FUNDAÇÃO GETULIO VARGAS
ESCOLA DE ECONOMIA DE SÃO PAULO

DANIEL ALBUQUERQUE MARANHÃO DE LIMA

ON THE DISTRIBUTIVE IMPACT OF UNCONVENTIONAL MONETARY POLICY

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Dissertação apresentada à Escola de Economia de São Paulo da Fundação Getulio Vargas como requisito para obtenção do título de Mestre em Economia de Empresas

Campo de Conhecimento:
Macroeconomia e Fricções Financeiras

Orientador: Prof. Dr. Bernardo Guimaraes

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ABSTRACT

In the aftermath of the 2007-08 financial crisis the Federal Reserve intervened to help fight the recession. However, it not only lowered interest rates, but also put in practice unconventional measures, including direct lending to companies in high-grade credit markets. These new measures were controversial and some opponents protested it for helping disproportionately the already wealthy individuals tied to the financial sector. We build on a conventional DSGE model for unconventional monetary policy evaluation and introduce two distinct types of agents, capitalists and workers, to assess its distributive impact. We find that the credit policy by the Fed was effective in labor markets, which helps relatively more workers, and introduced a new competitor to banks, the government, which hurts capitalists more. Thus, we find that the credit policy lowered inequality in the US.

Keywords: Unconventional monetary policy, Distributive analysis, Financial frictions.

RESUMO

Logo após à crise financeira de 2007-08 o Federal Reserve interveio para tentar controlar a recessão. No entanto, ele não apenas baixou os juros, como também adotou políticas não-convencionais, incluindo o empréstimo direto para empresas em mercados de crédito de alto nível. Estas novas medidas foram controversas e alguns opositores protestaram porque elas estariam ajudando desproporcionalmente aquelas pessoas ligadas ao sistema financeiro que já eram ricas. Nós utilizamos um modelo DSGE para a análise de políticas monetária não convencional e introduzimos dois tipos distintos de agentes, capitalistas e trabalhadores, para investigar o seu impacto distributivo. Nós encontramos que a política de crédito to Fed foi bem sucedida no mercado de trabalho, o que ajuda mais os trabalhadores, e introduziu um novo competidor no mercado bancário, o governo, o que prejudica mais os capitalistas. Logo, nós encontramos que a política de crédito diminuiu a desigualdade nos EUA.

Palavras-chave: Política monetária não-convencional, Análise distributive, Fricções financeiras.

Contents

1 Introduction

During the years of 2007-2009 the United States experienced an economic and financial recession. Usually, the Federal Reserve responds to such crisis with its main policy tool: the federal funds rate. In fact, it used the policy rate during the crisis, and the fed funds dropped from 5.25% in September, 2007, all the way to a range between 0% and 0.25% in December, 2008.

That was not enough, so the Federal Reserve and the Treasury also provided emergency assistance in many other forms for both financial institutions and non-financial companies following the crisis, such as buying equity stakes in the banking and automotive sectors, lending directly to firms in the commercial paper market, and buying mortgage-backed securities.[1] Those unconventional policies provoked backlash and protests from citizens that felt they helped disproportionately the rich, as they were target at firms.

Notably, while protests like "Occupy Wall Street" sparked a heated debate about the distributive impacts of the rescue policies by the government, the discussion was held mainly outside of the academia. As one report by the Federal Reserve of Philadelphia puts it: "Research focusing on the redistributive effects of unconventional monetary policy is virtually nonexistent" (Nakajima, 2015, p. 15).

The goal of this study is to help fill this void with a model-based evaluation of one of such policies, namely the direct lending to firms by the Fed in high-grade markets. To do so we build on papers that followed the Gertler and Kiyotaki (2010) framework for analyzing unconventional monetary policy.

Their model is a regular DSGE model, with a financial sector, in which households lend money to financial intermediaries, which in turn lend that money to firms. However, there is a financial friction in the process of lending money from households to banks that makes financial intermediaries balance-sheet constrained. This creates a financial accelerator, prevents banks from borrowing the whole amount of funds they would want without the friction and also enable them to run positive profits.

The financial friction is assumed to be present only when households lend to banks, and not to the government. The idea is that the government always honor its debt. Thus, there is room for government credit policy that raises the total amount of loans in the economy, as the Fed may borrow

[1] Calomiris, Eisenbeis and Litan (2011) provide a good review on the various forms of government responses.

from households without any frictions, and then lend to firms. It is in this framework that Gertler and Karadi (2011) and Gertler, Kiyotaki and Queralto (2012) analyze the impacts on aggregate variables, like output and investment, of direct lending by the Fed following a severe crisis.

Still, their models are not suitable to analyze distributional effects as there is perfect consumption insurance among all agents. What we do is to use a model very similar to the ones developed by Gertler and Karadi (2011) and Gertler, Kiyotaki and Queralto (2012), modified to introduce two types of agents: *workers* and *capitalists*. The main difference between the two types of agents is that capitalists can invest in outside equity of banks and are the owners of the firms in the model, while workers can only invest in risk-less bonds and labor is the main source of income. We believe this framework is suitable to highlight different dynamics of income following a crisis and the crisis response by a central bank.

To determine the distributive impacts of unconventional monetary policy we compare how the capitalists' shares of aggregate wealth and consumption would evolve with and without the credit policy in the first years after a crisis. We find that the direct lending by the central bank to firms is a progressive policy, as both the share of capitalists' wealth and consumption become smaller than they would be without the central bank's response.

There are two main reasons for the credit policy to be progressive. First, the policy is successful in curbing the recession, as it diminishes the drop in loans. This moderates the drop in investment, and capital accumulation raises faster, restraining the drop in output. As a result, the labor demanded is higher with the credit policy. Given that a large share of workers' income comes from wages, this helps them disproportionately, and less so capitalists.

The second reason is that when the central bank intervenes in credit markets, it takes possession of a share of the profits from financial intermediaries. The banking activity is profitable in the model because of the financial friction, and a large share of capitalists' income is profits from the banks they own. The intervention by the central bank has some degree of crowding out that lowers the profits from the banking sector, that now go to the government, which is then redistributed equally among capitalists and workers through lower lump-sum taxes. Thus, it is as the government acted as a new bank which is proportionately owned by capitalists and workers, unlike regular banks, which are solely owned by capitalists.

Importantly, as we show in Section 4.1, our aggregate results with two agents are similar to the ones reported by Gertler and Karadi (2011) and Gertler, Kiyotaki and Queralto (2012), which only have one agent. This means that our modification does not alter significantly the dynamics of the aggregate model found in the relevant literature, but it is able to highlight different movements behind aggregate variables.

Given the heated debate that sparked around the distributive impacts of unconventional monetary policy, naturally some contributions on the issue emerged, even though these policies were put in place not long ago. In 2015 the Hutchins Center on Fiscal and Monetary Policy of the Brookings Institution released three papers on the issue. Bivens (2015) descriptively analyzes data after the Large Scale Asset Purchases (LSAPs), or Quantitave Easing (QE), and compares them to what happened after a fiscal deal in 2010. He finds that the LSAPs were a progressive measure, since it drove house prices higher than other assets, and the middle class has a large share of their wealth allocated in housing.

In a similar fashion, Doepke, Schneider and Selezneva (2015) focuses on the distributive impacts of higher inflation (expected or unexpected) and use an overlapping generation model to find that it is progressive, since it distributes wealth from wealthier retirees to poorer mortgage holders. Finally, Beraja et al. (2015) look at data on refinancing of mortgages and find hat lower interest rates benefit areas less hit by the recession. They develop a theoretical model and argue that monetary policy may exacerbate regional differences in a monetary union (like the US) if local economic activity and housing prices are highly dispersed and correlated with each other. Other than the Hutchins' papers, Saiki and Frost (2014) look at household survey data in Japan and use a vector autoregression (VAR) to find that QE in Japan widened inequality through higher asset prices, held primarily by the wealthy.

None of the papers cited in the two paragraphs above analyze the direct lending by a central bank to firms. The papers above focus on indirect effects on inequality through lower interest rates or higher inflation, while we aim at more direct policies that involved lending money to companies. Importantly, our model has no nominal rigidities, thus it is ignoring the inflation channel of monetary policy and instead focuses on an unconventional channel, the mitigation of balance sheet constraints in financial intermediaries.

