sigma^2)$. $\omega^j_{t+1}$ is assumed to have unit mean. We denote its cumulative distribution function as $F(\omega^j_{t+1})$.

The entrepreneur rents out capital to output producers at price $\tilde{R}_{t+1}$. The rental income is subject to capital tax at rate $\tau^K_{t+1}$. The entrepreneur also chooses utilization rate $u^j_{t+1}$, which depends on capital utilization costs $\Psi^u\left(u^j_{t+1}\right)P_{t+1}K^j_t$, where:

$$\Psi^U\left(u^j_t\right) = \left(0.5b_0b^u\left(u^j_t\right)^2 + b_0\left(1-b^u\right)u^j_t + b_0\left(0.5b^u-1\right)\right). \tag{10}$$

Optimal capital utilization rate can be derived from the following equation:

$$\left(1-\tau^K_{t+1}\right)\tilde{R}^K_{t+1} = \Psi^{U'}\left(u^j_{t+1}\right)P_{t+1}. \tag{11}$$

Note that the optimal capital utilization rate is the same for all entrepreneurs.

Finally, the entrepreneur sells used capital to capital-producing firms at price $Q_{t+1}$. Overall capital return (which turns out to be the same for all entrepreneurs) can be written as:

$$R^K_{t+1} = \frac{(1-\delta)Q_{t+1} + \left(1-\tau^K_{t+1}\right)\tilde{R}^K_{t+1}u_{t+1} - \Psi^U\left(u_{t+1}\right)P_{t+1}}{Q_t}. \tag{12}$$

Now let's turn to how the entrepreneur finances his or her activities. Amount spent on purchase of capital equals the sum of the entrepreneur's net worth $N^j_t$ and the bank loan $B^j_t$. Using the approach suggested by [Bernanke et al., 1999], we assume that the entrepreneur bears all aggregate risk. The entrepreneur agrees to pay the state-contingent return $X^j_{t+1}$ on the loan unless the realization of $\omega^j_{t+1}$ is too low and he or she has to declare bankruptcy. Let's denote the threshold value $\overline{\omega}^j_{t+1}$ as follows:

$$\overline{\omega}^j_{t+1} R^K_{t+1} Q_t K^j_t = X^j_{t+1} B^j_t. \tag{13}$$

Then if realization of $\omega^j_{t+1}$ exceeds $\overline{\omega}^j_{t+1}$, the entrepreneur can repay the bank. Otherwise, he or she has to declare bankruptcy.

However, since realization of $\omega^j_{t+1}$ is entrepreneur's private information, he or she can choose to declare bankruptcy even when $\omega^j_{t+1} \geq \overline{\omega}^j_{t+1}$. To prevent this from happening, the bank can find out true $\omega^j_{t+1}$, but then the bank faces monitoring costs equal to $\mu \omega^j_{t+1} R^K_{t+1} Q_t K^j_t$.

To rule out opportunistic behaviour of entrepreneurs, banks monitor all entrepreneurs who declare bankruptcy. It ensures no opportunistic behaviour in equilibrium.

Hence, expected income of the entrepreneur can be written as:

$$\mathbb{E}_t \left\{ \left[ \int_{\overline{\omega}^j_{t+1}}^{\infty} \omega^j_{t+1} dF\left(\omega^j_{t+1}\right) - \left(1 - F\left(\overline{\omega}^j_{t+1}\right)\right) \overline{\omega}^j_{t+1} \right] R^K_{t+1} Q_t K^j_t \right\} =$$

$$= \mathbb{E}_t \left\{ \left[ 1 - \int_0^{\overline{\omega}^j_{t+1}} \omega^j_{t+1} dF\left(\omega^j_{t+1}\right) - \left(1 - F\left(\overline{\omega}^j_{t+1}\right)\right) \overline{\omega}^j_{t+1} \right] R^K_{t+1} Q_t K^j_t \right\}. \tag{14}$$

When $\omega^j_{t+1} < \overline{\omega}^j_{t+1}$, the entrepreneur declares bankruptcy and his or her income is equal to zero (all income he or she earned goes to the bank). When $\omega^j_{t+1} \geq \overline{\omega}^j_{t+1}$, the entrepreneur receives all capital income $\omega^j_{t+1} R^K_{t+1} Q_t K^j_t$ less the amount he or she owes to the bank $\overline{\omega}^j_{t+1} R^K_{t+1} Q_t K^j_t$.

To issue loans to entrepreneurs banks collect deposits from households $D_t$ at rate $R_{D,t}$. However, only a part of deposits collected can be used for that purpose. Government obliges banks to invest fraction $\nu_t$ of deposits collected in government bonds $B_{G,t}$:

$$B_{G,t} \geq \nu_t D_t. \tag{15}$$

Regulatory constraint (15) models FR: we assume that $\nu_t$ is high enough so that regulatory constraint holds as equality. The same approach to introducing FR is used in [Chari et al., 2020] among others.

Because of FR each unit of deposits collected is actually invested in a portfolio of corporate loans and government bonds with the share of government bonds equal to $\nu_t$. Let's denote the amount of deposits needed to issue the loan to the entrepreneur $j$ as $D^j_t$. The amount of government bonds associated with this loan can be denoted as $B^j_{G,t}$.

Banks operate on a perfectly competitive market. As mentioned above, entrepreneurs bear all aggregate risk. Moreover, banks can get rid of all idiosyncratic risk by diversifying among entrepreneurs. Consequently, banks' operations are characterized by the zero profit condition:

$$\left[ \left(1 - F\left(\overline{\omega}^j_{t+1}\right)\right) \overline{\omega}^j_{t+1} + (1-\mu) \int_0^{\overline{\omega}^j_{t+1}} \omega^j_{t+1} dF\left(\omega^j_{t+1}\right) \right] R^K_{t+1} Q_t K^j_t + R_{G,t} B^j_{D,t} - R_{D,t} D^j_t = 0. \tag{16}$$

Since banks' profits are always zero, optimal parameters of the loan contract can be determined by maximizing the expected profit of the entrepreneur (14) subject to the zero profit condition of the bank (16) and the regulatory constraint (15). It allows us to write first order conditions for $\overline{\omega}^j_{t+1}, K^j_t, B^G_t$. Importantly, it turns out that the ratio of net worth to capital is the same for all entrepreneurs. It ensures aggregation. Consequently, we can omit superscript $j$. Further details about first order conditions are available from the author upon request.

