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THE EFFECTS OF ROBO-SIGNING ON THE ECONOMY AND UNCONVENTIONAL MONETARY POLICY

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THE EFFECTS OF ROBO-SIGNING ON THE ECONOMY AND UNCONVENTIONAL MONETARY POLICY[*][+]

As Akerlof and Shiller (2009) argue, corruption and bad faith played an important role in determining the severity of the recent recessions in the US. This paper studies the impact of robo-signing, which is a typical example of economic bad faith, on the economy and unconventional monetary policy during the last financial crisis. We modify the DSGE model by Gertler and Karadi (2011) by including the features of robo-signing. The paper concludes that banks' bad faith magnifies the financial crisis through the transmission channel related to changes in the leverage of financial intermediaries and induces the central bank to conduct a more aggressive unconventional monetary policy. We suggest a theoretical framework for studying cases of economic bad faith during the last financial crisis, and provide a model that well fits the data.

JEL Classification: E44, E52, E58, G01, G21.

Keywords: robo-signing, unconventional monetary policy, bad faith, financial crisis.

1 Introduction

In the beginning of February 2012, the five largest US banks – Bank of America, JP Morgan Chase, Citigroup, Wells Fargo and Ally Financial, altogether serviced about 60 percent of mortgages in the US – and the coalition of the state attorneys general and federal agencies reached a $25 billion agreement, which was designed to help households which had suffered from the foreclosure abuse. The robo-signing scandal was the most striking revelation of the banks' improper behavior, which began during the last financial crisis, in 2010. The scandal centered around the fact that some employees of these banks, which were responsible for mortgage servicing and document preparation for foreclosures, often signed these documents without verifying them, hence the terminology "robo-signing" is used to describe this phenomenon. For example, the Bank of America, the second largest bank holding company in the US at that time, recognized that it was involved in more than 100,000 cases of improper foreclosures; sometimes the documents needed were absent, or in other cases the documents were not signed by all the counterparts. In a nutshell, many households illegally lost their real estate. In fact, the number of US households improperly foreclosed was more than one million. We believe that this phenomenon influenced the consequences of the recent financial crisis in the US. Akerlof and Shiller (2009) have a similar opinion on this, noting bad faith as a concomitant of economic recessions, including the last financial crisis.

The recent crisis was characterized by an increase in bank closures, in comparison with non-crisis times. According to the Federal Deposit Insurance Corporation, only 3 banks were closed in 2007, 25 in 2008 and 140 and 157 in 2009 and 2010 respectively. The main reasons for the banks' closure were insolvency and the violation of regulatory laws which monitor banking activities.

The aim of this paper is to study the qualitative and quantitative consequences of robo-signing for the economy and the unconventional monetary policy in the framework of the DSGE model. We consider a new transmission channel through which robo-signing affects the economy. This channel is associated with changes in financial intermediaries' leverage during the crisis, and the model is calibrated for the case of the US. Our paper contributes to the literature on unconventional monetary policy and economic bad faith since, to our knowledge, the phenomenon of robo-signing remains almost entirely unexamined from both an empirical and theoretical point of view. The first important contribution of our paper is that it constitutes the theoretical framework for studying the cases of economic bad faith during the last financial crisis. The second contribution is that many simulation estimates of the model fit the data well. Modifying Gertler and Karadi's (2011) model, we include not only the phenomenon of robo-

signing but also the particular characteristics of the last financial crisis, such as an increase in the number of bank closures. The model includes two striking features of robo-signing; on the one hand, financial intermediaries can divert funds and thus households may lose a fraction of their wealth but, on the other hand, the financial intermediaries pay compensation to the households. We study to what extent robo-signing influences the aggressiveness of unconventional monetary policy. It is also important to note that we endogenize the fraction of assets that financial intermediaries can divert. We consider incidences where the bargaining powers of financial intermediaries and households are equal, and also incidences where the financial intermediaries are more powerful.

During the recent financial crisis, the Federal Reserve System (the Fed) Fed was forced to conduct an unconventional monetary policy due to its inability to conduct traditional monetary policy, as the interest rate was approaching zero. Garcia-Cicco (2011) defines unconventional monetary policy as any departure from the Taylor rule. Klyuev et al. (2009) emphasize that unconventional monetary policy implies four things. First, a commitment to keeping policy rates low until recovery; second, providing the financial institutions with liquidity; third, purchasing long-term government securities that affect the long-term interest rates and, fourth, direct intervention in deteriorating credit markets. As a whole, these measures are similar to those specified by Bernanke (2009). Bernanke (2009) also argues that the Fe , in particular, conducted credit easing which focuses on the Fed's balance sheet composition, rather than quantitative easing, which focuses on the size of the balance sheet. Curdia and Woodford (2011) provide an extensive study of unconventional monetary policy with great emphasis on the central bank's balance sheet.

Unconventional monetary policy is examined in various papers by Mark Gertler with different co-authors. Gertler and Karadi (2011) incorporate financial intermediaries which face endogenous balance sheet constraints in the DSGE model. Their model provides the baseline for our paper, and is closely related to the financial accelerator model developed by Bernanke, Gertler and Gilchrist (1999). The financial accelerator approach shows how balance sheet constraints can limit the ability of non-financial firms to obtain investment funds. The last financial crisis demonstrated the significance of financial intermediaries although, as Gertler and Kiyotaki (2010) point out, most of the previous literature on macroeconomics with financial frictions considered intermediaries largely to be a veil. Gertler and Kiyotaki (2010) incorporate the inter-bank market in their DSGE model. During the last crisis, inter-bank markets were under severe strain, and banks found it difficult to obtain funds from each other. Gertler, Kiyotaki and Queralto (2012) endogenize the fraction of assets that can be diverted by financial intermediaries but do not provide any microfoundations for it. They assume that it is determined as

$$\Theta\left(x_t\right) = \theta\left(1 + \varepsilon x_t + \frac{\kappa}{2}x_t^2\right),$$ where $x_t = \dfrac{q_t e_t}{Q_t s_t}$ is the fraction of bank assets funded by outside equity. In this paper, the fraction of assets that households can lose due to financial intermediaries' opportunistic behavior is micro-founded. Its response to negative capital quality shock magnifies the crisis because, along with the sharp reduction in the financial intermediaries' net worth, the financial leverage ratio decreases and leads to an even further shrinking of their balance sheets. The issue of the transmission mechanism, which concerns a tightening of the financial leverage ratio is examined by Kiyotaki and Moore (2008), Brunnermeier and Pederson (2009) and Jermann and Quadrini (2012).

Galbraith (1954) emphasizes the cyclical nature of economic bad faith. Akerlof and Shiller (2009) note that "some economic fluctuations may be traced to changes over time in the prominence, and acceptability, of outright corruption" and "even more significantly, there are changes over time in the prevalence of bad faith". They also argue that each of the past recessions in the US involved corruption and bad faith scandals. Moreover, they state that the scandals played a role in determining the severity of each of these crises. We suggest that the robo-signing scandal is one of the typical examples of bad faith, similar to the cases considered by Akerlof and Shiller (2009).

The rest of the paper is organized as follows. Section 2 describes the financial sector according to the baseline Gertler, Karadi (2011) model. Section 3 describes our modification of the model, which includes the features of robo-signing and the transmission mechanism which is linked to the tightening of the leverage ratio. Section 4 details the results of the crisis simulations. Section 5 concludes the paper and summarizes our findings and their implications.

2   The Baseline Model

The crisis in the model is associated with the negative shock to the capital quality. Indeed, during the financial crisis of 2007-2012, the quality of many securities deteriorated. Consequently, the prices of mortgage-backed securities that used to make up a significant part of the financial intermediaries' assets dropped sharply. Under conditions such as these, financial intermediaries' balance sheets shrink, which in turn induces credit tightening. As a result, this leads to a serious downturn. In this paper, we focus our attentions on the financial sector. A brief description of the other parts of the model by Gertler, Karadi (2011) can be found in Appendix A.