Our work is also related to the literature that sprung after the paper by Gertler and Kiyotaki (2010) that presents a model to analyze the effects of a few unconventional monetary policies, as direct lending to firms and purchases of equity stakes in banks. Our model is closely related to two of such papers that followed. First, Gertler and Karadi (2011), which finds that direct lending helped to recover lending after the crisis, raising investment and ultimately capital accumulation and labor. Second, Gertler, Kiyotaki and Queralto (2012), which also allows banks to issue outside equity and finds that the anticipated credit policy causes banks to take on more risk. This moral hazard problem makes the policy less effective, and thus requires larger interventions during a crisis.

Other papers also used the same framework, including: Gertler and Karadi (2013), which allows the government to issue long-term bonds; Dedola, Karadi and Lombardo (2013) is an open-economy version, to study free-riding issues between countries; Villa and Wang (2011) estimates the model for the UK; Diniz and Guimaraes (2014) allows for sovereign debt crisis; and Aerosa and Coelho (2013), which estimates the model for Brazil and look at the impact of changes in reserve requirements. Notably, all of them have a single representative agent, thus are not fit to discuss distributive issues.

2 The Model

As mentioned before, the model is based on the Gertler and Karadi (2011) and Gertler, Kiyotaki and Queralto (2012) models for unconventional monetary policy. It is akin to the first model, although we add the possibility of banks issuing outside equity, as in the second. Furthermore, we make one significant modification and a few simplifications. The most significant change is the use of two different agents: capitalists and workers.

In fact, Gertler and Karadi (2011) already have two agents: bankers and workers. However, every family in the economy is composed of a fraction of workers and another of bankers, and bankers have an exogenous chance to turn into workers, and *vice-versa*. Notably, there is perfect insurance of consumption within families, so there is only one representative agent after all, which is the family, a fraction capitalist and another fraction worker.

We abandon the assumption of perfect insurance between the two types of agents (however, all agents of the same type are identical). Thus, we have two wholly different types of agents: (i) *capitalists*, who can invest their savings in risk-less bonds and outside equity of banks, derive utility from consumption and are owners of the firms in the economy; (ii) *workers*, who can save only in the form of risk-less bonds, but can work, derive utility from consumption and disutility from labor. Both types of agents pay the same amount of lump-sum taxes.

As one can see, the difference between workers and capitalists is not endogenous, but imposed. Nevertheless we believe it is appropriate to highlight some aspects of different dynamics of income, consumption and wealth, following a crisis and the crisis response by a central bank. Fundamentally, we want to highlight how an unconventional monetary policy might affect differently those that depend mostly on income from labor and invest only on more traditional assets (workers), from those that have a higher share of their income from return on capital (capitalists). Particularly, those that have their wealth attached to the financial sector, which we believe were the main targets of protests against the Fed's policies.

Apart from this modification, we also make some simplifications to the model. Some are minor, as we abstract from variable capital utilization and also assume a constant rate of depreciation. However we also abstract from any nominal rigidities in the model.[1] It simplifies the model considerably and we do not believe there is any insight lost on distributive impacts of unconventional

[1] All these simplifications were also made by Gertler, Kiyotaki and Queralto (2012).

monetary policy with a purely real model.[2] Additionally, with a purely real model without any kind of conventional monetary policy we know that any distributive impacts are due only to the unconventional monetary policy. Other aspects, such as habit formation, are kept in this model.

2.1 Households

There is a continuum of families, composed by a fraction η of capitalists and another fraction $(1-\eta)$ of workers. Capitalists are the owners of the firms of the model. As there is a continuum of each type of firm (banks, goods producers and capital producers), each capitalist owns $1/\eta$ firms of each type. They can lend money to banks (others than the ones they own) in the form of risk-less bonds, buy outside equity of banks and consume. They also receive profits from the firms they own. Capitalists cannot work, thus their objective is to maximize the utility from consumption

$$U_t^k = E_t\left[\sum_{i=0}^{\infty}\beta^i \ln\left(C_{t+i}^k - hC_{t+i-1}^k\right)\right],$$

subject to the following budget constraint: $C_t^k + B_t^k + q_t\bar{e}_t = (\Pi_t/\eta) + R_tB_{t-1}^k + R_t^e q_{t-1}\bar{e}_{t-1} - T_t$, where C_t^k denotes capitalists' consumption; B_t^k is risk-free bonds bought either from banks or from the government, and R_t its rate of return; $\bar{e}_t$ denotes shares of outside equity from banks, q_t its price, and R_t^e its rate of return; T_t is lump-sum taxes levied by the government; and Π_t is the sum of the profits in the banking sector and from capital producing firms (goods producers do not make any profits, as will become clear later) that are sent to capitalists.

We normalize $\bar{e}_t$ such that each share of outside equity is a claim on the return of one unit of asset held by the bank, adjusted by a shock on capital quality. Thus the rate of return of equity is given by

$$R_t^e = \frac{[Z_t + (1-\delta)q_t]\psi_t}{q_{t-1}}, \tag{1}$$

where Z_t is the income generated by a unit of capital, δ is the rate of capital depreciation and ψ_t is the shock on capital quality.

Capitalists choose an amount of consumption, risk-free bonds and shares of outside equity $(C_t^k, B_t^k, \bar{e}_t)$ to maximize their utility, subject to their budget constraint. Let ϱ_t^k and $\Lambda_{t,t+1}^k$ denote capitalists' marginal utility of consumption and stochastic discount factor, respectively. Then the

[2] If anything, unconventional monetary policy is probably more effective in taming the crisis in a model with nominal rigidities and a zero lower bound, as financial frictions would have a larger effect (see Gertler and Kiyotaki (2010) and Gertler and Karadi (2011)).

first-order conditions are

$$E_t\left[\Lambda^k_{t,t+1}\right] R_{t+1} = 1 \text{ , and} \tag{2}$$

$$E_t\left[\Lambda^k_{t,t+1} R^e_{t+1}\right] = 1, \tag{3}$$

with

$$\varrho^k_t = (C^k_t - hC^k_{t-1})^{-1} - \beta h E_t[(C^k_{t+1} - hC^k_t)^{-1}] \text{ , and} \tag{4}$$

$$\Lambda^k_{t,\tau} = \beta^{\tau-t}\frac{\varrho^k_\tau}{\varrho^k_t}. \tag{5}$$

Workers, on the other hand, can work, but they cannot invest in outside equity, only in the form of risk-less bonds. Also, they pay the same amount of lump-sum taxes as capitalists do. They choose amounts of consumption, labor and risk-free bonds bought (C^w_t, L_t, B^w_t) to maximize their utility

$$U^w_t = E_t\left[\sum_{i=0}^{\infty}\beta^i\left(\ln\left(C^w_{t+i} - hC^w_{t+i-1}\right) - \frac{\chi}{1+\varphi}L^{1+\varphi}_{t+i}\right)\right],$$

subject to the following budget constraint: $C^w_t + B^w_t = W_t L_t + R_t B^w_{t-1} - T_t$, where W_t denotes wages paid by goods producers to workers. Analogously, let ϱ^w_t and $\Lambda^w_{t,t+1}$ denote workers' marginal utility of consumption and stochastic discount factor, respectively. Then the first-order conditions to the problem described above are

$$E_t\left[\Lambda^w_{t,t+1}\right] R_{t+1} = 1 \text{ , and} \tag{6}$$

$$\chi L^\varphi_t = \varrho^w_t W_t, \tag{7}$$

with

$$\varrho^w_t = (C^k_w - hC^w_{t-1})^{-1} - \beta h E_t[(C^w_{t+1} - hC^w_t)^{-1}] \text{ , and} \tag{8}$$

$$\Lambda^w_{t,\tau} = \beta^{\tau-t}\frac{\varrho^w_\tau}{\varrho^w_t}. \tag{9}$$

2.2 Banks

Banks are the financial intermediaries in the economy. They raise funds each period so they can lend them to goods producers. Banks raise funds either through risk-free bonds sold to households, outside equity sold to capitalists, or they can use their own net worth. Banks lend money to firms in the form of perfect state-contingent debt. Let s_t^p denote the total amount of funds loaned by an individual bank to firms, and Q_t its price. Then the bank balance sheet is described by

$$Q_t s_t^p = b_t^p + q_t e_t + n_t, \tag{10}$$

where b_t^p is the total amount of bonds sold to households, e_t is the total amount of shares of outside equity sold to capitalists and n_t is the net worth of an individual bank.

We assume that once a bank is formed its owners cannot inject more capital in the form of net worth. Let R_t^k be the rate of return that the bank charges on its loans, which is state-contingent and will be determined later. Then the evolution of net worth of a bank is given by

$$n_{t+1} = R_{t+1}^k Q_t s_t^p - R_{t+1} b_t^p - R_{t+1}^e q_t e_t. \tag{11}$$

Equation (11) shows that each bank earns interest on the loans made to firms, but must repay its creditors and shareholders. Whatever is left is profit for the bank and raises net worth in the next period.