Before we proceed to other blocks of the model, it is interesting to examine one of the first order conditions describing the relationship between the return on deposits and the return on government debt:

$$\lambda^{ZPC}_t \left(R_{D,t} - R_{G,t}\right) = \lambda^{RC}_t \left(1 - \nu_t\right), \tag{17}$$

where $\lambda^{ZPC}_t$ is the Lagrange multiplier for zero profit condition (16) and $\lambda^{RC}_t$ is the Lagrange multiplier for the regulatory constraint (15). If regulatory constraint is not binding and $\lambda^{RC}_t = 0$ (i.e., there is no FR), the return on government debt should be equal to the return demanded by depositors. However, in the presence of FR government can reduce its interest payments ($\lambda^{RC}_t > 0$). In the model presented in this paper banks will compensate losses from investing in government debt by providing less favourable borrowing terms to entrepreneurs and the amount of capital will go down.

Finally, we need to provide the law of motion for the net worth of entrepreneurs:

$$\begin{aligned} N_{t+1} = \gamma^E \Big[ R^K_{t+1} Q_t K_t - \Big( R_{D,t} \left(Q_t K_t - N_t\right) + \left(R_{D,t} - R_{G,t}\right) B_{G,t} + \\ + \mu \int_0^{\overline{\omega}_{t+1}} \omega R^K_{t+1} Q_t K_t dF\left(\omega_{t+1}\right) \Big) \Big] + H^E_{t+1} e^{\eta^{NW}_{t+1}}. \end{aligned} \tag{18}$$

The overall profit of entrepreneurs equals total return on capital less the amount paid to banks. The latter is equal to the difference between compensation of depositors and receipts from investing in government debt. Monitoring costs should also be subtracted from entrepreneurs' profits because they are lost from the economy.

It is assumed that fraction $1 - \gamma^E$ of entrepreneurs' profit goes to Ricardian households. At the same time each period households provide entrepreneurs with some funds for their operations $H^E_{t+1} e^{\eta^{NW}_{t+1}}$. Here $\eta^{NW}_{t+1}$ is a zero mean AR(1) process which models shocks to entrepreneurial net worth.

## 2.3 Producers

There is a continuum of monopolistically competitive firms producing differentiated goods using the following production function:

$$Y^i_t = e^{\eta^A_t} \left(K^{S,i}_t\right)^{\alpha} \left(Z_t L^i_t\right)^{1-\alpha}, \tag{19}$$

where $Y^i_t$ is output produced by firm $i$, $K^{S,i}_t$ and $L^i_t$ are capital and labour services demanded by firm $i$, $\eta^A_t$ is a zero mean AR(1) process which models stationary technological shocks.

After solving the cost minimization problem, we can obtain demand for capital and labour services as well as the marginal costs $MC_t$:

$$(1-\alpha)MC_t Y_t = W_t L_t, \tag{20}$$

$$\alpha MC_t Y_t = \tilde{R}_t^K K_t^S, \tag{21}$$

$$MC_t = AC_t = e^{-\eta_t^A} Z_t^{\alpha-1} \left(\frac{\tilde{R}_t^K}{\alpha}\right)^{\alpha} \left(\frac{W_t}{1-\alpha}\right)^{1-\alpha}. \tag{22}$$

It is assumed that differentiated goods are aggregated via a CES-function, so that the demand on firm $i$'s product is:

$$Y_t^i = \left(\frac{P_t^i}{P_t}\right)^{-\zeta_t^Y} Y_t, \tag{23}$$

where $P_t^i$ is the price of firm $i$'s product, $P_t$ is the overall price level, $Y_t$ is the overall demand for output. Demand elasticity varies over time in accordance with corresponding shocks (price mark-up shocks):

$$\zeta_t^Y = \zeta^Y e^{\eta_t^Y},\ \eta_t^Y = \rho^Y \eta_{t-1}^Y + \varepsilon_t^Y,\ \varepsilon_t^Y \sim N\left(0, \sigma_Y^2\right). \tag{24}$$

We model nominal rigidities à la Rotemberg, so that price adjustment costs can be written as:

$$\Psi^P\left(\frac{P_t^i}{P_{t-1}^i}\right) P_t Y_t = \frac{\psi^P}{2}\left(\frac{P_t^i}{P_{t-1}^i (1+\pi_{t-1})^{\gamma^P} (1+\pi)^{1-\gamma^P}} - 1\right)^2 P_t Y_t. \tag{25}$$

This allows us to write producer's problem as follows:

$$\max_{P_t^i} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s e^{\eta_{t+s}^{\beta}} \lambda_{t+s}^{BC} \left\{\left(1-\tau_{t+s}^K\right)\left[P_{t+s}^i - MC_{t+s}\right]\left(\frac{P_{t+s}^i}{P_{t+s}}\right)^{-\zeta_{t+s}^Y} Y_{t+s} - \Psi^P\left(\frac{P_{t+s}^i}{P_{t+s-1}^i}\right) P_{t+s} Y_{t+s}\right\}, \tag{26}$$

where $\lambda_{t+s}^{BC}$ is the budget constraint Lagrange multiplier of Ricardian households. Ricardian households own firms, so firms' after-tax profits go to Ricardian households in form of dividends. First order conditions of this problem are available from the author upon request. Acknowledging that all producers are the same, we can omit superscript $i$.

## 2.4 Capital-producing firms

Capital-producing firms buy used capital from entrepreneurs. Then they buy investment goods $I_t$ from output producers to renew capital stock. Then capital firms sell this capital stock to entrepreneurs.

Investment process is subject to investment adjustment costs:

$$\Psi^I\left(\frac{I_t}{I_{t-1}}\right)I_t = \frac{\psi^I}{2}\left(\frac{I_t}{e^{\bar{z}}I_{t-1}} - 1\right)^2 I_t, \tag{27}$$

Hence, the capital accumulation equation can be written as follows:

$$K_t = (1-\delta)K_{t-1} + e^{\eta_t^{MEI}}\left(1 - \Psi^I\left(\frac{I_t}{I_{t-1}}\right)\right)I_t, \tag{28}$$

where $\eta_t^{MEI}$ is an AR(1) process which reflects shocks to marginal efficiency of investment.

Capital-producing firms maximize their discounted profits. Using (28) to simplify the expression for capital-producing firms' profit, we can write:

$$\max_{I_t} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s e^{\eta_{t+s}^{\beta}} \lambda_{t+s}^{BC}\left(\left(Q_{t+s}e^{\eta_{t+s}^{MEI}} - P_{t+s}\right)I_{t+s} - Q_{t+s}e^{\eta_{t+s}^{MEI}}\Psi^I\left(\frac{I_{t+s}}{I_{t+s-1}}\right)I_{t+s}\right). \tag{29}$$

First order conditions of this problem are available from the author upon request.