There are seven types of agents in the baseline Gertler, Karadi (2011) model: households, financial intermediaries, intermediate goods firms, capital producing firms, retail firms, government and the central bank. Financial intermediaries represent the financial sector in the

model. They obtain deposits from households and lend to the non-financial firms. Financial intermediary j has the following balance sheet equation:

$$Q_t S_{jt} = N_{jt} + B_{jt+1}, \tag{1}$$

where N_{jt} is the amount of net worth that a financial intermediary j has at the end of period t, B_{jt+1} is the amount of deposits which a financial intermediary j obtains from households, Q_t is the relative price of financial claims on firms that an intermediary j holds and S_{jt} is the quantity of these claims.

At $t+1$ households obtain the real gross return R_{t+1} from deposits in the financial intermediaries made in period t. R_{t+1} is the cost of borrowing for financial intermediaries. On the other hand, financial intermediaries obtain gross stochastic return R_{kt+1} from their assets. Therefore, the dynamics of the net worth of a financial intermediary j is determined by the difference between the return on assets and interest payments on liabilities:

$$N_{jt+1} = R_{kt+1} Q_t S_{jt} - R_{t+1} B_{jt+1} = \left(R_{kt+1} - R_{t+1} \right) Q_t S_{jt} + R_{t+1} N_{jt}, \tag{2}$$

where $\beta^i \Lambda_{t,t+1+i}$ is a stochastic discount factor. The condition under which the financial intermediary operates requires that the discounted returns on assets should not be less than the discounted cost of borrowing:

$$E_t \beta^i \Lambda_{t,t+1+i} \left(R_{kt+1+i} - R_{t+1+i} \right) \geq 0, \tag{3}$$

When capital markets are frictionless, the expression (3) holds as equality.

The objective of the financial intermediary j at the end of period t is to maximize its future expected wealth by choosing the optimal path for net worth:

$$
\begin{aligned}
V_{jt} &= \max E_t \sum_{i=0}^{\infty} (1-\theta) \theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left(N_{jt+1+i} \right) = \\
&\max E_t \sum_{i=0}^{\infty} (1-\theta) \theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left[\left(R_{kt+1+i} - R_{t+1+i} \right) Q_{t+i} S_{jt+i} + R_{t+1+i} N_{jt+i} \right]
\end{aligned}
\tag{4}
$$

where θ is a probability of a financial intermediary to survive in banking system.

In order to constrain the financial intermediary to expand the volume of its assets infinitely by obtaining the additional deposits from the households, Gertler and Karadi (2011) introduce the issue of the "moral hazard". It is assumed that, at the beginning of each period, the intermediary can behave opportunistically and divert the fraction λ of available assets. We treat this feature of the model as the first stage of robo-signing; as a result of the financial intermediaries' illegal actions, the households lose a proportion of their wealth. The financial intermediaries transfer diverted funds to the households of which they are a member. The

depositors can recover just the fraction $1-\lambda$, forcing the financial intermediary into bankruptcy. The fraction λ cannot be recovered. Therefore, we produce the inequality, which reflects the fact that the households deposit funds in the financial intermediary when the wealth from non-opportunistic behavior V_{jt} is at least no less lucrative than from opportunistic behavior $\lambda Q_t S_{jt}$:

$$V_{jt} \geq \lambda Q_t S_{jt}, \tag{5}$$

The inequality (5) is the incentive constraint. Moreover, Gertler and Karadi (2011) express the maximized expected wealth V_{jt} differently:

$$V_{jt} = \upsilon_t Q_t S_{jt} + \eta_t N_{jt}, \tag{6}$$

where

$$\upsilon_t = E_t \left\{ (1-\theta)\beta \Lambda_{t,t+1}\left(R_{kt+1} - R_{t+1}\right) + \beta \Lambda_{t,t+1}\theta x_{t,t+1}\upsilon_{t+1}\right\}, \tag{7}$$

$$\eta_t = E_t \left\{ (1-\theta)\beta \Lambda_{t,t+1}R_{t+1} + \beta \Lambda_{t,t+1}\theta z_{t,t+1}\eta_{t+1}\right\}, \tag{8}$$

Let us denote $x_{t,t+i} \equiv \dfrac{Q_{t+i}S_{jt+i}}{Q_t S_{jt}}$ as the growth rate of the financial intermediary's assets from

t to $t+i$ and $z_{t,t+i} \equiv \dfrac{N_{jt+i}}{N_{jt}}$ as the growth rate of the financial intermediary's net worth. υ_t is the

expected discounted marginal benefit from increasing assets $Q_t S_{jt}$ by a unit, holding N_{jt} at a constant level, η_t is the expected discounted benefit from increasing net worth N_{jt} by a unit, holding S_{jt} at a constant level.

Taking into account (6), we rearrange the incentive constraint (5) in the following way:

$$\eta_t N_{jt} + \upsilon_t Q_t S_{jt} \geq \lambda Q_t S_{jt}, \tag{9}$$

In the case when constraint (11) is binding, we get:

$$Q_t S_{jt} = \frac{\eta_t}{\lambda - \upsilon_t} N_{jt} = \phi_t N_{jt}, \tag{10}$$

where ϕ_t is a private leverage ratio which is equal to the ratio of assets intermediated by the financial intermediary j to the net worth of financial intermediary j. The financial intermediary's incentives to divert funds rise when the volume of assets S_{jt} increases, which holds net worth N_{jt} constant. Equation (10) constrains the level of the financial intermediary's leverage ratio; it cannot be larger than its value in the state when the benefits from opportunistic behavior equal the costs of it. In other words, the agency problem endogenizes the constraint on the financial intermediary's ability to obtain assets indefinitely.

By summing all the financial intermediaries' demands, we find the aggregate demand for assets to be:

$$Q_t S_t = \phi_t N_t, \tag{11}$$

where S_t is an aggregate volume of the intermediated assets and N_t is an aggregate net worth of the financial intermediaries. In equilibrium, fluctuations in the net worth N_t leads to fluctuations in the aggregate demand for assets.

Unconventional monetary policy measures mean direct intervention of the central bank in credit markets. It begins to function as a financial intermediary and directly lends funds to the non-financial firms. The total value of assets which are intermediated by the central bank is $Q_t S_{gt}$, where S_{gt} is the quantity of these financial claims. This policy can be interpreted as the purchase of high-quality private securities by the central bank. For instance, during the last financial crisis the Fed bought such securities as agency debt and mortgage-backed securities.

Therefore, the total value of intermediated assets $Q_t S_t$ consists of assets intermediated by private financial intermediaries $Q_t S_{pt}$ and assets intermediated by the central bank $Q_t S_{gt}$:

$$Q_t S_t = Q_t S_{pt} + Q_t S_{gt}, \tag{12}$$

When the central bank conducts unconventional monetary policy, it sells government bonds with the riskless rate R_{t+1} to households and lends the funds it obtains to non-financial firms at market rate R_{kt+1}.

The intermediation of the central bank is associated with both costs and benefits. The advantages of this type of intermediation are that, unlike private financial intermediaries, the central bank does not divert assets and it can freely expand its balance sheet. On the other hand, the central bank intermediation is associated with efficiency costs which equal τ per unit of supplied funds. They can be interpreted as the costs of finding the appropriate borrowers among non-financial firms.

It is suggested that the central bank gives the fraction ψ_t of the total value of credit to non-financial firms[1]:

$$Q_t S_{gt} = \psi_t Q_t S_t, \tag{13}$$

Combining (11) and (13), we transform (12) into the following:

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[1] In order to finance this activity, the government debt B_{gt} that equals $\psi_t Q_t S_t$ is issued. Therefore, earnings from the central bank's intermediation in period t equals $(R_{kt+1} - R_{t+1}) B_{gt}$.

$$Q_t S_t = \phi_t N_t + \psi_t Q_t S_t = \phi_{ct} N_t, \tag{14}$$

where ϕ_{ct} is a leverage ratio of the whole financial sector. It can also be treated as a leverage ratio for total intermediated funds. The equation for ϕ_{ct} is as follows:

$$\phi_{ct} = \frac{1}{1-\psi_t}\phi_t, \tag{15}$$

The leverage ratio for the whole financial sector positively depends on the fraction of assets that are intermediated by the central bank, which is the degree of unconventional monetary policy. As a result, by varying ψ_t the central bank can affect this leverage ratio and moderate the consequences of the crisis.

