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Comparative analysis of quantitative easing and money-financed fiscal stimulus

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Abstract
I study two types of unconventional monetary policy: quantitative easing (QE) and money-financed fiscal stimulus (MFFS), in a modified New Keynesian framework. I compare their effectiveness in stabilizing output and inflation when monetary policy is constrained by the effective lower bound. Money-financed fiscal stimulus performs better than quantitative easing, except the case of the TFP shock. It tends to cause lower inflation and output volatility. Nevertheless, it might be substantially more problematic in implementation as it demands cooperation between the central bank and the fiscal authority. Real reserve targeting (RRT) delivers similar outcomes as quantitative easing but is easier to implement.

Keywords:
unconventional monetary policy, quantitative easing, money-financed fiscal stimulus,

JEL Classification
E21, E30, E50, E58, E61

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1 Introduction

Throughout the last few years, conventional monetary policy has been constrained the effective lower bound. Central banks have resorted to unconventional policies to stabilize inflation and gross domestic product. These newly invented methods have been used with limited guidance coming from literature as most of the existing macroeconomic models were ill-suited to study these policies. This gap in the literature has spurred a wealth of new research employing richer frameworks incorporating various financial frictions.

In this paper, I investigate two types of unconventional policies, quantitative easing (together with real reserve targeting) and money-financed fiscal stimulus. I consider two different implementations of money-financed stimulus: as a universal tax cut and as a transfer to the unemployed individuals only. I conduct my analysis in a dynamic stochastic general equilibrium model based on Wei Cui and Vincent Sterk (2019). The key feature of the model is that households are characterized by different marginal propensities to consume out of the liquid and illiquid wealth. A policy that converts a part of illiquid wealth into liquid wealth has then first-order effects on the aggregate consumption and the behavior of the entire economy.

The most important findings are as follows. First, in reaction to exogenous shocks, both policies act in a similar manner. However, in the baseline calibration of the model, under MFFS, the general volatility of variables tends to be lower in the case of monetary policy shock and government expenditures shock. This is due to the QE's policy coefficients values. Second, RRT might be the best option if the effective lower bound is binding. Even though it is outperformed by MFFS, it is the most straightforward unconventional policy to conduct as there is no need for searching for optimal policy coefficients values, and there are no issues regarding cooperation between monetary and financial authorities.

The remainder of the paper is organized as follows. Section 2 describes the purpose of using unconventional monetary policies and provides a review of the related literature. Section 3 discusses the model's construction. Section 4 contains the model's calibration, followed by a comparative analysis of the effects of QE and MFFS on the key macroeconomic variables under various shocks. Section 5 concludes.

2 The reasons behind the usage of unconventional monetary policies

It is already more than twelve years since the beginning of the Great Recession, and the majority of the largest central banks still have not gone back with their reference rates to the level from before it. However, the whole world has already been struck by the new crisis caused by the pandemic of SARS-CoV-2. So it is again time for expansionary monetary policy action, but the policy space for the conventional policy measures is smaller than ever before. Therefore everything suggest that this time usage of unconventional tools will also be necessary. Before the Great Recession, central banks were able to mitigate by cutting their reference interest rates by several percentage points. However, at the turn of the late 2000s and early 2010s, in many countries, they were cut to near-zero levels. For many economies, the stimulus was still insufficient. In some of them, authorities decided to apply negative interest rates, but none of them had decreased the policy interest rate below -0.75 percentage points (Switzerland, Denmark) for fear of a liquidity trap and disrupting the functioning of critical financial institutions. At the same time, if the central banks were to continue acting according to their pre-crisis behavior approximated by a Taylor rule, the nominal interest rates would have had to be reduced much further; for example, in the United States of America, below -4% (Bernanke 2015). Even though the location of the effective lower bound varies over countries as it depends on financial system regulations and various cultural and sociological factors of a given economy, that is a value that seems to be out of reach of any central bank. Once conventional policy lost its power, as the effective lower bound was approached, central bankers turned to unconventional monetary policy tools. During the last crisis, many of them have used QE and forward guidance.