## 2.5 The government and the central bank

The government collects taxes and spends them on government purchases and transfers to households, financing the difference between revenues and expenses via government debt. Government budget constraint can be written as follows:

$$\tau_t^C P_t C_t + \tau_t^W W_t L_t + \tau_t^K\left[\tilde{R}_t^K K_t^S + (P_t - MC_t)Y_t\right] + D_{G,t} = P_t G_t + Tr_t + R_{G,t-1}D_{G,t-1}, \tag{30}$$

where $Tr_t$ is the overall level of transfers to households.

Laws of motion of tax rates are as follows:

$$x_t = \rho^x x_{t-1} + (1-\rho^x)x + \varepsilon_t^x,\ \varepsilon_t^x \sim N\left(0, \sigma_x^2\right),\ x \in \{\tau^C, \tau^W, \tau^K\}, \tag{31}$$

where $x$ is the steady state value of variable $x_t$.

The government follows a set of fiscal rules. Paths of government purchases and transfers to households depend on both fiscal policy shocks and the necessity to stabilize debt:

$$X_t = \left(e^{\bar{z}}X_{t-1}\right)^{\rho^X}\left(\overline{X_t}\left[\frac{DtY_t}{DtY}\right]^{-\gamma_D^X}\right)^{1-\rho^X} e^{\varepsilon_t^X},\ \varepsilon_t^X \sim N\left(0, \sigma_X^2\right),\ X \in \{G, Tr^R, Tr^{NR}\}, \tag{32}$$

where $\overline{X_t}$ is the level of variable $X_t$ on the balanced growth path (i.e. in absence of macroeconomic shocks), $DtY_t$ is the ratio of government debt to GDP and $DtY$ is its steady state counterpart.

Fiscal rules are introduced in order to ensure the stabilization of government debt when various shocks hit the economy. Government can stabilize the government debt via any of these three fiscal instruments. When government faces high level of debt, it can either cut down its purchases or, for example, decide to cancel indexation of transfers. In general we provide for both possibilities. Choosing certain values for $\gamma_D^G, \gamma_D^{Tr^R}, \gamma_D^{Tr^{NR}}$ will change numerical results, but will not change the model's dynamics significantly.

Finally, the government also sets the parameter $\nu_t$ in the regulatory constraint imposed on banks (15). Basically, we could assume that the law of motion of the regulatory parameter $\nu_t$ is identical to those of tax rates. Indeed, papers which study the effects of FR in general equilibrium models usually assume that tightness of FR does not systematically vary with changes in the economy (for example, see [Kriwoluzky et al., 2018], [Isakov and Pekarski, 2017]).

However, it might be more reasonable to believe that tightness of FR policies depends on the current state of the economy and the government budget. For example, if the government currently faces a comparatively high level of debt, it would tend to tighten FR policies to lower debt service expenses and normalize government debt level. At the same time, if economy faces recession, the government might decide to loosen FR policies to support economy during crisis. Hence, we write the law of motion of the regulatory constraint parameter as follows:

$$\nu_t = \rho^\nu \nu_{t-1} + (1-\rho^\nu)\left(\nu + \gamma_D^\nu\left(\frac{DtY_t}{DtY} - 1\right) + \gamma_Y^\nu\left(\frac{Y_t^*}{\overline{Y}_t^*} - 1\right)\right) + \varepsilon_t^\nu,\ \varepsilon_t^\nu \sim N\left(0, \sigma_\nu^2\right) \tag{33}$$

where $\nu$ is the steady state value of the regulatory constraint parameter, $Y_t^*$ is the value of used GDP (sum of household consumption, investment and government purchases) and $\overline{Y}_t^*$ is its counterpart on the balanced growth path. Adding sort of a "fiscal rule" for FR policy is a novelty proposed in this paper. As we show below it might be important to allow for this effect when estimating a model with FR.

Central bank conducts monetary policy by using the Taylor rule similar to the one used in [Smets and Wouters, 2007]:

$$\frac{R_{CB,t}}{R_{CB}} = \left(\frac{R_{CB,t-1}}{R_{CB}}\right)^{\rho^M}\left(\left(\frac{1+\pi_t}{1+\pi}\right)^{\gamma_\pi^M}\left(\frac{Y_t^*}{\overline{Y}_t^*}\right)^{\gamma_Y^M}\left(\frac{Y_t^*}{e^{z_t}Y_{t-1}^*}\right)^{\gamma_{dY}^M}\right)^{1-\rho^M} e^{\varepsilon_t^M}, \tag{34}$$

where $R_{CB,t}$ is the monetary policy interest rate which determines the nominal short-term rate in the economy, namely, the deposit interest rate. $\varepsilon_t^M$ is a normally distributed zero mean random variable which models monetary policy shocks.

## 2.6 Final remarks on the model

Before we proceed to the simulations of the model, we stationarize equations of the model because they are written in non-stationary terms. Then the steady state of the model is found and first-order approximation around the steady state is used for simulations.

To obtain the model without FR we rewrite the problem used to determine optimal conditions of the entrepreneur's loan. In case of no FR, we simply maximize expected profit of the entrepreneur (14) subject to the zero profit condition of the bank (16). In absence of the regulatory condition (15) the return on government bonds is always equal to the return demanded by depositors.

# 3 Calibration of parameters

We calibrate the model described in section 2 using parameter values which are typical for US economy. We use the example of US economy to study general consequences of FR. If FR turns out to change the transmission of macroeconomic shocks significantly, then it is necessary to provide for such a mechanism when estimating a DSGE model for countries which use FR policies in the form of obliging financial sector to hold government bonds.

For most parameters we use values documented in [Smets and Wouters, 2007] who estimate a DSGE model using US data. Steady state levels of GDP growth and inflation rates are calibrated to match their averages in the US data over the 1980-2019 period. The same is true for steady state levels of government purchases, debt and tax rates. Note that we use methodology proposed by [McDaniel, 2007] to calculate effective tax rates using the US macroeconomic data.

Choosing steady state ratio of FR revenues to GDP is more difficult because it is an unobservable variable with no conventional parameter in the literature dedicated to DSGE models. We set FR revenues at a conservative level of 0.1% of GDP.

When calibrating financial sector parameters we follow the approach suggested by [Bernanke et al., 1999]. We set entrepreneurial survival rate equal to 0.9728 and assume that yearly bankruptcy rate is 3%. In addition, we set the ratio of entrepreneurial net worth to capital to equal 0.5 (close to the average value observed in the data). Steady state risk-premium of entrepreneurs is equal 2.2% a year based on the difference between the return on corporate and government long-term bonds in the US data.