Let x_t be the ratio of outside equity to total loans made of a given bank, so that

$$x_t = \frac{q_t e_t}{Q_t s_t^p}. \tag{12}$$

Then inserting equations (10) and (12) into (11) we get

$$\begin{aligned} n_{t+1} &= R_{t+1}^k Q_t s_t^p - R_{t+1}(Q_t s_t^p - q_t e_t - n_t) - R_{t+1}^e q_t e_t \\ &= (R_{t+1}^k - R_{t+1}) Q_t s_t^p + (R_{t+1} - R_{t+1}^e) q_t e_t + R_{t+1} n_t \\ &= (R_{t+1}^k - R_{t+1}) Q_t s_t^p + (R_{t+1} - R_{t+1}^e) x_t Q_t s_t^p + R_{t+1} n_t \\ &= \left[R_{t+1}^k - R_{t+1} + x_t (R_{t+1} - R_{t+1}^e)\right] Q_t s_t^p + R_{t+1} n_t. \end{aligned} \tag{13}$$

It is clear from equation (13) that for banks to earn more than the risk-free rate of return they must charge a positive spread $(R_t^k - R_t)$ on loans. Without any frictions, banks would raise funds until the spread was reduced to zero, and there would not be any expected profits in the banking sector. To limit banks' ability to raise funds from households and to introduce a friction that generates a financial accelerator in the model, we assume an agency problem between financial intermediaries and households.

Specifically, the assumption is that after raising funds the bank can divert a share of these funds for its owner. If that happens, bankruptcy follows and households can recover only the assets that were not diverted. We follow Gertler, Kiyotaki and Queralto (2012) and assume that the ability to divert funds depends on banks' capital structure. The rationale is that debt disciplines banks to make payments back to its creditors every period, while dividends are made at the discretion of the management and profits are hard to be monitored. While it may be that banks benefit from having some outside equity, we focus our attention on calibrations where more outside equity at the margin hurts banks' ability to divert funds. Hence, we assume that the share $\Theta(x_t)$ of funds that a bank can divert is a convex function of x_t:

$$\Theta(x_t) = \theta \left(1 + \varepsilon x_t + \frac{\kappa}{2} x_t^2\right). \tag{14}$$

Creditors know that banks may divert assets, so they will only lend as long as it is not advantageous for banks to divert assets. Let V_t be the maximized value of staying in the business and not diverting assets for a bank. We have then the following incentive constraint

$$V_t \geq \Theta(x_t) Q_t S_t^p. \tag{15}$$

If the condition above does not hold, banks will diver assets and households will not lend more funds to a bank.

The agency problem discussed above prevents banks from issuing risk-less bonds and lending to firms until the spread $(R_t^k - R_t)$ on loans is zero. However, banks might find it optimal to accumulate net worth until it no longer needs outside financing. In that situation, banks again might drive the spread towards zero. To also prevent that from happening we make an assumption similar to that of Gertler and Karadi (2011) and impose that a bank survives each period with a probability σ. This way banks have a finite expected survival of $1/(1-\sigma)$ periods.

As each capitalist owns $1/\eta$ banks, each period $(1-\sigma)/\eta$ banks of a given capitalist exit and she finances an equal number of new banks. We assume the probability σ to be independent of banks' characteristics. When a bank is closed, it pays its creditors and shareholders what it owns, and then transfers its net worth back to the household. To finance new banks, we assume that capitalists transfer them seed money, which is a fraction $\xi/(1-\sigma)$ of the capital from exiting banks.

As long as banks are constrained in their ability to raise funds, the spread is positive and banks earn a greater risk-adjusted rate of return than capitalists do on its investments. Thus, banks will prefer to build net worth until they exit and then transfer everything to the household that owns it, rather than making dividend payments in intermediate periods. Therefore, the bank's objective will be to choose its capital structure (s_t^p, n_t, x_t) to maximize the present value of expected terminal net worth given by

$$V_t = \max E_t \left[\sum_{i=0}^{\infty} \Lambda^k_{t+i,t+1+i} (1-\sigma)\sigma^i n_{t+i} \right],$$

subject to equations (13) and (15). We can also rewrite the bank's problem as a Bellman equation, as in

$$V_t = \max E_t \left[\Lambda^k_{t,t+1} ((1-\sigma) n_t + \sigma V_{t+1}) \right].$$

Gertler, Kiyotaki and Queralto (2012) use a guess-and-verify method and show[3] that the solution to the problem in (15) is a function of the balance sheet components:

$$V_t = (\mu_{st} + x_t \mu_{et}) Q_t s^p_t + \nu_t n_t, \tag{16}$$

where μ_{st}, μ_{et} and ν_t are time-dependent coefficients solved using guess-and-verify, and are shown below.

Notice that when the incentive constraint is biding we can use (15) and (16) to write

$$Q_t s^p_t = \phi_t n_t, \tag{17}$$

where ϕ_t is the maximum leverage ratio of banks authorized by households, given by

$$\phi_t = \frac{\nu_t}{\Theta(x_t) - (\mu_{st} + x_t \mu_{et})}, \tag{18}$$

with

$$\nu_t = E_t[\Lambda^k_{t,t+1} \Omega_{t+1}] R_{t+1}, \tag{19}$$

$$\mu_{st} = E_t[\Lambda^k_{t,t+1} \Omega_{t+1} (R^k_{t+1} - R_{t+1})], \tag{20}$$

$$\mu_{et} = E_t[\Lambda^k_{t,t+1} \Omega_{t+1} (R_{t+1} - R^e_{t+1})] \text{ , and} \tag{21}$$

$$\Omega_{t+1} = 1 - \sigma + \sigma[\nu_{t+1} + \phi_{t+1}(\mu_{st+1} + x_{t+1}\mu_{et+1})]. \tag{22}$$

Equations (16) and (19) through (21) shows possible interpretation for the parameters in the bank's value function: ν_t is the expected marginal value of raising net worth, while holding total assets intermediated (s^p_t) and the choice of capital structure (x_t) constant; μ_{et} is the expected marginal value of changing the capital structure, and as equation (21) shows, a bank will prefer

[3]We also have a proof in the Appendix.

to finance itself with outside equity rather than with debt the smaller R^e_{t+1} is when compared to R_{t+1}; finally μ_{st} is the expected marginal value of expanding assets while holding net worth and x_t constant, and equation (20) shows that it depends positively on the spread $(R^k_{t+1} - R_{t+1})$ charged by banks.

Furthermore, equations (15) and (16) show that the restriction will be binding if $\Theta(x_t)$ is large enough when compared to $\mu_{st}t$. Otherwise, the continuing value of expanding assets would be greater than that of diverting assets, and there would be no incentives for the bank to divert assets. In our calibrations, $\Theta(x_t)$ is high enough such that the constraint binds. In this case, equation (18) shows that the maximum leverage ratio allowed, ϕ_t, is increasing in the risk-less rate of return and in the premium. The reasoning is that higher rates of return increase the continuing value for the bank and then households can allow a higher degree of leverage. On the other hand, if the bank can divert more assets, the leverage allowed will be smaller, as the incentives constraint will bind sooner.

With a higher incentive to divert assets, in equilibrium banks can intermediate less funds, which impacts negatively investments, capital and output. That is what happens in a crisis situation. On the other hand, when there is a crisis the spread rises, which raises the continuing value of the bank, hence the leverage ratio allowed increases.

The set of equations (19) through (21) also shows that the bank has an augmented discount factor when compared to capitalists, which equals to $\Lambda^k_{t+1}\Omega_{t+1}$. To better understand it, first notice that equations (16) and (17) allow us to write

$$V_{t+1} = [(\mu_{st+1} + x_{t+1}\mu_{et+1})\phi_{t+1} + \nu_{t+1}]n_{t+1},$$

thus $\partial V_{t+1}/\partial n_{t+1} = (\mu_{st+1} + x_{t+1}\mu_{et+1})\phi_{t+1} + \nu_{t+1}$. Then we can interpret Ω_t in equation (22) as the average marginal value of net worth across the states of continuing or exiting the banking sector. When a bank exits the market, which happens with probability $1-\sigma$, it gives net worth back to the household. However, with probability σ the bank continues to exist, and the continuing value of the bank V_{t+1} will be impacted by $\partial V_{t+1}/\partial n_{t+1}$.