The central bank conducts both conventional and unconventional monetary policy. Conventional monetary policy, which is conducted during times of non-crisis, is illustrated by the Taylor rule:

$$i_t = (1-\rho)\left[i + \kappa_\pi \pi_t + \kappa_Y\left(\log Y_t - \log Y_t^*\right)\right] + \rho i_{t-1} + \varepsilon_t, \tag{16}$$

where i_t is the nominal interest rate, ρ is a smoothing parameter, $\rho \in (0;1)$, i is the nominal interest rate in steady state, π_t is the inflation rate, Y_t is the level of output, Y_t^* is the natural level of output and ε_t is the monetary shock. During the crisis, the central bank does not smooth the interest rate ($\rho = 0$) and conduct unconventional monetary policy.

The central bank begins to play the role of intermediary by funding the fraction ψ_t of the whole intermediated assets in the economy. During the crisis, the credit spreads significantly rise and the central bank expands its credit in response to this. The unconventional monetary rule is defined as:

$$\psi_t = \psi + \nu E_t\left[\left(\log R_{kt+1} - \log R_{t+1}\right) - \left(\log R_k - \log R\right)\right], \tag{17}$$

where ψ is a steady state fraction of the assets that are intermediated by the central bank, $\left(\log R_k - \log R\right)$ is a steady state credit spread and ν is a feedback parameter of the unconventional monetary policy. The larger ν is, the greater the intensity of policy response to deviations of the credit spread, relative to its steady state value. Now let us turn to our modification of Gertler and Karadi's (2011) model.

3 Robo-Signing and New Transmission Mechanism

Despite the advantages of Gertler and Karadi's (2011) model, it does not take into account some important characteristics of the last financial crisis. This section contains our modification of

their model, which includes the feature that some of the largest American banks paid compensation to households which suffered from their abuses (which we refer to as the second stage of robo-signing) and the fact that the crisis was characterized by an increase in the quantity of bank closures in the US.

Among other extensions of the framework, Gertler and Kiyotaki (2010) suggest a complementary mechanism through which problems in the financial sector can transmit to the economy. This transmission mechanism is related to a tightening of the financial leverage ratio. We endogenize the fraction of assets that can be diverted by banks in order to incorporate the mechanism in the model. An increase of this fraction during the crisis period will lead to the reduction of the financial leverage ratio.

In the basic Gertler and Karadi (2011) model, the following transmission mechanism can be observed; the negative capital quality shock reduces the effective amount of capital which in turn reduces asset values. Moreover, given the financial leverage ratio constraint, the shrinking of intermediaries' balance sheets leads to a reduction in the demand for assets and, as a consequence, a drop in asset price Q_t and investment. Reducing asset prices further weakens the balance sheets. As a result, the total quantity of credit decreases, which negatively affects the economy.

We consider the transmission mechanism, which implies that negative capital quality shock increases the fraction of assets that can be diverted by financial intermediaries. Gertler and Kiyotaki (2010) explain this phenomenon with the efficiency of financial markets; ceteris paribus, the less efficient they are, the less households can recover from the financial intermediaries. Another explanation refers to the increase in asset specificity to the borrowers during the crisis period. Endogenous move of the fraction of assets that financial intermediaries can divert affects the incentive constraint, which limits the intermediaries' financial leverage ratio. The leverage ratio shrinks, leading to much stricter limits on financial intermediaries to expand their assets. Therefore, for any given level of N_t less credit can be offered to the non-financial firms. A drop in credit supply leads to the insufficient funding of non-financial firms and, as a result, negatively affects the economy.

In the baseline model, a financial intermediary can behave as it should (in this case its welfare equals V_{jt}) or opportunistically, when it diverts the share λ of assets and get $\lambda Q_t S_{jt}$. As a result, the households cannot get back the fraction of their assets which were given to the financial intermediaries. During the last financial crisis, households actually lost a fraction of their property due to the banks' improper behavior (the first stage of robo-signing). However, financial intermediaries also suffered from robo-signing, since they had to pay compensation for

their actions (the second stage of robo-signing). Moreover, some banks were closed due to insolvency or violation of legislation.

Therefore, if a financial intermediary j acts opportunistically and diverts the assets, it has two strategies. The first is to pay compensation F_t to the households. It allows the financial intermediary to continue operating in the banking sector. In this case its welfare equals $\lambda Q_t S_{jt} - F_t + V_{jt}$. The second strategy is not to pay compensation to the households. In this case the financial intermediary diverts $\lambda Q_t S_{jt}$ (reserve welfare) and then a regulator closes it. The household as an owner of the financial intermediary sells it by liquidation value $\xi_t V_{jt}$. During the crisis, the negative shock of capital quality decreases it.

Consequently, each household has the following options; if the financial intermediary pays the compensation, the household obtains F_t and if the financial intermediary does not pay the compensation, the household obtains $\xi_t V_{jt}$ by selling it (reserve compensation).

Compensation size is derived through the process of interaction between financial intermediaries and households. We use the same approach as Jermann and Quadrini (2012).

$$\max_{F_t} \left\{ \left(\pi_t^{FI} - \overline{\pi}_t^{FI} \right)^{\vartheta} \left(\pi_t^{H} - \overline{\pi}_t^{H} \right)^{1-\vartheta} \right\}, \tag{18}$$

where ϑ is the financial intermediaries' bargaining power, π_t^{FI} is a financial intermediary's wealth when it pays compensation which equals $\lambda Q_t S_{jt} - F_t + V_{jt}$, $\overline{\pi}_t^{FI}$ is a financial intermediary's reserve wealth (no compensation for households and closing) which equals $\lambda Q_t S_{jt}$, π_t^{H} is a household's compensation which equals F_t and $\overline{\pi}_t^{H}$ is a household's reserve wealth (no compensation for households and closing) which equals $\xi_t V_{jt}$.

We incorporated the second stage of robo-signing into the model, which implies that abusing financial intermediaries pay compensations to households.

Substituting the equations for π_t^{FI}, $\overline{\pi}_t^{FI}$, π_t^{H} and $\overline{\pi}_t^{H}$, we get the following bargaining problem:

$$\max_{F_t} \left\{ \left(V_{jt} - F_t \right)^{\vartheta} \left(F_t - \xi_t V_{jt} \right)^{1-\vartheta} \right\}, \tag{19}$$

Therefore, the optimal size of compensation is:

$$F_t = V_{jt} \left(1 - \vartheta \left(1 - \xi_t \right) \right), \tag{20}$$

Taking into account the compensations that should be paid by the financial intermediaries, the incentive constraint becomes the following:

$$V_{jt} \geq \lambda Q_t S_{jt} - F_t + V_{jt},\tag{21}$$

Substituting (20) into (21) we get:

$$V_{jt} \geq \Psi_t Q_t S_{jt},\tag{22}$$

where $\Psi_t = \dfrac{\lambda}{1 - \vartheta(1 - \xi_t)}$ is a fraction of assets that financial intermediaries can divert under the conditions of the compensation payments.

Given this, we endogenize the fraction of assets that can be diverted by financial intermediaries. As proposed in Gertler, Kiyotaki (2010), this negatively depends on the capital quality, since during the crisis financial intermediaries begin to divert more funds. Indeed, this feature occurred during the last financial crisis.

Combining (9) and (21), we get the following expression for incentive constraint:

$$\eta_t N_{jt} + \upsilon_t Q_t S_{jt} \geq \Psi_t Q_t S_{jt},\tag{23}$$

When the constraint (23) is binding we get the modified version of (10):

$$Q_t S_{jt} = \frac{\eta_t}{\Psi_t - \upsilon_t} N_{jt} = \phi_t N_{jt},\tag{24}$$

So, the new expression for financial leverage is the following:

$$\phi_t = \frac{\eta_t}{\Psi_t - \upsilon_t},\tag{25}$$

The financial intermediaries' financial leverage negatively depends on the fraction of assets that the intermediaries can divert. Consequently, an increase of this fraction during the crisis leads to a reduction in financial leverage. Moreover, during the crisis, the leverage ratio for the total intermediated funds ϕ_{ct} also decreases. This concludes the description of our modifications of the model.