Detailed information on the calibrated parameters in presented in Table 1.

Note that we provide two possible values for parameters $\gamma_D^\nu$ and $\gamma_Y^\nu$ which enter the law of motion for the regulatory constraint parameter $\nu_t$. The reason is that we would like to study the implications of assuming that $\nu_t$ reacts to the state of government budget and the economy. This will help us to assess whether it is important to provide for such an opportunity when estimating a DSGE model with FR. Hence, in Section 4 we compare three alternative calibrations of the model with FR: (a) $\gamma_D^\nu = 0$, $\gamma_Y^\nu = 0$; (b) $\gamma_D^\nu = 0.1$, $\gamma_Y^\nu = 0$; (c) $\gamma_D^\nu = 0.1$, $\gamma_Y^\nu = 0.5$.

# 4 Results

In this section we compare impulse responses to macroeconomic shocks in the model without FR ("no-FR model") and the model with FR ("FR model"). It will allow us to conclude how the presence of FR changes transmission of macroeconomic shocks.

**Tab. 1. Calibration of model's parameters**

| Parameter | Value | Description |
|---|---|---|
| $100\bar{z}$ | 0.37 | Steady state growth rate of output |
| $100\pi$ | 0.65 | Steady state inflation rate |
| $n$ | 0.90 | Share of Ricardian households |
| $\beta$ | 0.99 | Households discount factor |
| $h$ | 0.70 | Habit formation parameter |
| $\Omega^C$ | 1.38 | Inverse elasticity of intertemporal substitution |
| $\Omega^L$ | 1.83 | Inverse Frisch elasticity |
| $\psi^P$ | 15 | Price adjustment costs parameter |
| $\psi^W$ | 15 | Wage adjustment costs parameter |
| $\gamma^P$ | 0.24 | Price indexation parameter |
| $\gamma^W$ | 0.58 | Wage indexation parameter |
| $\zeta^Y$ | 1.64 | Demand elasticity for differentiated goods |
| $\zeta^L$ | 1.70 | Demand elasticity for labour |
| $\psi^I$ | 5.74 | Investment adjustment costs parameter |
| $b_u$ | 1.00 | Capital utilization costs parameter |
| $\alpha$ | 0.33 | Share of capital in production |
| $100\delta$ | 2.50 | Capital depreciation rate |
| $\tau^K$ | 0.22 | Capital tax rate |
| $\tau^W$ | 0.22 | Wage tax rate |
| $\tau^C$ | 0.09 | Consumption tax rate |
| $100\Delta^{FR}$ | 0.10 | FR revenues to GDP ratio in steady state |
| $\omega^G$ | 0.15 | Government purchases to GDP ratio in steady state |
| $\omega^{Debt}$ | 2.71 | Government debt to GDP ratio in steady state |
| $\gamma_D^G$ | 0.00 | Reaction of government purchases to debt |
| $\gamma_D^{Tr^R}$ | 1.30 | Reaction of Ricardian households transfers to debt |
| $\gamma_D^{Tr^{NR}}$ | 0.00 | Reaction of non-Ricardian households transfers to debt |
| $\gamma_D^\nu$ | 0.00 / 0.10 | Reaction of regulatory constraint parameter to debt |
| $\gamma_Y^\nu$ | 0.00 / 0.50 | Reaction of regulatory constraint parameter to GDP |
| $\gamma_\pi^M$ | 2.04 | Reaction of the CB rate to inflation |
| $\gamma_Y^M$ | 0.08 | Reaction of the CB rate to GDP |
| $\gamma_{dY}^M$ | 0.22 | Reaction of the CB rate to change in GDP |
| $\sigma$ | 0.27 | Idiosyncratic risk parameter |
| $\mu$ | 0.10 | Monitoring costs parameter |
| $\gamma^E$ | 0.97 | Entrepreneurial survival rate |
| $100\bar{h}^E$ | 0.45 | Ratio of start-up capital transfer to GDP |
| $\rho$ | 0.85 | Persistence of shocks |

In addition, we consider several calibrations of our FR model. The first calibration assumes that regulatory environment does not change throughout the business cycle ($\gamma_D^\nu = 0$, $\gamma_Y^\nu = 0$). Government does not systematically adjust parameters of the regulatory constraint imposed on banks, i.e. $\nu_t$ remains constant.

Under second calibration ($\gamma_D^\nu = 0.1$, $\gamma_Y^\nu = 0$) government adjusts the regulatory constraint parameter in accordance with changes in the level of government debt. When the level of debt is higher than usual, government tightens financial repression to reduce its interest rate payments and, consequently, debt level.

Third calibration assumes that the government reacts not only to its debt level, but also to the current state of the economy ($\gamma_D^\nu = 0.1$, $\gamma_Y^\nu = 0.5$). When the economy experiences recession, the government loosens regulatory requirements so that the economy recovers faster.

Figure 1 shows the response of the economy to a contractionary monetary policy shock ($\varepsilon_t^M$). The grey solid line corresponds to the no-FR model and the black lines correspond to three calibrations of the FR model. Responses of main macroeconomic variables in the no-FR model are standard for financial frictions models (see [Christiano et al., 2011]). A temporary increase in the CB rate reduces inflation, investment and household consumption. A decline in output lowers the net worth of entrepreneurs which leads to an increase in the external finance premium and worsens the borrowing conditions for entrepreneurs.

The presence of FR in the model changes responses of main macroeconomic variables to a monetary policy shock. The initial negative output response is lower in magnitude because a temporary increase in interest rates leads to a rise in investment, not a decline. Initial decline in inflation is lower in magnitude, but it is more persistent. The reason behind these differences lies in the way FR changes the dynamics of corporate debt and borrowing conditions.

In both models, higher interest rates and lower tax receipts lead to an increase in government debt. In the FR model, it has some additional implications for the model's dynamics. Due to an increase in government budget deficit, government needs to issue more debt. However, financially repressed private sector is not willing to supply those funds on the same terms. To issue more debt, government has to offer higher return on its debt. It implies lower savings on interest payments due to FR. For this reason the spread between the return on deposits and the return on government debt (FR spread) decreases. Lower deposits-government bonds spread allows banks to offer better borrowing terms to entrepreneurs (the external finance premium falls). The rise in corporate debt turns out to be more substantial than the fall in the entrepreneurial net worth and private investment increases. Moreover, in the FR model the decline in the entrepreneurial net worth is much less substantial than in the no-FR model.