Finally, we still have to determine the capital structure of the banking sector. In the Appendix we prove that when banks choose (x_t, s^p_t, n_t) to maximize equation (16), subject to equations (14) and (15), then

$$x_t = -\frac{\mu_{st}}{\mu_{et}} + \left[\left(\frac{\mu_{st}}{\mu_{et}}\right)^2 + \frac{2}{\kappa}\left(1 - \varepsilon\frac{\mu_{st}}{\mu_{et}}\right)\right]^{1/2}. \tag{23}$$

Without any agency problem between households and banks, issuing equity would always be preferable for financial intermediaries, as equity has a state-contingent return and banks are risk-averse. Thus, if the economy performs poorly, the low returns on assets is carried on to the shareholder. On the other hand, risk-less bonds promise a fixed rate of return, regardless of the state of the economy, relocating the risk to the bank.

However, more equity financing means that the incentive constraint will become tighter, limiting the ability of the bank to perform loans. Therefore, banks will choose a mixed composition for the balance sheet, composed of debt, outside equity and net worth.

Now that we know that x_t depends only on μ_{st} and μ_{et}, we can conclude that x_t and ϕ_t do not depend on any bank-specific factors, as shown by equations (18) through (22). Thus, every bank chooses the same capital structure x_t and the degree of leverage ϕ_t. Given equation (24), we can write

$$Q_t S_t^p = \phi_t N_t, \tag{24}$$

where N_t and S_t^p denotes total net worth of the banking sector and total loans by banks to firms, respectively.

Total net worth of the banking sector N_t is the sum of the net worth of existing banks that did not exit the market (N_t^o) with the net worth of entering banks (N_t^y). The dynamic for the net worth of existing banks is given by equation (13), which together with equation (17) allows us to write

$$n_{t+1} = \left\{ \left[R_{t+1}^k - R_{t+1} + x_t(R_{t+1} - R_{t+1}^e) \right] \phi_t + R_{t+1} \right\} n_t.$$

However, only $(1-\sigma)$ banks survive from one period to the next, then we have that

$$N_{t+1}^o = (1-\sigma) \left\{ \left[R_{t+1}^k - R_{t+1} + x_t(R_{t+1} - R_{t+1}^e) \right] \phi_t + R_{t+1} \right\} N_t. \tag{25}$$

Also, we assumed that the new $(1-\sigma)$ banks receive a fraction $\xi/(1-\sigma)$ of exiting banks' total capital at the end of the period, which means that

$$N_{t+1}^y = \xi R_{t+1}^k Q_t S_t^p = \xi R_{t+1}^k \phi_t N_t. \tag{26}$$

Then, equations (25) and (26) give us the dynamic for total net worth of financial intermediaries:

$$N_{t+1} = (1-\sigma) \left\{ \left[R_{t+1}^k - R_{t+1} + x_t(R_{t+1} - R_{t+1}^e) \right] \phi_t + R_{t+1} \right\} N_t + \xi R_{t+1}^k \phi_t N_t. \tag{27}$$

2.3 Unconventional Monetary Policy

The unconventional monetary policy analysed in this study is the credit policy performed by the Fed. In the aftermath of the financial crisis, the central bank performed direct lending to companies in commercial paper markets. We follow Gertler and Karadi (2011) and assume that the government issues risk-less bonds to households to perform loans directly to companies in times of distress.[4]

The benefit of government intermediation is that there is no agency problem between households and the government. In other words, the government always honor its debt. However, we assume that there is an efficiency cost τ per unit of asset intermediated, which will be paid by the government with a raise in lump-sum taxes.

We model the credit intervention by the government ($Q_t S_t^g$) as a fraction of total assets in the economy ($Q_t S_t$), in the form of

$$Q_t S_t^g = \zeta_t Q_t S_t, \tag{28}$$

with

$$\zeta_t = \nu_g[\big(E_t[R_{t+1}^k] - R_{t+1}\big) - (R^k - R)], \tag{29}$$

where R^k and R are the steady-state values for R_t^k and R_t, respectively. The rationale behind equation (29) is that the Fed intervened in high-grade credit markets when it saw spreads rise in the midst of a financial turmoil. As spreads lower and return to normal levels (the steady-state level) the Fed reduced its credit program. Notice that in the steady state $\zeta = 0 = S_g$.

The sum of total loans will be given by

$$Q_t S_t = Q_t S_t^g + Q_t S_t^p = \zeta_t Q_t S_t + Q_t S_t^p,$$

thus

$$S_t = \frac{S_t^p}{1 - \zeta_t}. \tag{30}$$

It is important to note that we do not assume any form of subsidy from the central bank to non-financial firms in the form of lower interest rates. The rates charged by the central bank to firms is the market rate R_{t+1}^k, the same used by banks in their loans. However, in a economy where the incentive constraint for banks binds, this credit intervention by the central bank raises the supply

[4] This formulation is equivalent to the one which the government borrows to lend to banks, which then lend to non-financial firms.

of total loans because there is no agency problem between households and the government. Thus, as we will show in the simulations, this intervention effectively raises total assets loaned $Q_t S_t$ and reduces the spread $(R^k_{t+1} - R_{t+1})$, helping the economy to return to normal conditions.

The budget constraint for the central bank and the government is

$$G + \tau Q_t S^g_t + Q_t S^g_t + R_t B^g_{t-1} = T_t + R^k_t Q_t S^g_{t-1} + B^g_t,$$

where B^g_t is total bonds issued by the government, both to capitalists and workers; and G is the steady-state level of government expenditure. If we make the reasonable assumption that the government issues new bonds to exactly match its need to make new loans ($B^g_t = Q_t S^g_t$), then the budget constraint can be simplified to

$$G + \tau \zeta_t Q_t S_t = T_t + (R^k_t - R_t)\zeta_{t-1} Q_{t-1} S_{t-1}. \tag{31}$$

The equation above shows us that taxes will be raised or lowered following a credit market intervention by the central bank depending on how large is the inefficiency cost τ, and on the ability of the central bank to make profits on loans.

2.4 Goods Producers

The non-financial firms of the model are standard. Goods producers sell final goods in a competitive market, using labor and capital as inputs. They pay wages W_t to workers in return for their labor, and they buy capital from capital goods producers to use in a period.

To buy capital, goods producers borrow funds from banks and from the government, when there is unconventional monetary policy. Hence, to buy an amount K_{t+1} of capital to use in the following period, firms borrow an amount S_t of funds, such that

$$Q_t K_{t+1} = Q_t S_t. \tag{32}$$

At the end of the following period, goods producers sell the capital back to capital producers and buy new capital. Depreciated capital has a unit price of replacement, while the amount of capital that did not depreciate does not need any refurbishing.

To make it clear, there are no frictions in the market for lending between banks (or the central bank) and firms. The rate of return R^k_{t+1} charged on goods producers is state-contingent, as we assume banks are able to monitor perfectly firms, and firms are able to commit to paying those loans.

As a result, banks can secure all the return from capital and goods firms do not make any profits. Hence, we can think of the banks (and therefore the capitalists) as owners of goods producers.

The production function is given by

$$Y_t = (\psi_t K_t)^{\alpha}((1-\eta)L_t)^{(1-\alpha)}. \tag{33}$$

Note that L_t is the amount of labor that one worker is going to provide (and W_t is wage paid to a single worker for a unit of work). However, there are only $(1-\eta)$ workers in the economy, so the total amount of labor is $(1-\eta)L_t$.

As we normalize the price of the final good to unit, the objective of the firm is the following:

$$\max_{L_t}(\psi_t K_t)^{\alpha}((1-\eta)L_t)^{(1-\alpha)} - W_t(1-\eta)L_t,$$

while the choice of capital is done by capital producers. The first-order condition of the maximization problem above is

$$W_t(1-\eta) = (1-\alpha)\frac{Y_t}{L_t}. \tag{34}$$

As mentioned, any profits from capital that would arise are sent back to banks. Income from capital come from its utilisation in the production function as well as from selling it back to capital producers. Then, a bank that borrows an amount $Q_{t-1}K_t$ in period $t-1$ must have the following:

$$R_t Q_{t-1} K_t = \alpha Y_t + Q_t(1-\delta)\psi_t K_t + (Q_t - 1)\delta\psi_t K_t.$$

Rearranging the equation above shows us the formula for the rate of return charged by banks

$$R_t^k = \frac{[Z_t + (Q_t - \delta)\psi_t]}{Q_{t-1}}, \tag{35}$$

where $Z_t = \alpha Y_t / K_t$.