As a policy, QE first emerged at the meeting of the Monetary Policy Board of the Bank of Japan in 1999, when the country was struggling with deflation. Even though it had little support from economic theory at the time, it was implemented in March of 2001 by the purchase of ¥35 trillion (approximately 300 billion of United States dollars) worth of government bonds over a three-year time window (Ueda 2001). However, central banks have used to expand their balance sheets before. These interventions were usually connected with financing governments during wars and other geopolitical or financial crises. For example, during World War II, the total assets of central banks in a number of countries approached 40% of gross domestic product (Ferguson, Schaab, Schularick 2015). However, they were not treated then as monetary policy operations, as we would nowadays interpret these actions. QE is an expansive unconventional monetary policy based on purchasing large amounts of assets by the central bank, which is financed by issuing new reserves, so in other words, by base money creation. Originally, QE referred to purchasing government bonds, but soon, central banks started to switch to other, often much riskier types of assets than those usually used when conducting open market operations, like corporate bonds or mortgage-based securities. Broadening the scope of purchased assets also has its own name - qualitative easing, and, as mentioned earlier, is often combined with QE into quantitative and qualitative easing. In turn, so-called credit easing is QE targeted at a specific market. There is also a particular case of QE called RRT when there is a directly specified target of steady real reserves level. Hence, in the absence of shocks, there is one-to-one movement between the price level and the amount of nominal reserves (Cui, Sterk 2019).

In 2014 the former United States Federal Reserve System's chairman Ben Bernanke said, "The problem with quantitative easing is that it works in practice, but doesn't work in theory." However, that is not an entirely accurate statement. It rather just does not work in a standard New Keynesian model, which for the time being, has been the most popular modern macroeconomic framework. This is not a suitable environment for modeling unconventional monetary policies (except forward guidance) because they work by mitigating drawbacks of financial markets distortions, what is hard to show if the model assumes these markets to be frictionless. To capture the effect of policies like the QE model used in the analysis has to include financial frictions and other market imperfections (Chen, Cúrdia, Ferrero, 2012; Gertler, Karadi 2011; Gertler, Karadi 2013; Hohberger, Priftis, Vogel 2020; Williamson, 2012).

Recently the subject of QE has been tackled by numerous researchers. Haldane et al. (2016) focused on the impact quantitative easing has on financial markets. They identify two kinds of channels, ones through which standard policy operates are recast for unconventional ones: monetary policy signaling, reducing uncertainty and exchange rate; and ones specific to QE: portfolio rebalancing, liquidity effects, bank lending stimulation. They study the impact of QE’s announcement on various kinds of assets among a few markets, which central banks conducted it as a response to the Great Recession. A clear pattern emerges, short and long bond rates in the two-day window declined, and the size of this shift was positively associated with the size of the announcement relative to the economy’s gross domestic product. Yet, changes were not large - mostly up to 20 basis points in absolute terms. Further analysis indicates that QE did not always decrease the uncertainty, which was measured by changes in the VIX index in the two-day window. To examine the impact of QE on the economy, they estimate the expanded version of the SVAR model by Weale and Wieladek (2016). They divided the purpose of conducting large-scale assets purchases programs into two categories: stimulating the economy by buying long-time bonds and stabilizing conditions at the bank funding market by providing additional liquidity through short-time operations. As they expected, expanding balance sheets tended to boost gross domestic product and inflation rate, raise equity prices and push down long-time interest rates, although responses differ substantially across countries. Only for the first category programs, results were statistically significant. They also find huge international spillover effects.

On the other hand, Cui and Sterk (2019) concentrate on the assets liquidation effect of QE. Following decomposition used before for conventional monetary policy by Kaplan, Moll, and Violante (2018), they split the QE impact for the direct and indirect effect. The first one comes from a difference in the marginal propensities to consume out of the liquid and illiquid assets. Under QE, the central bank buys less liquid assets for the newly created reserves of the same worth, resulting in a shift in private savings' structure, which increases aggregate consumption. In turn, the indirect effect captures mostly the impact of price stickiness. Flexible prices suppress the reaction of an economy for QE. In contrast, sticky ones may boost it even more because if the prices were fully flexible, they would change one to one with reserves created for the purpose of QE. They find that QE is able to anchor inflation expectations just as well as the conventional monetary policy. Further, they find that both conventional policy and QE perform similarly when the goal is to stabilize either output or inflation. However, when the point is to stabilize them simultaneously, QE outperforms conventional policy. Lastly, they examine the welfare effects. Under QE, welfare is much more sensitive for deviations from the optimal coefficients. Interestingly the optimal coefficients in the QE policy rule are close to zero, so outcomes of RRT are comparable to the optimal QE.