That said, it is important to note that this result does not revoke long-term effects of FR. Government still enjoys lower interest rate than the one which government would have to pay in the absence of FR. In addition, the level of private investment and capital is lower in the model with FR because such policy discourages investment. However, the presence of FR implies that a rise in CB interest rate leads to an increase in private investment conditional on the fact that regulatory

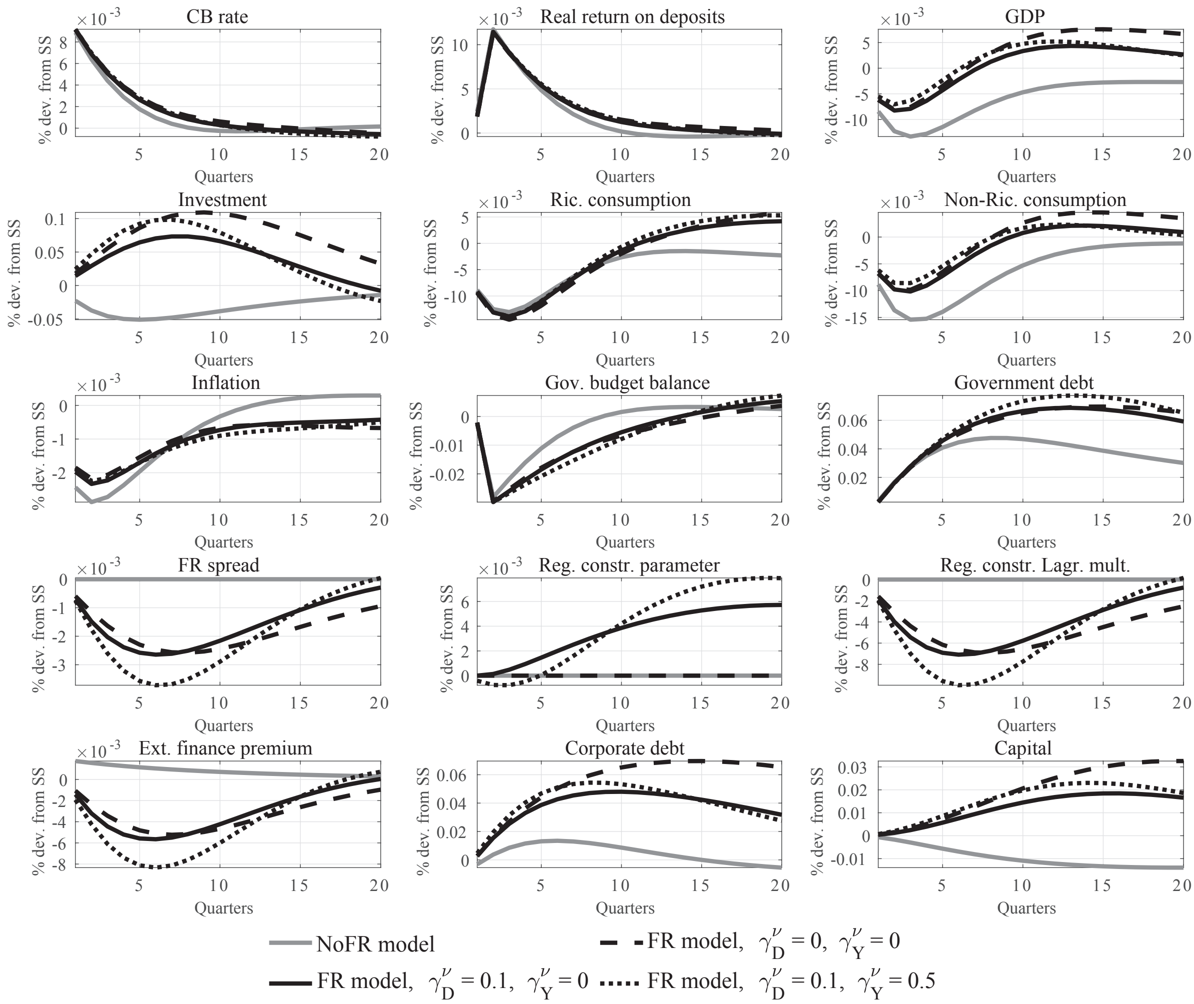


Fig. 1. Impulse responses to monetary shock

environment does not change substantially.

At first Ricardian consumption response is almost identical in both models. However, in the FR model a lower decline in GDP leads to a less substantial decline in households' income (wages and dividends). Moreover, higher income allows Ricardian households to invest more funds in bank deposits and their wealth increases further. Hence, two years after the shock consumption exceeds its steady state level. It leads to GDP being above its steady state level in the FR model.

As for consumption of non-Ricardian households, the presence of FR does impact its response to a contractionary monetary policy shock. Since non-Ricardian households do not save any income, higher interest rates do to incentivize non-Ricardian households to save more of their income. Non-Ricardian households fully consume all of their income, hence, a less substantial decline in wages in the presence of FR leads to a less substantial fall in non-Ricardian consumption.

As was mentioned above, a decline in inflation caused by a contractionary monetary policy shock is more persistent in the FR model. The reason is the dynamics of the rental price of capital which has a direct impact on the costs of production and, consequently, on the general price level.

In the no-FR model, an increase in the interest rate on deposits and a higher level of the external finance premium cause the required return on capital to go up and stay above its steady state level for some time. It translates into dynamics of the rental price of capital and causes inflation to go up.

In the FR model, the external finance premium decreases quite substantially. Hence, the required return on capital and the rental price of capital stay below their steady state levels for some time. It causes a more persistent decline in the inflation rate.

To sum up, in the presence of FR an additional link between government budget balance and private financial market emerges. Since a contractionary monetary policy shock leads to a higher budget deficit, government needs to issue more debt. However, repressed private sector cannot provide these funds to government unless it offers a higher return on its debt and decreases the spread between deposits and government debt. The reduction in spread allows financial sector to offer better terms to its clients (in our model these are entrepreneurs who borrow from banks). Consequently, private investment does not fall, it increases. Initial reduction in GDP is lower and some time after the shock GDP goes above its steady state level. Overall, in case of a monetary policy shock we find evidence of countercyclicality of FR.

A positive response of investment to a contractionary monetary policy shock differs from the prediction of standard New-Keynesian models. However, empirical literature finds evidence that sometimes it might be the case. For instance, [Tenreyro and Thwaites, 2016] estimate responses of several variables to monetary policy shocks using US data. They conclude that during first quarters after a contractionary monetary policy shock investment indeed can go up.