2.5 Capital Producers

Capital producers use depreciated capital and final goods bought from goods producers to invest and make new capital. They sell both new and refurbished capital at price Q_t. We assume there is flow adjustment cost associated with new capital.

Let I_t be gross capital created, I_t^n be net capital created, and I_{ss} the steady-state level of investment. As with other firms, capitalists are the owners of capital producers. Accordingly, capital producers objective is to choose I_t^n to maximize

$$\max E_t \left[\sum_{i=0}^{\infty} \Lambda^k_{t+i,t+1+i} \left\{ (Q_{t+i} - 1) I^n_{t+i} - f\left(\frac{I^n_{t+i} + I_{ss}}{I^n_{t+i-1} + I_{ss}} \right) (I^n_{t+i} + I_s s) \right\} \right],$$

with

$$f\left(\frac{I^n_t + I_{ss}}{I^n_{t-1} + I_{ss}} \right) = \frac{\eta_i}{2} \left(\frac{I^n_t + I_{ss}}{I^n_{t-1} + I_{ss}} - 1 \right)^2, \tag{36}$$

$$I^n_t = I_t - \delta \psi_t K_t \text{ , and} \tag{37}$$

$$K_{t+1} = \psi_t K_t + I^n_t. \tag{38}$$

The first-order condition of the problem above is

$$Q_t = 1 + f(\cdot) + \frac{I^n_t + I_{ss}}{I^n_{t-1} + I_{ss}} f'(\cdot) - E_t \left[\Lambda^k_{t,t+1} \left(\frac{I^n_{t+1} + I_{ss}}{I^n_t + I_{ss}} \right)^2 f'(\cdot) \right]. \tag{39}$$

Notice that, because $f'(1) = 0$, profits for capital producers only arise outside of the steady-state. Any profits that they make are sent to capitalists. We are now able to determine the sum of profits from banks and non financial firms Π_t. It is the sum of profits from capital producers, plus what capitalists receive from exiting banks, minus what they give to new banks. Hence

$$\Pi_t = [Q_t - 1 - f(\cdot)] I^n_t - N^y_t + \sigma N^o_t / (1 - \sigma),$$

where we make an adjustment in N^o_t because it is the new worth of continuing banks, while we want the net worth of exiting banks.

2.6 Equilibrium and Aggregates

We now proceed to establish market clearing for some markets in the economy. First, total supply must equal total demand in the final goods market

$$Y_t = C_t + I_t + f(\cdot)(I^n_t + I_{ss}) + G + \tau \zeta_t Q_t S_t. \tag{40}$$

In the equity market, all shares sold by banks must be bought by some capitalist. Each bank sells an amount of shares equal to $x_t Q_t s^p_t$, and each capitalist buys an amount $q_t \bar{e}_t$ shares. However, there are only η capitalists, thus

$$\eta q_t \bar{e}_t = x_t Q_t S_t^p. \tag{41}$$

Regarding the division of aggregate variables between capitalists and workers we must have

$$C_t = \eta C_t^k + (1-\eta) C_t^w \text{ , and} \tag{42}$$

$$B_t = \eta B_t^k + (1-\eta) B_t^w, \tag{43}$$

with

$$B_t = B_t^p + B_t^g = B_t^p + \zeta_t Q_t S_t,^{5} \tag{44}$$

where B_t^p is the total amount of bonds sold by banks to households.

Then, funding for all the assets loaned in the economy, both by banks and by the central bank, will be divided as:

$$Q_t S_t = N_t + B_t + x_t Q_t S_t (1-\zeta_t). \tag{45}$$

Finally, we must define the equation for the exogenous shock on capital quality, wich will follow an AR(1) process

$$\psi_t = \rho_\psi \psi_{t-1} + \epsilon_t. \tag{46}$$

Equations (1)-(9), (18)-(24), (27), (29)-(35), (37)-(46) and the budget constraint for workers determine the 35 variables in the model: R_t^e, q_t, ψ_t, $\Lambda_{t,t+1}^k$, R_t, ϱ_t^k, C_t^k, $\Lambda_{t,t+1}^w$, L_t, W_t, ϱ_t^w, C_t^w, ϕ_t, ν_t, μ_{st}, μ_{et}, x_t, Ω_t, S_t^p, N_t, Q_t, ζ_t, S_t, T_t, K_t, Y_t, R_t^k, I_t^n, I_t, C_t, $\bar{e}_t$, B_t, B_t^k, B_t^w and B_t^p.

[5] How B_t^k and B_t^w are divided between B_t^p and B_t^g is not relevant, since bonds issued by banks and by the government are perfect substitutes.

3 Methodology

3.1 Solution

The model is solved through a first-order linear approximation around its steady-state, using Dynare. While this method is straightforward and simpler to solve, not using a second-order approximation means that we are giving up on the influence of second moments on the dynamics of the model. This is important because there is risk-premium in the economy.

In the steady-state without any risk there is no difference for capitalists between investing in risk-free bonds or in outside equity. As equations (2) and (3) show, their return must be equal: $R^k = R^e = 1/\Lambda^k$. Thus, without risk, they are identical.

However, with the possibility of shocks to the quality of capital they cease to be perfect substitutes in the view of capitalists. As equation (1) shows, the return on outside equity is related to return on capital on the following period, which depends on the shock. Thus, as discussed before, equity financing is preferred for banks because it is state-contingent. On the other hand, capitalists would always prefer bond over outside equity if the returns were the same because the first guarantees the return, while the second does not.

Therefore, banks have to offer households a premium on outside equity over bonds. Still, as the method employed here is of first order, the notion of risk-premium will not be present in our model. As a result, capitalists will be indifferent between bond and outside equity and banks will choose their capital structure so to minimize its impact on the incentive restriction. In other words, they will choose x_t to minimize $\Theta(x_t)$. This optimization depends only on the parameters ε and κ, which do not change over time. Thus, banks will always have the same capital structure during our exercises in the next section.[1]

3.2 Calibration

We calibrate most of the parameters in the model with the same values of Gertler and Karadi (2011), or in order to meet the same targets.

[1]The fact that banks will not change their capital structure following a shock makes an alternative policy, equity injections in banks, equivalent to the baseline credit intervention analysed here. This also happens in Gertler and Karadi (2011).

Table 1: Parameters Values

Conventional		Other	
β	0.990	ν_g	100
δ	0.025	τ	0.1%
α	33.0%	ρ_ψ	0.67
χ	3.409	σ	0.947
φ	0.276	ξ	0.004
h	0.750	η	1.0%
η_i	1.728	x	10.0%

First, there are conventional parameters that have exactly the same value as those in Gertler and Karadi (2011). These are: $\beta, \delta, \alpha, \chi, \varphi, h$ and η_i. Their values, as well as others, are shown in Table 1.

Second, the next three parameters are less conventional, but their values were also taken from Gertler and Karadi (2011): τ is the inefficiency cost of the government and Gertler and Karadi (2011) argue that 0.1% is a higher bound, worst case scenario, on the real cost of intermediating high-grade assets in the US economy; ν_g is meant to mimic an aggressive credit policy, implying that the central bank represents about 20% of the credit market; ρ_ψ is the auto-regressive parameter in the equation for the shock on the quality of capital, and we also set it equal to 2/3.

Third, we have three targets to help us calibrate four new parameters. The parameters are: x_t, the ratio of inside equity to total assets; σ, the rate of survival of bankers; ξ the ratio of funding of new banks; and θ, which helps to pin down how much banks can divert assets, $\Theta(x_t)$.[2]

On the other hand, the three targets, which were set by Gertler, Kiyotaki and Queralto (2012), are: an spread $(R^k - R)$ in the steady state of 1% a year; an aggregate leverage ratio (the ratio of loans to inside ant outside equity) $Q_tS_t/(N_t + x_tQ_tS_t)$ of 4; and a ratio of inside to outside equity of 2/3.

There are still three targets left. First, We set the level of government expenditure so that it represents 17.5% of GDP in the steady-state.

Second, opponents of the credit policy by the Fed claimed that it helped disproportionately wealthy people with high stakes on bank's equity. Therefore, we want the capitalist type of agent to be significantly wealthier than workers, but we also want that wealth to be tied to the financial sector of the economy.

[2]As explained above, κ and ε determine x_t, which is constant in a first-order approximation. Thus, it is as if x_t is a parameter.

By setting η equal to 1%, capitalists' wealth responds to movements in banks' value and profit. Coincidentally, protests in the aftermath of the crisis were targeted at "the 1%".