4   Crisis Simulation

Calibration

We use the same parametrization as Gertler and Karadi (2011). Table 1 in Appendix B contains the parameters of the model. In the first crisis simulation, we consider the equal bargaining power of households and financial intermediaries. In the second crisis simulation, we examine instances when financial intermediaries have twice as much bargaining power. We recalibrate the parameter λ which accounts for the fraction of assets which can be diverted by financial intermediaries in the baseline model, in order to make the initial value of Ψ_t, which is the

fraction of assets that can be diverted by financial intermediaries under conditions of compensation payments, equal to 0.381^2.

Crisis

Now let us consider the first crisis simulation. As in the Gertler and Karadi (2011) model, in this paper the crisis is associated with a decline in capital quality or in the quality of the intermediary assets. We examine the dynamics of the following variables: the parameter of capital quality ξ_t, the fraction of assets that financial intermediaries can divert Ψ_t, output Y_t, consumption C_t, capital stock K_t, investment I_t, asset price Q_t, labor L_t, the financial intermediaries' net worth N_t, inflation π_t, credit spread $R_{kt+1} - R_{t+1}$ and the fraction of assets intermediated by the central bank ψ_t. Moreover, we compare the baseline model by Gertler and Karadi (2011) and its modification, as proposed in this paper. There are three regimes of monetary policy: conventional monetary policy (no credit market intervention, $v = 0$), moderate unconventional monetary policy (moderate credit market intervention, $v = 10$) and aggressive unconventional monetary policy (aggressive credit market intervention, $v = 100$). We show that the crisis become more severe if the transmission mechanism described in this paper starts to work. This is an important finding, because this mechanism accounts for some of the variation in the economic variables and underestimating it can lead us to misunderstand the roots of crises. Including this transmission mechanism allows us to obtain results that are closer to the actual data in comparison with results from Gertler and Karadi (2011)'s baseline model.

Capital quality shock is an AR(1) process with a quarterly autoregressive factor, which equals 0.66. As in the baseline model, the crisis is associated with a 5 percent unanticipated decline in capital quality. Figure 1 depicts the capital quality shock and corresponding response of the fraction of assets which is diverted by financial intermediaries. The latter initially increases by 2.5 percent, which is confirmed by real events; during the last financial crisis, the number of improperly foreclosed households and the value of improperly diverted assets significantly rose.

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[2] Initially in Gertler, Karadi (2011) the parameter λ equals 0.381, i.e. the fraction of assets the financial intermediary can divert is 38.1 percent. The authors acknowledge that with some modest changes to the model, it would possible to make this value much lower. We modify the model so that the parameter λ, which denotes the fraction of assets the financial intermediary can divert when no compensation is paid in our model, is twice lower.

**Figure 1. Capital quality shock and response of fraction of assets diverted by financial intermediaries**
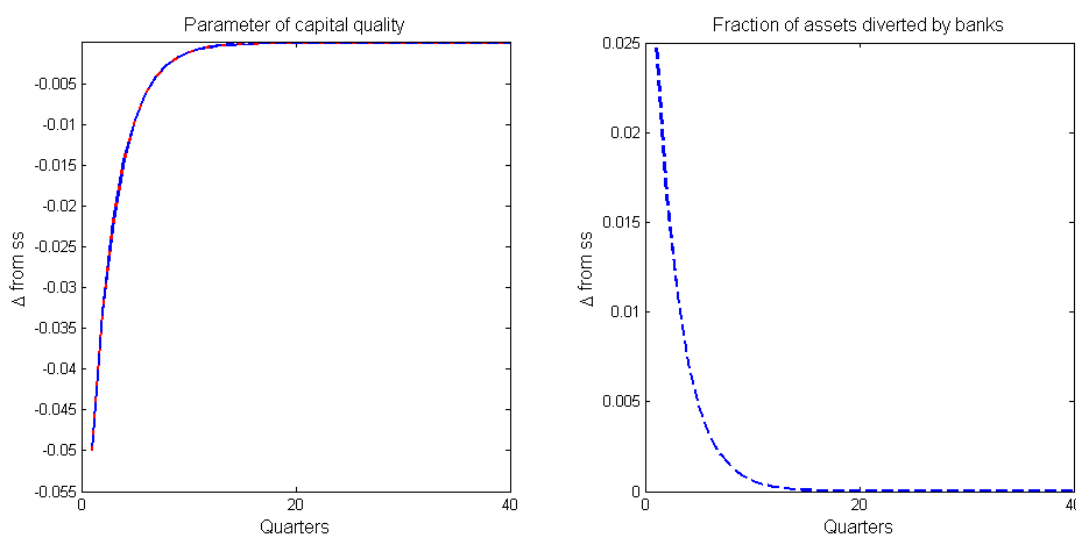
Figures 2-6 consider the other variables. The red solid line depicts Gertler and Karadi's (2011) baseline model and the blue dotted line represents our model. The dynamics of each variable is considered under the different unconventional monetary policy regimes. Table 2 in Appendix C contains the quantitative results of the crisis simulation. Figure 2 shows that, during the crisis, an endogenous move in the fraction of assets which is diverted by financial intermediaries leads to a greater decline in output and consumption, in comparison with the baseline model. The dynamics of output and consumption which were generated by the models are of similar magnitude as during the last financial crisis. It takes about five years for output and much more than five years for consumption to recover. According to FRED economic data, after the beginning of the last financial crisis, it took approximately fifteen quarters for the US's real GDP to recover, and during the recession it decreased by approximately 4.2 percent. Our model shows the same result under the conditions of an aggressive unconventional monetary policy and Gertler and Karadi's (2011) model shows it under conditions of moderate unconventional monetary policy. During the last financial crisis, real consumption in the US fell by more than 2.7 percent. Both models overestimate the size of reduction of consumption. Indeed, it is impossible to precisely identify the real magnitude of ν.

Figure 2. Responses of output and consumption to a capital quality shock
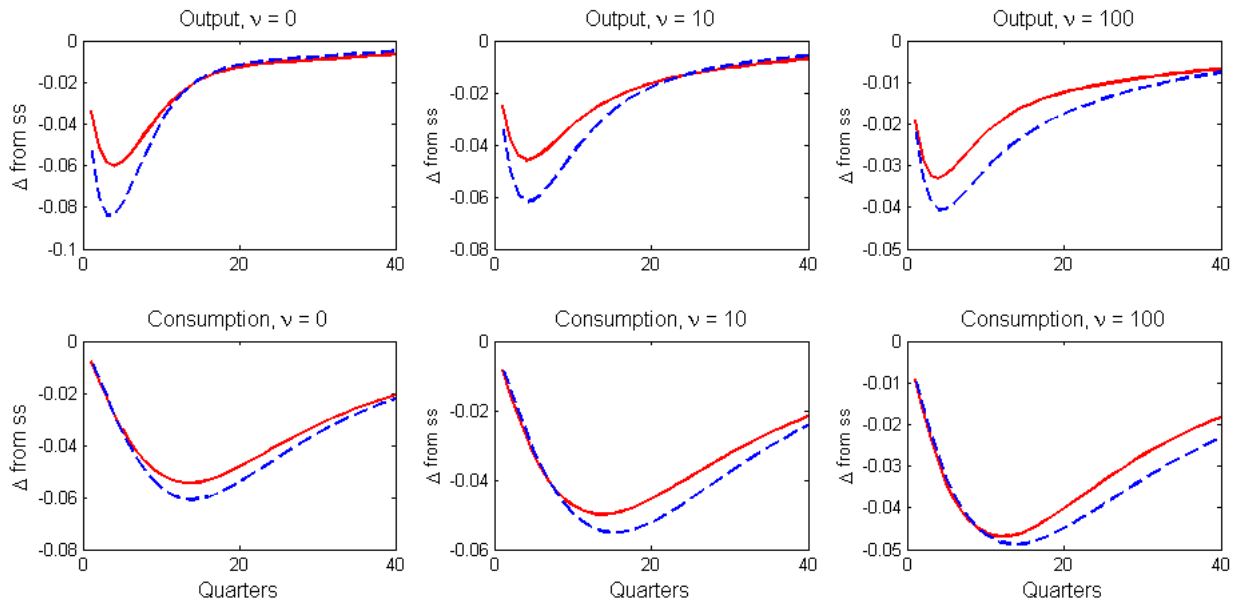
Both our model and the baseline models show that an absence of unconventional monetary policy during the crisis leads to an almost 15 percent decline in the effective capital stock during the first two years. According to Gertler and Karadi (2011), the loss in value of the housing stock relative to the total capital stock was that much. According to the FRED economic data, the US's gross private domestic investment fell by almost 34 percent during the last financial crisis. The results of our model are very close to this magnitude and surpass the baseline model in precision.