Finally, it is necessary to comment on differences between three calibrations of the FR model. If the regulatory environment (the value of the regulatory constraint parameter $\nu_t$ in this case) does not vary with changes in the state of the economy or the level of government debt, the responses

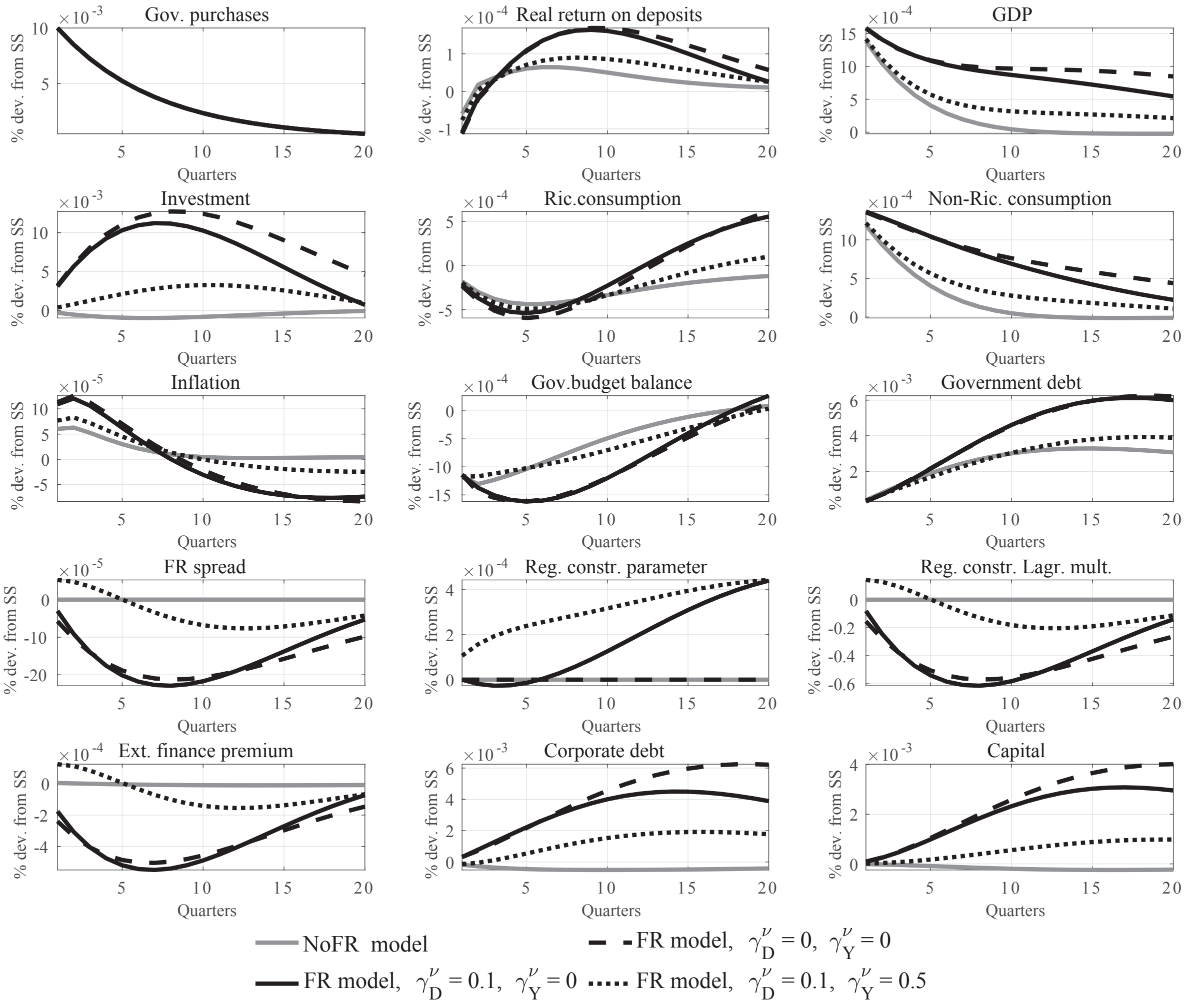


Fig. 2. Impulse responses to government purchases shock

of output and other variables to a monetary policy shock are quite persistent. Adding the reaction of $\nu_t$ to the level of debt decreases persistence of GDP response. In this case, the growth of government debt caused by an increase in the CB rate leads to FR tightening. Consequently, the growth of corporate debt and investment is less substantial under this calibration (the black solid line as opposed to the black dashed line). If we add the reaction of $\nu_t$ to changes in GDP, output response to monetary shock is still less persistent, however, on impact the difference between the FR model and the no-FR model increases. The GDP decline caused by a contractionary monetary shock forces government to loosen FR which stimulates private investment.

Hence, providing for the reaction of the regulatory constraint parameter to the level of government debt and the state of the economy might help the model to better explain the data. Allowing for such a possibility might be important when estimating the model. Moreover, if a contractionary monetary policy shock is accompanied by a discretionary increase in the tightness of FR the overall response of investment which we see in the data might actually be negative.

Now let's turn to the impact of FR on the transmission mechanism of fiscal policy. Figure 2 shows impulse responses to a 1% increase in government purchases ($\varepsilon_t^G$).

Responses of main macroeconomic variables in the no-FR model are exactly as we expect them to be. Higher level of government purchases crowds out private consumption and investment. However, the overall impact on GDP is positive. In addition, a positive government spending impulse leads to a temporary increase in inflation. Corporate credit market reacts to this shock only slightly.

In the FR model, the positive response of output is larger than in the no-FR model. An increase in government spending leads to accumulation of government debt. As discussed previously, government can issue more debt only if it offers better terms to its investors. Hence, the spread between the return on deposits and the return on government debt (FR spread) decreases. It allows banks to offer better borrowing terms to entrepreneurs which in turn drives private investment up. This result differs from the prediction one would obtain from a standard DSGE model without FR. However, some papers do find an investment crowding-in effect of government spending (for example, see [Burriel et al., 2010], [Iwata, 2013]).

Note that monetary policy shocks and government purchases shocks both cause government debt to go up, which turns out to stimulate private investment in the FR model. However, in case of government purchase shocks a rise in private investment is accompanied by an overall positive output response. Hence, in this case we witness procyclicality of FR. Its mechanisms amplify government spending shocks and increase effectiveness of this fiscal policy instrument.

Note that on impact the response of Ricardian consumption is almost identical in both models. At the same time non-Ricardian consumption increases more substantially in the FR model. A rise in output translates into an increase in wages and non-Ricardian households can afford a higher level of consumption. The presence of non-Ricardian households amplifies FR effects in the model.