Finally, we set the the amount of bonds held by capitalists and by workers in the steady state such that the share of total wealth owned by the top 1% is equal to 35%, which is in line with recent evidence for the US.[3]

[3] See Wolff (2012).

4 Results

In this section we will present the results from two exercises: (i) a comparison between our results and those of Gertler and Karadi (2011), both without unconventional monetary policy; (ii) our main result, which is the comparison between the responses with and without unconventional monetary policy of our model with capitalists and workers. All Impulse Response Functions (IRFs) show the response of the variables in percentage deviations from steady-state, and cover a span of 40 periods. As the models are meant to mimic the quarterly behavior of the US economy, this is equivalent to 10 years.

4.1 Comparison with Gertler and Karadi (2011)

Before going to our main result, we believe it is important to compare the behavior of the aggregate variables in our model to those of a benchmark model in the literature of financial frictions. Also, this first exercise will help us better understand the dynamics of the model.

As Gertler and Karadi (2011) argue in their paper, their model is a standard DSGE model with financial frictions with the goal to provide a "quantitative macroeconomic model where it is possible to analyze the effects of unconventional monetary policy" (Gertler and Karadi, 2011, p. 18). Thus, they add several features to their model to improve its empirical properties, as price rigidity, flow adjustment costs of investments, variable capital utilization, etc.

Our main goal is to provide a model-based evaluation of the distributive impact of an unconventional monetary policy. To do so, we believe our model needs first to capture the broad dynamic of the US economy after the crisis, and that is why we chose to build upon models that had this goal.

However, as mentioned in more detail in Section 2, we modified the Gertler and Karadi (2011) model quite a bit. Although we kept some aspects of the model (as habit formation and flow adjustment costs) we made a few simplifications (we do not have variable capital utilization nor price rigidity) and one major change, which is the introduction of two different agents, instead of a representative one.

As a result of all the changes and simplifications, our model could present a significantly different dynamic following a crisis. In order to verify that, we compare the response to a 5% quality shock in our model to that of Gertler and Karadi (2011). Figure 1 shows the result for some selected variables for both models, and the responses do not include unconventional monetary policy. The comparison with unconventional monetary policy is in the Appendix. It turns out that the results are quite similar with and without unconventional monetary policy, which we interpret as a sign that our model captures the essence of their model.

As Figure 1 shows, the dynamic of the economy in our model is quite similar to that in Gertler and Karadi (2011). The broad response is the same: when there is a shock to the quality of capital, capital drops, and so does total output and aggregate consumption. If there were no financial frictions, both interest rates would move perfectly together, investment would pick up shortly after the crisis and the economy would be back in the steady-state relatively fast.

However, with financial frictions, financial intermediaries take a hit in their balance sheet. As banks are leveraged, net worth of bankers falls drastically and their ability to perform loans is impaired because the incentive restriction is binding. Then comes the financial accelerator that further deepens the recession: the spread increases, the amount of loans made decreases, and investment is slow to recover. Thus, it takes several more periods for the economy to return to steady-state.

Even though the comparison shows that the responses are quite similar, there are differences. In our model the initial shock to financial intermediaries' net worth is harder, but it returns to steady-state much faster. In the real economy, output drops less, as investment and capital recover faster.

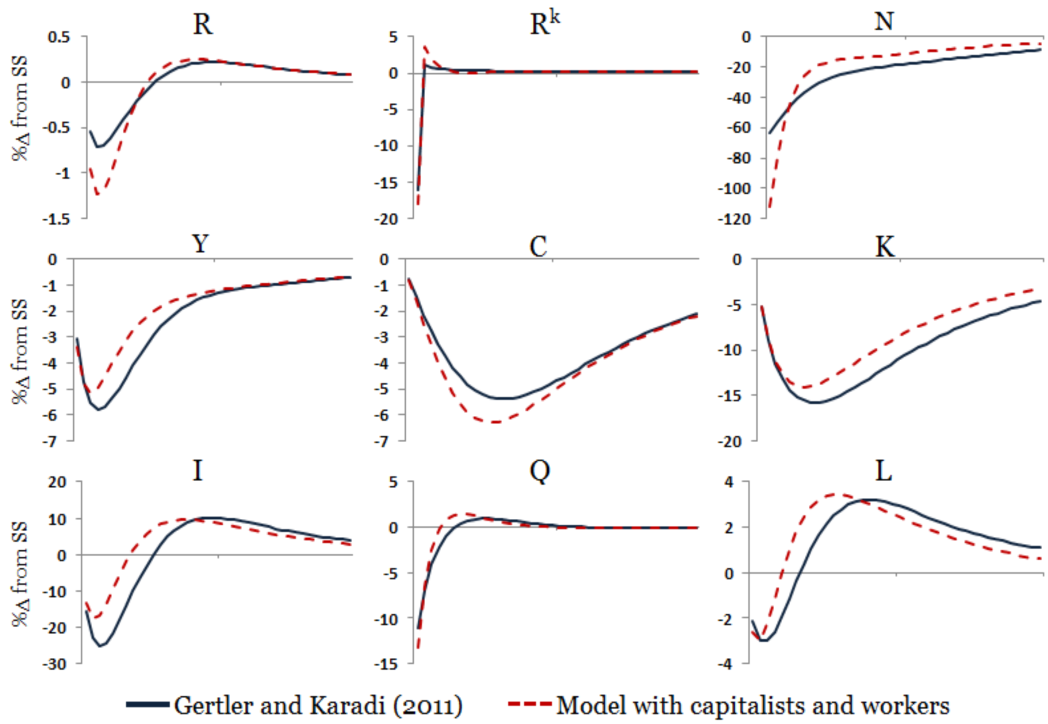
The harsher impact on financial intermediaries may be explained by the introduction of outside equity. With this other form of financing for banks, which represents 10% of the balance sheet, the net worth of financial intermediaries represents a smaller percentage of total assets loaned. Thus, in our calibration, the leverage ratio ϕ_t is equal to 6.67, while in Gertler and Karadi (2011) the value in steady-state of ϕ_t is equal to 4.[1] With a higher leverage, the impact on banks of an equal shock in the quality of capital is greater.

On the other hand, in our model the economy seems to recover faster initially. This can be explained by the introduction of two agents. In our model, capitalists do not enjoy income from labor, and workers no longer receive profits from banks, when compared to the model of Gertler and Karadi (2011). Also, we calibrate the division of bonds in the steady-state such that most of them are held by capitalist.

As a result from the introduction of two separate agents, income from labor is far more important now for workers than it was for the representative agent in the model of Gertler and Karadi

[1] However, as mentioned in Section 3.2 we follow Gertler, Kiyotaki and Queralto (2012) and set the ratio of aggregate leverage to be equal to 4 as well in our model.

Figure 1. Responses to a capital quality shock, without unconventional monetary policy.



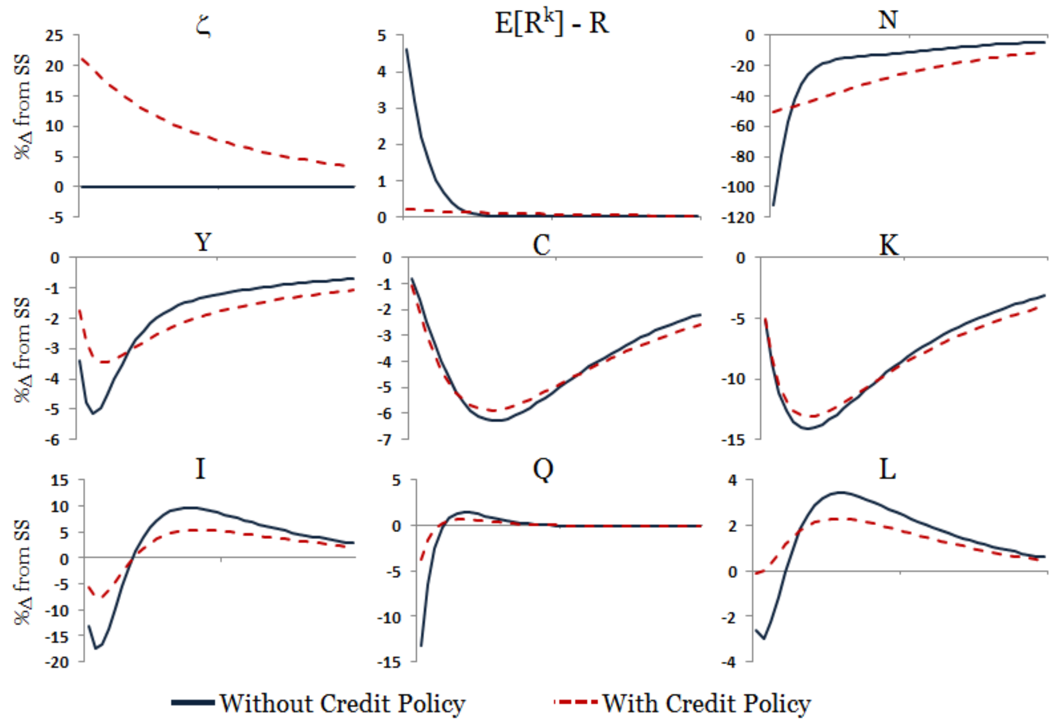
(2011). Therefore, the fall in wages that follow a recession hurts workers more now. In response, in our model workers raise their supply of labor faster to try to maintain the same level of consumption. This rise in the labor supply elevates the productivity of capital and thus gives incentives for a faster recovery of capital accumulation and, as a consequence, output.