Figure 3. Responses of capital stock and investment to a capital quality shock
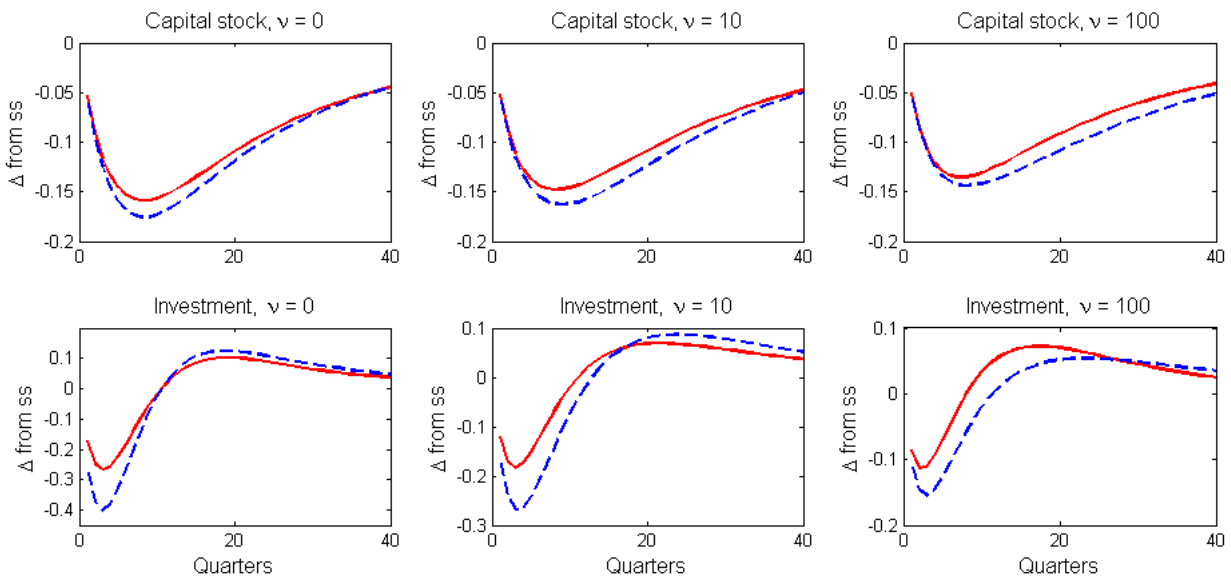
After the crisis, households initially work less. According to the FRED economic data, during the last financial crisis the reduction in the number of employed people in the US reached

15

almost 5.7 percent. It is clear that the results of our model are quite close to this magnitude and reflect reality better than the baseline model does. Due to the necessity of meeting the balance sheet constraint, a drop in asset quality produces a fire-sale of assets. Consequently, the market price of capital decreases. S&P 500 quarterly data show that the most significant percentage quarter drop in the value of this index happened in the third quarter of 2008, and amounted to more than 22.5 percent. Again, our model demonstrates results more reflective of reality than the baseline one.

Figure 4. Responses of asset price and labor to a capital quality shock
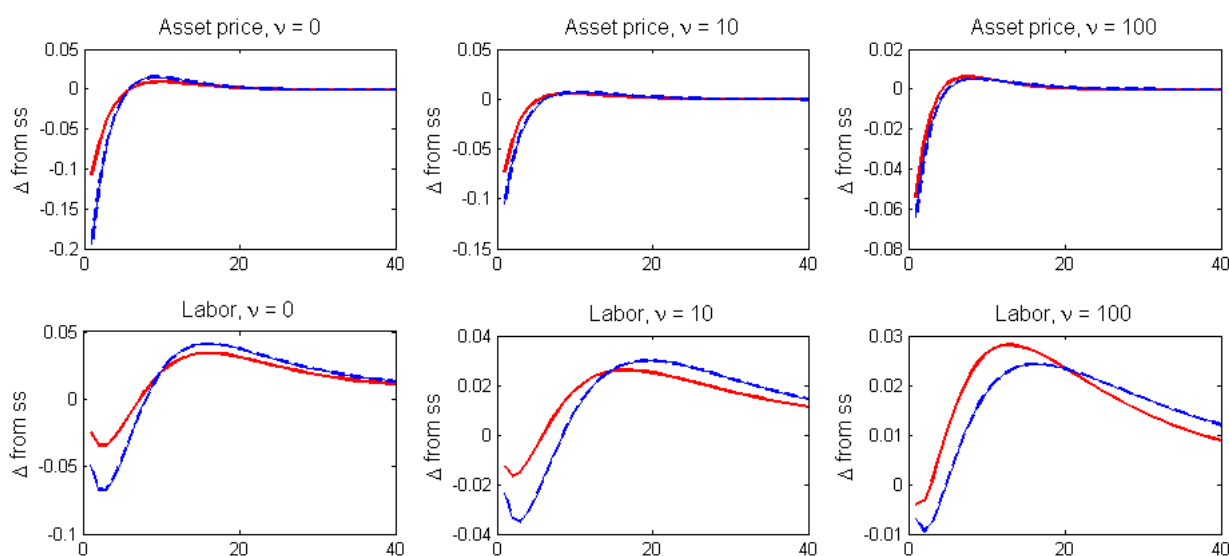
Financial intermediaries' net worth reacts significantly to the crisis. There are several distinct differences between the two models. Even in the case of aggressive unconventional monetary policy, the initial drop in net worth equals almost 40 percent in the baseline model and 70 percent in the modified one. The models demonstrate the slow recovery of net worth towards a steady state. According to data from the Federal Reserve Bank of Cleveland, during the last financial crisis the rate of inflation in the US fell significantly. Therefore, the dynamics of inflation proposed by our model and Gertler and Karadi's (2011) model agrees with the actual data.