Finally, let's analyze the differences between alternative calibrations of the FR model. Unless we assume that government adjusts the regulatory constraint parameter in accordance with the output dynamics, effects caused by the introduction of FR are substantial and persistent. However, if government tightens regulatory constraint in response to a significant increase in GDP, the impact of FR goes down. Moreover, it might be quite reasonable to tighten regulatory requirements from a practical point of view because current fiscal policy will eventually lead to accumulation of debt. Higher FR revenues can prevent excessive government debt accumulation in the future.

Figure 3 compares IRFs derived from two models for three more shocks, namely, a stationary technology shock, an entrepreneurial net worth shock and a consumption tax rate shock.

First column of Figure 3 depicts impulse responses to a stationary technology shock ($\varepsilon_t^A$). In both models a positive temporary technology shock leads to an increase in GDP, however, the introduction of FR to the model reduces the magnitude of output response. On impact the difference is not that substantial, however, several quarters after the shock it becomes larger.

The mechanism behind this is exactly the same as the one described above. Despite the fact that initially positive technological shock increases government debt, several quarters after the shock it goes below its steady state level. In other words, government does not need that much debt

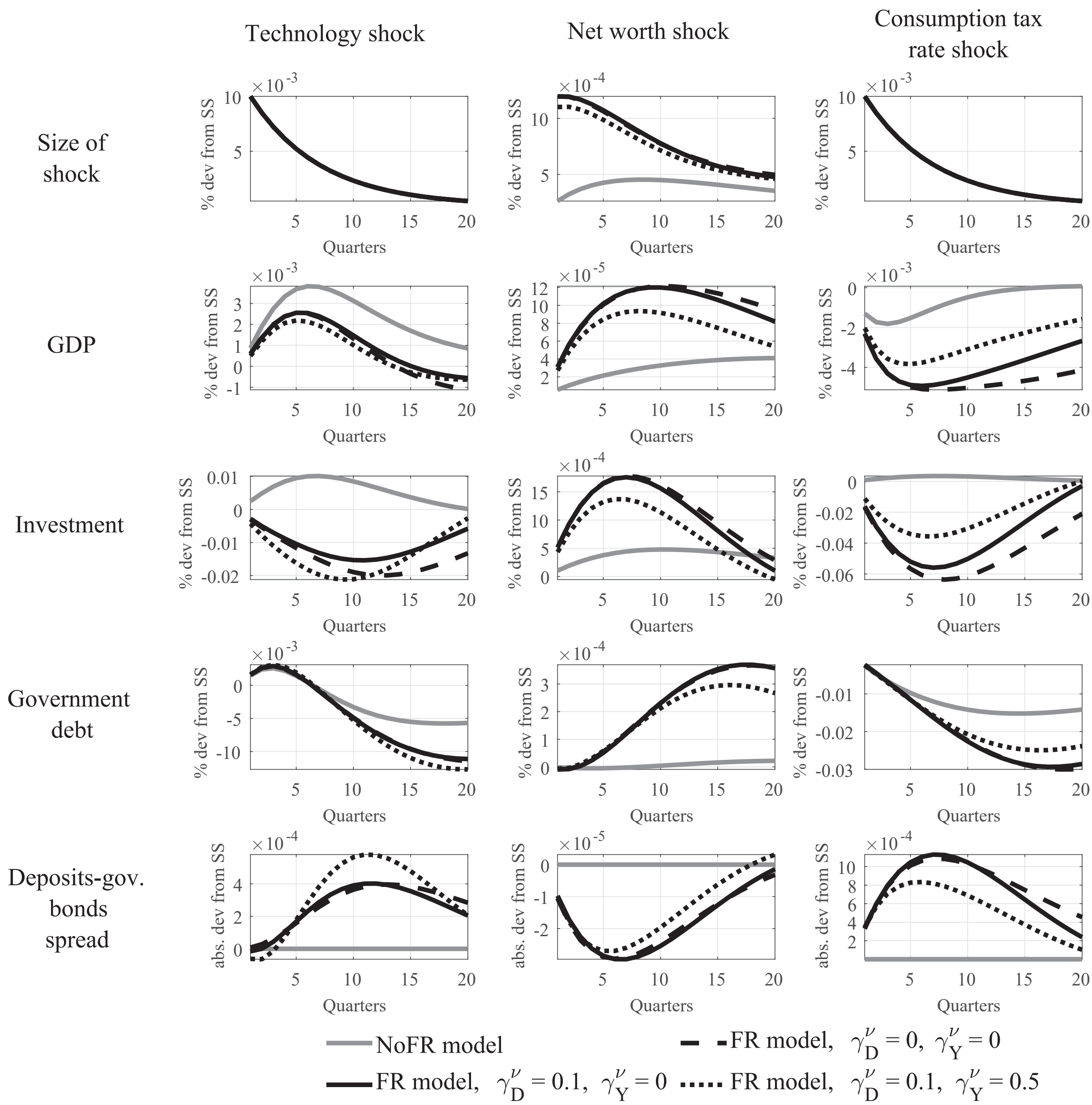


Fig. 3. Impulse responses to several types of shocks

and gets the chance to offer less favourable terms on its debt to banks. This translates into worse borrowing conditions for entrepreneurs. Despite the fact that a significant increase in the external finance premium happens only several quarters after the shock, investment declines on impact due to investment smoothing incentives in the economy.

So, FR dampens output response to a stationary technology shock. In general, FR can either amplify or dampen output response depending on the nature of the shock experienced by the economy. If in the standard model without FR the shock simultaneously increases output and government debt, then the presence of FR amplifies the shock. The need to issue more debt forces the government to reduce the spread between deposits and government debt leading to better borrowing terms for entrepreneurs and higher investment. However, if the shock increases the output level but leads to a decline in government debt, the presence of FR dampens the output response. The latter is true for a technology shock.

The second column of Figure 3 shows responses to a positive entrepreneurial wealth shock (i.e. a temporary increase in transfers from households to entrepreneurs, $\varepsilon_t^{NW}$). Note that an increase in transfers is exactly the same in both models, however, the overall change in the net worth turns out to be much more substantial in the FR model. The reason is that in the FR model the overall output response is higher. A positive net worth shock forces the central bank to increase its policy rate. Consequently, government debt goes up. As discussed above, it leads to a decrease in the spread between deposits and government debt and stimulates investment. In the end, positive output response turns out to be much more substantial in the FR model. Adding the reaction of the regulatory constraint parameter to output dynamics into the model slightly reduces this effect.

Finally, the third column of Figure 3 shows impulse responses to an increase in consumption tax rate ($\varepsilon_t^{\tau^C}$). Since this shock simultaneously decreases output and government debt, the presence of FR amplifies the impact of increasing the tax rate on the output dynamics. The same is true for temporary increases in other tax rates.