4.2 Distributive Analysis

Now we proceed to our main result, which is the analysis in our model of the distributive impact of the credit policy following a crisis in our model with two distinct types of agents. To do so we compare the IRFs with and without monetary policy of several variables in our model. As Figure 2 shows, the impact of unconventional monetary policy in aggregate variables in our model is in line with what previous models found.

Following a crisis, as the spread in interest rates would rise, the government lends an amount equivalent to 20% of the capital stock. This is equivalent to an aggressive credit policy. In a moment when banks are severely constrained in their ability to gather funds from households and lend to firms, the intervention by the central bank effectively raises the amount of loans. This is true because there are no frictions in the lending from households to the government, while banks are incentive constrained.

Figure 2. Responses to a capital quality shock



The intervention is highly successful in containing the rise in spreads, as one can see in Figure 2. Hence, with more funds being loaned, in the medium term investment and the capital stock recover faster and as a result output rises.

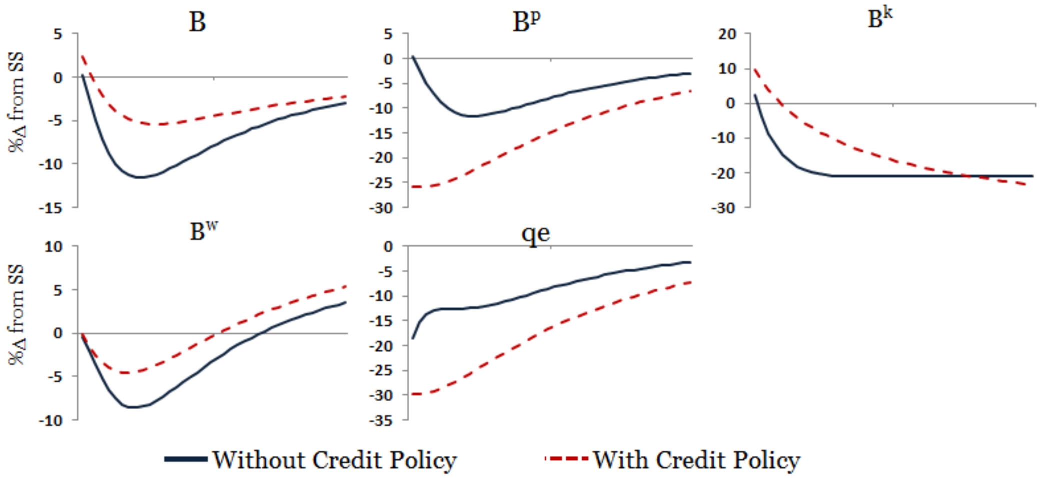
However, the variables in Figure 2 do not tell us about distributive impacts. To better understand what is going on comparatively between capitalists and workers it is useful for us to look first ate the variables in Figure 3.

What Figure 3 shows us first is that the central bank did in fact manage to gather more funds from households than would be possible without the credit policy. From the first IRF we can see the total amount loaned by households to the government and banks B_t is higher with monetary policy than without it through the 10 years shown. Also, B^k and B^w show us that both capitalists and workers loan more if a credit policy is present.

Although B_t increased, one can also observe that the amount loaned to private banks B_t^p falls substantially with the intervention by the central bank. In other words, even though the total amount of credit available in the economy rises, there is some degree of crowding out. Not every unit of credit loaned by the central bank is a new unit.

A second important takeaway from Figure 3 is that the amount of outside equity available in the economy falls substantially with the credit policy. This happens because the share of outside equity

Figure 3. Responses to a capital quality shock



x_t is a constant percentage of total loans made by private banks $Q_t S_t^p$ in our exercise. With the crowding out by the government, the amount of loans by private banks decreases, and the amount of outside equity needed to finance it also falls.[2]

The conclusion that, when the central bank intervenes in credit markets, private banks face a new competitor (the government) helps us better understand the IRFs in Figure 4.

As one can see, after the crisis, the intervention by the central bank reduces capitalists' consumption C^k trough the entire IRF. On the other hand, workers' consumption falls mildly in the short term, but then recovers faster and is greater than it would be otherwise until the medium to long term.

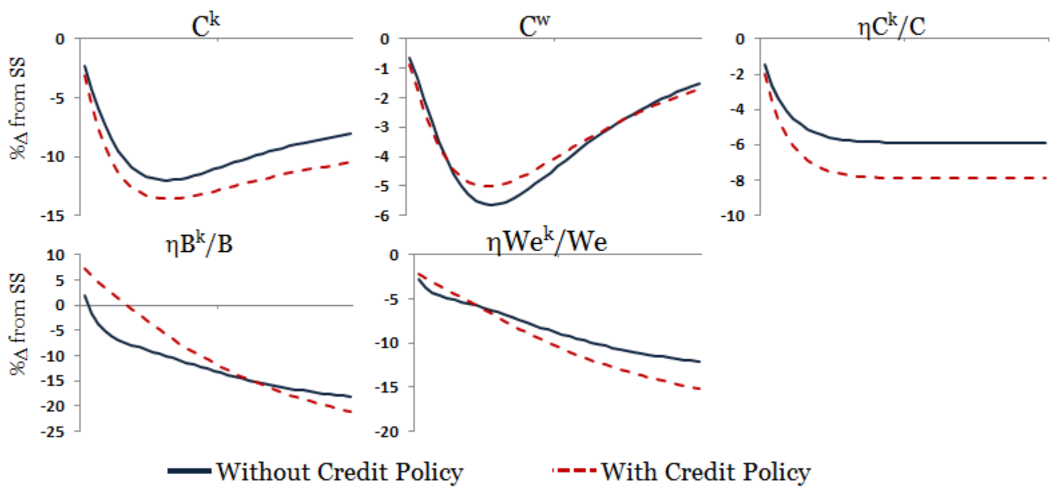
The net effect of both movements can be best seen in the graph for $\eta C^k/C$, which shows deviations from the steady state of the ratio of capitalists' consumption to aggregate consumption. As it is clear, the credit policy works better for workers than for capitalists in terms of consumption.

Some of the fall in capitalists' consumption can also be explained by the next graph, which shows the deviations from the steady state of the percentage of bonds that are held by capitalists, or $\eta B^k/B$. Credit policy makes capitalists save more in form of bonds than they used to do.

This happens because the credit policy takes away from capitalists a big source of revenue, which is profit from banks, while it increases a big source of revenue for workers, which is income from labor, as can be seen by the rise in hours worked in Figure 2. Thus, capitalists become more

[2]Gertler, Kiyotaki and Queralto(2012) take into account second moments in their paper, thus x_t changes in their exercises. However, the overall effect of credit policy on the share of outside equity financing is not clear. While the belief in a credit policy makes banks issue less (relatively to the steady state)outside equity in the steady state, when a crisis hits it also falls less when compared to an economy where agents believe that a credit policy will not happen, and they are right.

Figure 4. Responses to a capital quality shock



dependent on income from savings.

The big initial rise in bond holdings by capitalists, while there is a smaller movement in that direction by workers, helps to explain why the share of wealth owned by capitalists $\eta We^k/We$ rises too in the beginning.

It is important to emphasize that the initial rise in inequality as measured by wealth is due to a smaller level of consumption by capitalists. They are not wealthier and consuming more, they got wealthier initially because they chose to consume less. Thus, looking only to the effect of the credit policy on wealth can be misleading.

Ultimately, people accumulate wealth to consume, and to smooth consumption. In that sense, we find that the credit policy benefits more workers than capitalists, as can be seen by the dynamics of the share of goods consumed by capitalists, and by the individual dynamics of both workers and capitalists' consumption.