Figure 5. Responses of financial intermediaries' net worth and inflation to capital quality shock
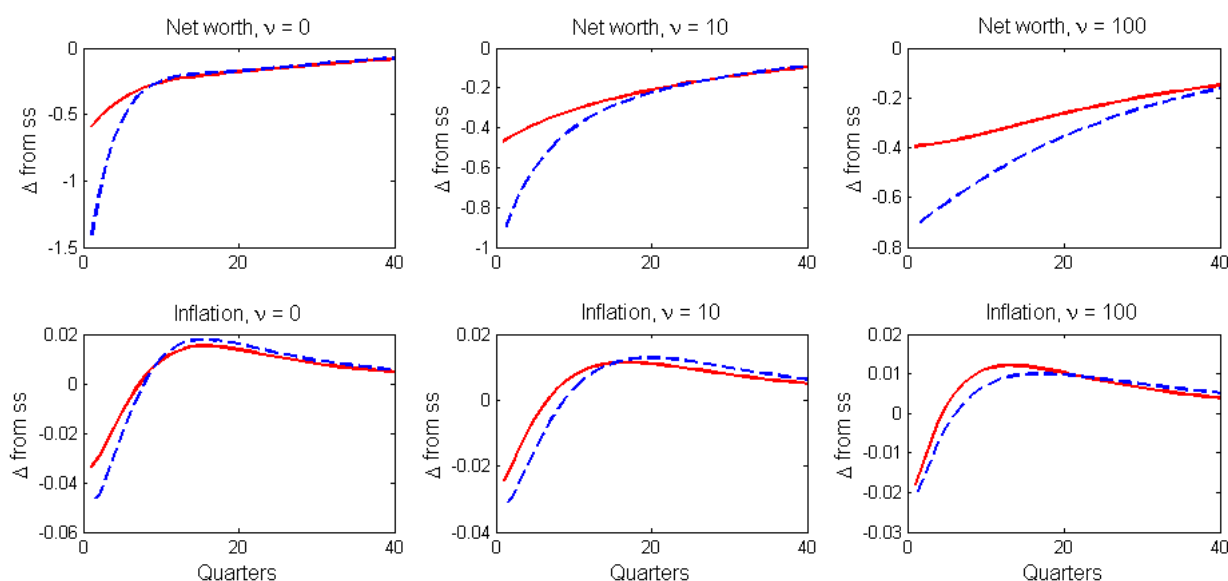
Moreover, the crisis induces a rise in credit spread, which is the spread between the expected return on capital and the riskless interest rate, and credit market intervention by the central bank leads to its contraction. Christiano (2011) notes that an unconventional monetary policy has a significant impact on interest rate spreads. Although the data on TED-spread shows that, during the last financial crisis, the percentage increase was higher than both the models demonstrate, our model proposes that interest rate spreads rose significantly more than the baseline model predicts. The tightening of the financial leverage ratio in our model induces a greater increase in credit spread, which forces the central bank to conduct a more aggressive unconventional monetary policy. Moderate credit market intervention ($\nu = 10$) leads to an expansion of the central bank balance sheet to 6.29 percent of the total value of capital stock in the baseline model and 15.39 percent in our model. An aggressive unconventional monetary policy is associated with 14.39 percent and 35.05 percent respectively. The results confirm that robo-signing affects the intensity of unconventional monetary policy. We suggest that estimation of the value of the share of assets, which is intermediated by the Fed, in the total US assets is a prospective direction for future research.

Figure 6. Responses of credit spread and fraction of assets intermediated by central bank to a capital quality shock
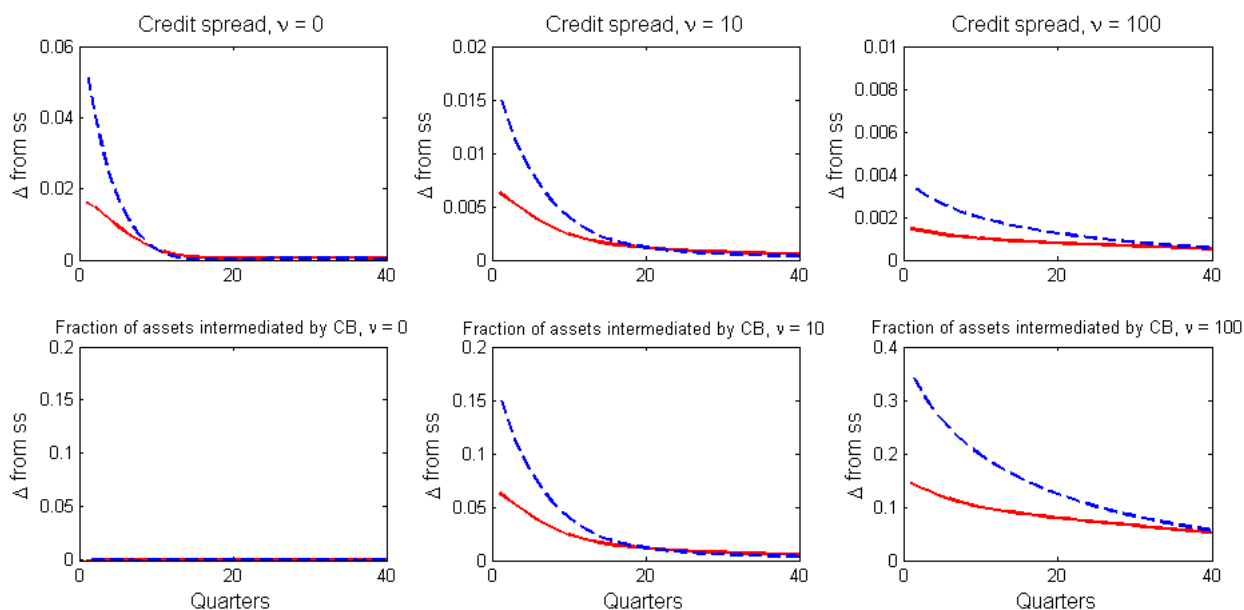
The simulation demonstrates that a tightening of the financial leverage ratio induced by an endogenous move in the fraction of assets diverted by financial intermediaries magnifies the crisis, as argued by Gertler and Kiyotaki (2010). In each case, the unconventional monetary policy significantly moderates the crisis. It damps high credit spreads and decelerates the drop in investment. The more aggressive the policy, the more successful the central bank is at moderating the crisis. According to Figure 6, when the central bank conducts a moderate unconventional monetary policy, it ceases to act as a financial intermediary after approximately five years in both the baseline and our models. In the case of aggressive credit market intervention, it takes significantly more time. The Fed began introducing an unconventional monetary policy in the fall of 2007. On 13 September 2012, i.e. five years later, the third round of quantitative easing was announced. The Fed decided to launch a new open-ended bond purchasing program of agency mortgage-backed securities, and also to keep its rates extremely low until at least 2015. As a result, the question of the terms of the unconventional monetary policy remains open. We mentioned above that the exact value of parameter ν is unknown, and so neither the baseline, nor our model can definitively predict when the US's unconventional monetary policy will come to an end.

The second crisis simulation, when financial intermediaries have twice as much bargaining power than households, ($\vartheta = 2/3$) provides almost the same results as the first crisis experiment. However, an increase in the financial intermediaries' bargaining power slightly magnifies the crisis, and induces the central bank to expand its balance sheet more than when they both have

equal bargaining powers. This is rather reasonable, because the more powerful the financial intermediary is, the less amount of compensation it should pay to households and the greater the fraction of assets it can divert. This follows on from (20) and from the equation for the fraction of assets Ψ_t that financial intermediaries can divert under the conditions of compensation payments. As we noted earlier, an increase in this fraction magnifies the recession. Table 3 in Appendix C contains the quantitative results.

5   Conclusion

We modified Gertler and Karadi's (2011) quantitative monetary DSGE model in order to study the effects of robo-signing on the economy and on the performance of unconventional monetary policy. Besides robo-signing, we also included important features of the last financial crisis, such as an increase in the number of bank closures. In our model, we considered two characteristics of robo-signing. First, each financial intermediary can divert a fraction of the households' assets. Second, in this case the intermediary should pay compensation to aggrieved households; otherwise it will be forced to close. This stage of robo-signing began in February 2012, when the five largest US banks were forced to pay compensation to the households which had suffered from foreclosure abuse. By making the fraction of assets that can be diverted by financial intermediaries endogenous, we allowed for an additional transmission mechanism that works through the affecting financial leverage ratio. During the crisis, robo-signing, which is associated with an increase of this fraction, leads to a tightening of the financial leverage ratio. It also affects the incentive constraint which limits their leverage ratio. Leverage ratio shrinks and it leads to a stricter limit on financial intermediaries' ability to expand their assets, which therefore magnifies the recession. A similar idea is proposed by Gertler and Kiyotaki (2010). Robo-signing is therefore seen to affect the intensity of unconventional monetary policy, which encourages the central bank to conduct it more aggressively. Moreover, we show that an increase in financial intermediaries' bargaining power slightly magnifies the crisis, although it does not seriously affect the results.