Table 2 summarizes the impact of FR on responses of GDP and its components to all shocks included in the model. Note that the presence of FR amplifies all fiscal shocks making fiscal policy more efficient. Interestingly, in the no-FR model an increase in transfers to Ricardian households does not have any impact on GDP and its components. It simply leads to a temporary increase in government debt accompanied by a temporary increase in deposits held by Ricardian households. In the presence of FR it is no longer the case. An increase in government debt due to higher expenses leads to a fall in the spread between the return on deposits and the return on government debt. It stimulates private investment and causes an increase in GDP.

In addition, FR amplifies output response to entrepreneurial net worth shock and households preference shock (which changes their intertemporal preferences). In these cases, we document procyclicality of FR.

The sensitivity of output to other shocks turns out to be lower in the FR model. The presence of FR dampens output response to both price and wage mark-up shocks and changes in monetary policy. In addition, the response of output to stationary technology shocks and marginal efficiency

**Tab. 2. Impact of the presence of FR on the impulse responses of output and its components to various macroeconomic shocks**

| | $\varepsilon_t^A$ | $\varepsilon_t^{MEI}$ | $\varepsilon_t^\beta$ | $\varepsilon_t^L$ | $\varepsilon_t^Y$ | $\varepsilon_t^{NW}$ | $\varepsilon_t^M$ | $\varepsilon_t^G$ | $\varepsilon_t^{\tau^C}$ | $\varepsilon_t^{\tau^W}$ | $\varepsilon_t^{\tau^K}$ | $\varepsilon_t^{Tr^R}$ | $\varepsilon_t^{Tr^{NR}}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GDP | | | | | | | | | | | | | |
| FR model | + | + | +* | + | + | +* | – | +* | –* | –* | –* | +* | +* |
| NoFR model | +* | +* | + | +* | +* | + | –* | + | – | – | – | 0 | + |
| Investment | | | | | | | | | | | | | |
| FR model | –* | – | + | – | – | +* | +* | +* | –* | –* | –* | +* | +* |
| NoFR model | + | +* | –* | +* | +* | + | – | – | + | – | – | 0 | – |
| Ric. cons. | | | | | | | | | | | | | |
| FR model | +* | +* | + | +* | +* | –* | –* | –* | – | – | – | –* | –* |
| NoFR model | + | + | +* | + | + | – | – | – | –* | –* | –* | 0 | – |
| Non-Ric. cons. | | | | | | | | | | | | | |
| FR model | –* | + | +* | –* | – | +* | – | +* | –* | –* | –* | +* | +* |
| NoFR model | – | +* | + | – | –* | + | –* | + | – | – | – | 0 | + |

*Notes:* "+" and "–" indicate the direction of response. "*" indicates the model with the largest magnitude of response (average response during first eight quarters). Note that in this case "FR model" corresponds to the calibration which assumes no reaction of the regulatory constraint parameter to the state of the economy or the level of government debt. $\varepsilon_t^A$ stands for a stationary technology shock, $\varepsilon_t^{MEI}$ is a marginal efficiency of investment shock, $\varepsilon_t^\beta$ is a household preference shock (it changes intertemporal preferences), $\varepsilon_t^L$ stands for a wage mark-up shock, $\varepsilon_t^Y$ is a price mark-up shock, $\varepsilon_t^{NW}$ is an entrepreneurial wealth shock, $\varepsilon_t^M$ is a monetary policy shock, $\varepsilon_t^G$ is a government purchases shock, $\varepsilon_t^{\tau^C}$ stands for a consumption tax shock, $\varepsilon_t^{\tau^W}$ is a labour tax shock, $\varepsilon_t^{\tau^K}$ is a capital tax shock, $\varepsilon_t^{Tr^R}$ is a Ricardian transfers shock, $\varepsilon_t^{Tr^{NR}}$ is a non-Ricardian transfers shock.

of investment shocks declines in the presence of FR.

# 5 Conclusion

This paper studies the impact of FR on transmission mechanisms of macroeconomic shocks in a DSGE model with financial frictions. It turns out that FR can change the output response quite substantially, either amplifying or dampening the initial impulse.

Introducing FR to the model creates an additional link between changes in the government fiscal position and the dynamics of corporate credit terms. If some shock leads to a higher budget deficit (for example, due to a decrease in revenues), then the government needs to issue more debt. However, repressed private sector will not supply those funds unless the government offers a better return on its debt. To issue more debt the government has to reduce the spread between the return on deposits and the return on government debt. The decline in this spread translates into better borrowing terms for entrepreneurs. Now banks face lower losses on government bonds and do not require such a high compensation on the corporate credit market to break even.

Consequently, in the model with FR, the government's need to issue more debt stimulates private investment. This effect takes place unless the government decides to issue more debt by substantially tightening FR policy.

For shocks, which simultaneously cause an increase in GDP and an increase in government debt, the presence of FR amplifies the output response. However, if in the standard model without FR the shock leads to higher output and lower government debt, adding FR to the model dampens the response of output.

In particular, FR dampens a decline in output caused by a contractionary monetary policy shock. Instead of a fall in private investment predicted by standard New Keynesian models, in the model with FR we witness a rise in private investment in response to a contractionary monetary policy shock.

In addition, FR policy increases the efficiency of fiscal policy. An increase in government spending or a decrease in tax rates is accompanied by a rise in government debt. In accordance with the mechanism described above it leads to a rise in private investment in the model with FR as opposed to crowding-out of private investment in a standard model without FR. Importantly, there is some empirical evidence that supports these unconventional predictions of the model with FR.

Overall, FR can have quite a substantial impact on the transmission of macroeconomic shocks which drive the business cycle. Consequently, FR affects households' welfare by amplifying certain shocks and dampening the others. However, due to the fact that depending on the shock FR can either increase or decrease the output response, its overall impact on households' welfare is ambiguous. Still, when deciding whether to use FR policies or not and when interpreting the business cycle, it might be important to consider the effects described in this paper.

Finally, analysis presented in the paper suggests that when building a model we should allow the regulatory constraint parameter to react to the level of government debt and the current output gap. In other words, the law of motion of the regulatory constraint parameter should provide for this possibility. Otherwise, the economy's response to shocks might be too persistent. It could turn out to be a critical issue when estimating the model with FR.

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Mariia A. Elkina

Financial Research Institute of the Ministry of Finance of the Russian Federation (Moscow, Russia). Centre for Macroeconomic Research. Junior Research Fellow. National Research University Higher School of Economics (Moscow, Russia). International Laboratory for Macroeconomic Analysis. Research Intern. E-mail: elkina@nifi.ru