5 Conclusion

We built on previous DSGE models for the analysis of unconventional monetary policy to evaluate the distributive impact of a credit policy put in practice by the Federal Reserve after the recent financial crisis. To do so, instead of using a representative agent, we introduce two different types of agents: capitalists and workers.

First we show that, even with the modifications we made, the variables in our model capture the dynamics present in a benchmark model in the literature. Second, our main result, contrary to popular beliefs and many protests held against policies by the Fed and the Treasury, is that unconventional monetary policy benefited workers more than capitalists.

Our results come mainly from two channels. The first channel is that the monetary policy boosted credit available in the economy, which led to more investments by firms, which in turn led to a better market for labor. As workers depend more on income from labor than capitalists do, the overall effect benefits workers more.

The second channel is a crowding out effect. Even though the government raised the amount of loans made, some of it crowded-out private banks. What happened is that new competition by the Fed decreased private banks' market share. As a result, private banks' profit also decreased, which hurt capitalists more.

Therefore, we find that the net effect of the unconventional monetary policy was pro-worker. It is important to emphasize that we find that the share of capitalists' wealth rises initially with the unconventional monetary policy, but that was due to lower consumption and not higher income.

Our work employed a first-order approximation around the steady-state. It would be interesting to do higher-order approximations to test if second moments could change significantly any of the responses of the model, and the final verdict on the distributive impact. This would also allow the analysis of equity injections, which was another policy practiced by the Fed and other Central Banks.

Also, we made some assumptions to distinguish workers from capitalists. One possible extension would be to allow capitalists to provide labor, maybe of a different type.

Finally, we used a particular model for unconventional monetary policy that rests on a particular assumption about financial frictions between households and banks. Further research must be done to assess if the same distributive results are present in other frameworks.

Bibliography

Aerosa, W. D. and Coelho, C. A. (2013). Using a dsge model to assess the macroeconomic effects of reserve requirements in brazil. *Banco Central Do Brasil Working Paper Series*, (303).

Beraja, M., Fuster, A., Hurst, E., and Vavra, J. (2015). Regional heterogeneity and monetary policy. *Hutchins Center for Fiscal Monetary Policy Working Paper*, 13.

Bivens, J. (2015). Gauging the impact of the fed on inequality during the great recession. *Hutchins Center for Fiscal Monetary Policy Working Paper*, 12.

Calomiris, C. W., Eisenbeis, R. A., and Litan, R. E. (2011). Financial crisis in the us and beyond. *The World in Crisis: Insights from Six Shadow Financial Regulatory Committees from Around the World*, pages 1–60.

Dedola, L., Karadi, P., and Lombardo, G. (2013). Global implications of national unconventional policies. *Journal of Monetary Economics*, 60(1):66–85.

Diniz, A. and Guimaraes, B. (2014). Financial disruption as a cost of sovereign default.

Doepke, M., Schneider, M., and Selezneva, V. (2015). Distributional effects of monetary policy. *Hutchins Center for Fiscal Monetary Policy Working Paper*, 14.

Gertler, M. and Karadi, P. (2011). A model of unconventional monetary policy. *Journal of monetary Economics*, 58(1):17–34.

Gertler, M., Karadi, P., et al. (2013). Qe 1 vs. 2 vs. 3...: A framework for analyzing large-scale asset purchases as a monetary policy tool. *International Journal of central Banking*, 9(1):5–53.

Gertler, M., Kiyotaki, N., et al. (2010). Financial intermediation and credit policy in business cycle analysis. *Handbook of monetary economics*, 3(3):547–599.

Gertler, M., Kiyotaki, N., and Queralto, A. (2012). Financial crises, bank risk exposure and government financial policy. *Journal of Monetary Economics*, 59:S17–S34.

Nakajima, M. et al. (2015). The redistributive consequences of monetary policy. *Business Review*, (Q2):9–16.

Saiki, A. and Frost, J. (2014). Does unconventional monetary policy affect inequality? evidence from japan. *Applied Economics*, 46(36):4445–4454.

Villa, S. and Yang, J. (2011). Financial intermediaries in an estimated dsge model for the united kingdom. *Bank of England Working Paper*, 14.

Wolff, E. N. (2012). The asset price meltdown and the wealth of the middle class. Technical report, National Bureau of Economic Research.

A Appendix

A.1 Proof of the guess-and-verify

As shown in Gertler, Kiyotaki and Queralto (2012), for the guess in equation (16) to be correct, we must have:

$$
\begin{aligned}
(\mu_{st}+x_t\mu_{et})Q_t s_t^p + \nu_t n_t = \\
&= E_t\left[\Lambda_{t,t+1}^k\left\{(1-\sigma)n_{t+1} + \sigma((\mu_{st+1}+x_{t+1}\mu_{et+1})Q_{t+1}s_{t+1}^p + \nu_{t+1}n_{t+1})\right\}\right] \\
&= E_t\left[\Lambda_{t,t+1}^k\left\{(1-\sigma)n_{t+1} + \sigma((\mu_{st+1}+x_{t+1}\mu_{et+1})\phi_{t+1}n_{t+1} + \nu_{t+1}n_{t+1})\right\}\right] \\
&= E_t\left[\Lambda_{t,t+1}^k\left\{(1-\sigma) + \sigma((\mu_{st+1}+x_{t+1}\mu_{et+1})\phi_{t+1} + \nu_{t+1})\right\}n_{t+1}\right] \\
&= E_t\left[\Lambda_{t,t+1}^k\Omega_{t+1}n_{t+1}\right] \\
&= E_t\left[\Lambda_{t,t+1}^k\Omega_{t+1}\left\{(R_{t+1}^k - R_{t+1} + x_t(R_{t+1}-R_{t+1}^e))Q_t s_t^p + R_{t+1}n_t\right\}\right],
\end{aligned}
$$

where we used equations (13), (17) and (22). Thus we can see that, if equations (19), (20), (21) and (22) hold, then the guess is correct.

A.2 Finding x_t

Again, following Gertler, Kiyotaki and Queralto (2012), the bank's objective is to maximize the following Lagrangian:

$$L = (\mu_{st}+x_t\mu_{et})Q_t s_t^p + \nu_t n_t + \lambda_t[(\mu_{st}+x_t\mu_{et})Q_t S_t^p + \nu_t n_t - \theta(1+\varepsilon x_t + (\kappa/2)x_t^2)Q_t s_t^p],$$

where λ_t is a Lagrangian multiplier.

The first-order conditions are:

$$\begin{aligned}(1+\lambda_t)\mu_{et}Q_t s_t^p &= \theta(\varepsilon+\kappa x_t)Q_t s_t^p\lambda_t,\\ (1+\lambda_t)(\mu_{st}+x_t\mu_{et}) &= \lambda_t\Theta(x_t)\text{ , and}\\ (\mu_{st}+x_t\mu_{et})Q_t s_t^p+\nu_t n_t &= \Theta(x_t)Q_t s_t^p.\end{aligned}$$

Using the two first first-order conditions, we have that:

$$\begin{aligned}\theta(\varepsilon+\kappa x_t)(\mu_{st}+x_t\mu_{et}) &= \theta(1+\varepsilon x_t+(\kappa/2)x_t^2)\mu_{et}\\ \varepsilon\mu_{st}+\varepsilon x_t\mu_{et}+\kappa x_t\mu_{st}+\kappa\mu_{et}x_t^2 &= \mu_{et}+\varepsilon x_t\mu_{et}+(\kappa/2)x_t^2\\ (\kappa/2)x_t^2\mu_{et}+\kappa x_t\mu_{st} &= \mu_{et}-\varepsilon\mu_{st}\\ (\kappa/2)x_t^2+\kappa x_t(\mu_{st}/\mu_{et}) &= 1-\varepsilon(\mu_{st}/\mu_{et}).\end{aligned}$$

Then adding $(\mu_{st}/\mu_{et})^2$ on both sides:

$$\begin{aligned}(x_t+(\mu_{st}/\mu_{et}))^2 &= (\mu_{st}/\mu_{et})^2+(2/\kappa)(1-\varepsilon(\mu_{st}/\mu_{et}))\\ x_t &= -\frac{\mu_{st}}{\mu_{et}}+\left[\frac{\mu_{st}}{\mu_{et}}^2+\frac{2}{\kappa}\left(1-\varepsilon\frac{\mu_{st}}{\mu_{et}}\right)\right]^{1/2},\end{aligned}$$

which is equal to equation (23).

A.3 Figure 5

Figure 5. Responses to a capital quality shock, with unconventional monetary policy.