The first important result of our paper is that it sheds light on the possible issues for the economy as a whole which arise from banks' improper behavior, particularly robo-signing. Traditionally, the models do not include the transmission mechanism, which we have considered in this paper, and we demonstrate how significant this becomes during the financial crisis. The second important result of this paper is that many simulation estimates of our model fit the data well, and describe it better than Gertler and Karadi's (2011) baseline model, which does not contain some of the last financial crisis's key features. Our model demonstrates the quantitative

results for the output, which are close to the real data (a 4.2 percent decrease in the actual data and a 4.0-6.2 percent decrease in our model), capital stock, investment (a 34 percent actual decrease and 27-40 percent decrease in our model), asset prices (a 22.5 percent actual decrease and 19.4 percent decrease in our model) and labor (a 5.7 percent actual decrease and 3.5-6.8 percent decrease in our model). Other variables show similar results with the actual data dynamics, but the quantitative results are not as close.

The main goal for future research in this area is to study the role of animal spirits and economic bad faith in crises in order to prevent their influence in future recessions. Akerlof and Shiller (2009) have outlined this problem and our paper contributes to the theoretical framework on this.

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Appendix A

Brief description of the model by Gertler and Karadi (2011)[3]

Households

Households in the model traditionally consume, save and supply labor to non-financial firms. Each household consists of two types of members – workers and bankers. Workers, whose share in each household equals $1-f$, supply labor to non-financial firms while bankers, whose share in each household equals f, manage financial intermediaries. A banker stays in banking sector next period with probability θ. With probability $1-\theta$ it becomes worker. At any period of time the number of bankers who become workers equals the number of workers who become bankers. The households' preferences are represented by

$$\max \mathrm{E}_t \left[\sum_{i=0}^{\infty} \beta^i \left(\ln\left(\mathrm{C}_{t+i} - h\mathrm{C}_{t+i-1} \right) - \frac{\chi}{1+\varphi} \mathrm{L}_{t+i}^{1+\varphi} \right) \right], \tag{A.1}$$

where C_t is consumption, L_t is labor supply, h is habit formation parameter.

The households' budget constraint is given by

$$\mathrm{C}_t = \mathrm{W}_t \mathrm{L}_t + \Pi_t - \mathrm{T}_t + \mathrm{R}_t \mathrm{B}_t - \mathrm{B}_{t+1}, \tag{A.2}$$

where W_t is a real wage, Π_t is a profit from ownership non-financial firms and financial intermediaries, T_t is lump sum tax, R_t is a one-period riskless gross real return on deposits to financial intermediaries or government debt from $t-1$ to t, B_{t+1} is short term debt acquired by the households.

If γ_t denotes the marginal utility of consumption, the first order conditions are the following:

$$\gamma_t = (\mathrm{C}_t - h\mathrm{C}_{t-1})^{-1} - \beta h \mathrm{E}_t (\mathrm{C}_{t+1} - h\mathrm{C}_t)^{-1}, \tag{A.3}$$

$$\gamma_t \mathrm{W}_t = \chi \mathrm{L}_t^{\varphi}, \tag{A.4}$$

$$\mathrm{E}_t \beta \Lambda_{t,t+1} \mathrm{R}_{t+1} = 1, \tag{A.5}$$

where $\Lambda_{t,t+1} \equiv \dfrac{\gamma_{t+1}}{\gamma_t}$.

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[3] Here we do not provide the description of financial sector.

Intermediate Goods Firms

The competitive firms in this sector produce intermediate goods that are sold to retail firms. At the end of period t a firm buys capital K_{t+1} and use it in subsequent period. After production at $t+1$ an intermediate goods firm can sell the capital to capital producing firms. In order to buy capital the firms issue S_t financial claims by price Q_t and sell it to financial intermediaries. The number of financial claims equals the number of units of capital acquired:

$$Q_t K_{t+1} = Q_t S_t, \tag{A.6}$$

The production function of intermediate goods firms is given by

$$Y_t = A_t (U_t \xi_t K_t)^\alpha L_t^{1-\alpha}, \tag{A.7}$$

where Y_t is output, A_t is total factor productivity, U_t is utilization rate of capital, ξ_t is the quality of capital. Its negative shock is a source of the crisis in the model.

By solving the standard profit maximization problem we get the following first order conditions:

$$P_{mt}(1-\alpha)\frac{Y_t}{L_t} = W_t, \tag{A.8}$$

$$P_{mt}\alpha \frac{Y_t}{U_t} = \delta'(U_t)\xi_t K_t, \tag{A.9}$$

$$P_{mt}\alpha \frac{Y_t}{K_t} + Q_t \xi_t - \delta(U_t)\xi_t - R_{kt}Q_{t-1} = 0, \tag{A.10}$$

where P_{mt} is the price of intermediate goods, $\delta(U_t)$ is a depreciation rate.

Capital Producing Firms

Competitive capital producing firms, on the one hand, buy depreciated capital from intermediate goods producing firms and repair it and, on the other hand, build new capital. Then it sells both repaired and new capital. Given that the cost of replacing the depreciated capital is unity and the price of a unit of new capital equals Q_t, the problem of a capital producing firms is the following:

$$\max E_t \sum_{\tau=t}^{\infty} \beta^{T-t} \Lambda_{t,\tau} \left\{ (Q_\tau - 1)I_{n_\tau} - f\left(\frac{I_{n_\tau} + I_{ss}}{I_{n_{\tau-1}} + I_{ss}}\right)(I_{n_\tau} + I_{ss}) \right\}, \tag{A.11}$$

where I_{n_τ} is net investment, I_{ss} is investment in steady state. Gertler and Karadi (2011) introduce flow adjustment costs of investment and assume that $f(1) = f'(1) = 0$, $f''(1) > 0$.

Net investment is defined as

$$I_{n_\tau} \equiv I_t - \delta(U_t)\xi_t K_t,$$ (A.12)

where I_t is gross investment.

The optimal price of capital is determined from the following first order condition:

$$Q_t = 1 + f(\Box) + \frac{I_{n_\tau} + I_{ss}}{I_{n_{\tau-1}} + I_{ss}} f'(\Box) - E_t \beta \Lambda_{t,t+1} \left(\frac{I_{n_{t+1}} + I_{ss}}{I_{n_t} + I_{ss}}\right)^2 f'(\Box),$$ (A.13)

Retail Firms

Retail firms take one unit of intermediate good for production one unit of final output. Final output of the economy is given by a CES composite:

$$Y_t = \left[\int_0^1 Y_{ft}^{\frac{\varepsilon-1}{\varepsilon}} df\right]^{\frac{\varepsilon}{\varepsilon-1}},$$ (A.14)

where Y_{ft} is output of the retail firm f.

Solving cost minimization problem, we obtain the following equations:

$$Y_{ft} = \left(\frac{P_{ft}}{P_t}\right)^{-\varepsilon} Y_t,$$ (A.15)

$$P_t = \left[\int_0^1 P_{ft}^{1-\varepsilon} df\right]^{\frac{1}{1-\varepsilon}},$$ (A.16)

At any period of time a retail firm can adjust its price with probability $1-\varsigma$. Moreover, it can index its price to the lagged rate of inflation. The firms choose the optimal price P_t^* by solving the following pricing problem:

$$\max_{P_{ft}} E_t \sum_{i=0}^{\infty} \varsigma^i \beta^i \Lambda_{t,t+i} \left[\frac{P_{ft}}{P_{t+i}} \prod_{k=1}^{i} (1+\pi_{t+k-1})^{\varsigma_P} - P_{mt+i}\right] Y_{ft+i},$$ (A.17)

where π_t is the rate of inflation from $t-i$ to t.

The first order condition is the following:

$$\sum_{i=0}^{\infty} \varsigma^i \beta^i \Lambda_{t,t+i} \left[(\varepsilon-1)\prod_{k=1}^{i}(1+\pi_{t+k-1})^{\varsigma_P} \frac{P_t^*}{P_{t+i}} - \varepsilon P_{mt+i}\right] Y_{t+i} = 0,$$ (A.18)

Rearranging $\mu = \varepsilon/\varepsilon - 1$, we get the following equation for the optimal retail price:

$$\sum_{i=0}^{\infty} \varsigma^i \beta^i \Lambda_{t,t+i} \left[\prod_{k=1}^{i}(1+\pi_{t+k-1})^{\varsigma_P} \frac{P_t^*}{P_{t+i}} - \mu P_{mt+i}\right] Y_{t+i} = 0,$$ (A.19)

The equation for the aggregate price level is derived from the law of large numbers:

$$P_t = \left[(1-\varsigma)(P_t^*)^{1-\varepsilon} + \varsigma \left(\prod_{t-1}^{\varsigma_P} P_{t-1} \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}, \tag{A.20}$$

General Equilibrium

The resource constraint of the economy is given by

$$Y_t = C_t + I_t + f\left(\frac{I_{n_\tau} + I_{ss}}{I_{n_{\tau-1}} + I_{ss}} \right)(I_{n_\tau} + I_{ss}) + G_t + \tau \psi_t Q_t K_{t+1}, \tag{A.21}$$

where G_t is government consumption, $\tau \psi_t Q_t K_{t+1}$ is cost of the central bank intermediation.

The equation for capital accumulation is given by

$$K_{t+1} = \xi_t K_t + I_{nt}, \tag{A.22}$$

Government expenditures are financed by lump sum taxes and earnings from the central bank intermediation:

$$G + \tau \psi_t Q_t K_{t+1} = T_t + (R_{kt} - R_{t-1})B_{gt-1}, \tag{A.23}$$

This completes the description of the model by Gertler and Karadi (2011).

Appendix B

Table 1. Parameters

β	0.99	Discount rate
h	0.815	Habit formation parameter
χ	3.409	Relative weight of labor in utility
φ	0.276	Inverse Frisch elasticity of labor supply
λ	0.1905	Fraction of assets that can be diverted by banks in conditions of no compensation payments in the first crisis simulation
λ	0.127	Fraction of assets that can be diverted by banks in conditions of no compensation payments in the second crisis simulation
θ	0.972	Probability of a banker to stay a banker next period
α	0.33	Effective capital share
U	1.00	Steady state utilization rate of capital
$\delta(U)$	0.025	Steady state depreciation rate of capital
ε	4.167	Elasticity of substitution
ς	0.779	Probability of keeping the prices fixed
ς_P	0.241	Measure of price indexation
κ_π	1.5	Inflation coefficient of the Taylor rule
κ_Y	0.125	Output gap coefficient of the Taylor rule
ρ	0.8	Smoothing parameter of the Taylor rule
G/Y	0.2	Steady state share of government consumption
ϑ	0.5	Bargaining power of financial intermediaries in the first crisis simulation
ϑ	2/3	Bargaining power of financial intermediaries in the second crisis simulation

Appendix C

Table 2. Maximum positive and negative deviations from steady state in the baseline model and in our model, %

	$\nu = 0$				$\nu = 10$				$\nu = 100$			
	Baseline		Modified		Baseline		Modified		Baseline		Modified	
	pos	*neg*	*pos*	*neg*	*pos*	*neg*	*pos*	*neg*	*pos*	*neg*	*pos*	*neg*
Fraction of assets diverted by banks	-	-	2.50 (1)	0	-	-	2.50 (1)	0	-	-	2.50 (1)	0
Output	0	-6.03 (4)	0	-8.39 (3)	0	-4.59 (4)	0	-6.19 (4)	0	-3.31 (4)	0	-4.06 (4)
Consumption	0	-5.45 (13)	0	-6.08 (14)	0	-4.99 (14)	0	-5.51 (15)	0	-4.69 (12)	0	-4.88 (14)
Capital stock	0	-15.88 (8)	0	-17.55 (8)	0	-14.79 (8)	0	-16.28 (9)	0	-13.55 (7)	0	-14.40 (8)
Investment	10.22 (19)	-26.76 (3)	12.45 (19)	-40.23 (3)	6.90 (21)	-18.35 (3)	8.67 (24)	-26.87 (3)	7.22 (17)	-11.29 (2)	5.39 (23)	-15.48 (3)
Asset price	0.89 (10)	-10.62 (1)	1.48 (9)	-19.41 (1)	0.56 (9)	-7.32 (1)	0.66 (10)	-10.44 (1)	0.61 (7)	-5.40 (1)	0.51 (8)	-6.45 (1)
Labor	3.40 (16)	-3.43 (2)	4.10 (16)	-6.77 (3)	2.60 (16)	-1.67 (2)	2.99 (19)	-3.50 (3)	2.81 (13)	-0.42 (1)	2.42 (16)	-0.95 (2)
Net worth of banks	0	-59.27 (1)	0	-144.7 (1)	0	-46.72 (1)	0	-92.03 (1)	0	-39.53 (1)	0	-71.72 (1)
Inflation	1.53 (16)	-3.37 (1)	1.78 (16)	-4.86 (1)	1.14 (16)	-2.43 (1)	1.28 (19)	-3.27 (1)	1.21 (13)	-1.81 (1)	1.00 (16)	-2.11 (1)
Credit spread	1.60 (1)	0	5.26 (1)	0	0.63 (1)	0	1.54 (1)	0	0.14 (1)	0	0.35 (1)	0
Fraction of assets intermediated by central bank	0	0	0	0	6.29 (1)	0	15.39 (1)	0	14.39 (1)	0	35.05 (1)	0

Notes: Quantitative results of the first crisis experiment, i.e. financial intermediaries and households have equal bargaining power ($\vartheta = 0.5$). The quarter in which the peak or the bottom is reached is in parentheses.

Table 3. Maximum positive and negative deviations from steady state in the baseline model and in our model, %

	$\nu = 0$				$\nu = 10$				$\nu = 100$			
	Baseline		Modified		Baseline		Modified		Baseline		Modified	
	pos	*neg*	*pos*	*neg*	*pos*	*neg*	*pos*	*neg*	*pos*	*neg*	*pos*	*neg*
Fraction of assets diverted by banks	-	-	3.33 (1)	0	-	-	3.33 (1)	0	-	-	3.33 (1)	0
Output	0	-6.03 (4)	0	-9.64 (3)	0	-4.59 (4)	0	-7.08 (4)	0	-3.31 (4)	0	-4.56 (5)
Consumption	0	-5.45 (13)	0	-6.29 (14)	0	-4.99 (14)	0	-5.80 (15)	0	-4.69 (12)	0	-5.05 (15)
Capital stock	0	-15.88 (8)	0	-18.11 (8)	0	-14.79 (8)	0	-17.00 (9)	0	-13.55 (7)	0	-14.96 (9)
Investment	10.22 (19)	-26.76 (3)	13.15 (18)	-46.42 (3)	6.90 (21)	-18.35 (3)	10.00 (24)	-31.64 (3)	7.22 (17)	-11.29 (2)	5.75 (26)	-18.35 (3)
Asset price	0.89 (10)	-10.62 (1)	1.92 (9)	-26.56 (1)	0.56 (9)	-7.32 (1)	0.81 (11)	-12.71 (1)	0.61 (7)	-5.40 (1)	0.48 (9)	-7.24 (1)
Labor	3.40 (16)	-3.43 (2)	4.36 (15)	-8.58 (2)	2.60 (16)	-1.67 (2)	3.34 (20)	-4.65 (3)	2.81 (13)	-0.42 (1)	2.43 (19)	-1.35 (2)
Net worth of banks	0	-59.27 (1)	0	-243.4 (1)	0	-46.72 (1)	0	-135.5 (1)	0	-39.53 (1)	0	-100.3 (1)
Inflation	1.53 (16)	-3.37 (1)	1.86 (15)	-5.59 (1)	1.14 (16)	-2.43 (1)	1.41 (19)	-3.77 (1)	1.21 (13)	-1.81 (1)	0.99 (19)	-2.31 (1)
Credit spread	1.60 (1)	0	8.98 (1)	0	0.63 (1)	0	2.29 (1)	0	0.14 (1)	0	0.52 (1)	0
Fraction of assets intermediated by central bank	0	0	0	0	6.29 (1)	0	22.88 (1)	0	14.39 (1)	0	51.84 (1)	0

Notes: Quantitative results of the second crisis experiment, i.e. financial intermediaries have twice larger bargaining power than households ($\vartheta = 2/3$). The quarter in which the peak or the bottom is reached is in parentheses.

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