Notwithstanding, the situation since the Great Recession has changed, and monetary tools that were successful then, this time, might be insufficient. A subsequent round of QE may not be compelling because many central banks' balance sheets are already high, and gains from expanding it further might not provide a strong stimulus. Moreover, as QE is anticipated to take place, it will not get the premium from taking the market by surprise. However, there are some monetary policy tools that have not been used to this date, and monetary authorities might pick them up this time.

MFFS is one of them. It is a theoretical concept proposed by Milton Friedman, which owes its alternative name, helicopter money, to its first description in his book The Optimum Quantity of Money and Other Essays (Friedman 1969, pp. 4-5): „Let us suppose now that one day a helicopter flies over this community and drops an additional $1.000 in bills from the sky, which is, of course, hastily collected by members of the community. Let us suppose further that everyone is convinced that this is a unique event which will never be repeated". Of course, in reality, no central bank will literally drop any money from the sky. Instead, it would be coordinated action between monetary and fiscal policymakers, which would either take the shape of an increase in government transfers or tax cuts, in both cases financed by additional creation of reserves in contrast to standard debt financing. While there are many hurdles to overcome in the implementation details, such policy should stay effective even when other monetary tools become incapable, or the government turns out to be constrained by budget discipline (Gali 2020a). What is interesting, a similar idea to the MFFS was a part of the Chicago plan from 1933 and consecutive A Program for Monetary Reform (Douglas et al.

1939). They were sets of ideas on how to repair the American economic system proposed, respectively, after the Great Depression and the recession of 1937-1938. However, it was not implemented at that time.

Among adherents of MFFS, Jordi Gali is one of the most influential. In his recent paper (Gali 2020b), he examines the effects of fiscal stimulus financed by money creation, rise in government expenditures versus taxes cut, under different conditions, standard times versus zero lower bound, and compared its effectiveness with the debt-financed one. In so-called regular times, when zero lower bound is not binding, both types of debt-financed policies are inefficient due to the Ricardian equivalence. On the contrary, when financed by money creation, it causes a decline in the real interest rate through increased liquidity. Here Ricardian equivalence does not hold because a money financed tax cut expands households' lifetime budget constraint. Boost in subsequent periods is driven by inflation and a lower real interest rate. Things are not so unambiguous when the nominal interest rate is constrained by zero lower bound (ZLB). Debt financed increase in government expenditures now lowers real interest rate because of lack of increase in nominal interest rate by the central bank and higher expected inflation what mitigates effects of shock. The government spending multiplier is very high under ZLB, consistent with Lawrence, Eichenbaum, Rebelo (2011), and Eggertsson (2011). Under ZLB money financed policies are once again more effective. However, their performance is only slightly better than the debt-financed ones.

3 The model

The framework used in the following analysis is a modified version of the model by Cui and Sterk (2019). It is the New Keynesian model with heterogeneous agents that assumes a closed economy. Six types of agents populate the economy: households, goods-producing firms, mutual fund, banks, the government, and the central bank. When constrained by the effective lower bound, monetary policy works through the channel of changing the structure of households' assets as the households have a much higher marginal propensity to consume out of liquid assets than out of illiquid ones. All budget constraints are given in real terms.

3.1 Households

The economy is inhabited by a continuum of households that are infinitely-lived and ex-ante identical. Their preferences are given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t U[C_t(i), N_t(i)] \quad (1)$$

where:

· β is households' discount factor

· $N_t(i)$ denotes hours worked by i[th] household

· $C_t(i)$ denotes i[th] household consumption basket composed of j goods

$$C_t(i) \equiv \int_0^1 \left(C_t(i,j)^{\frac{\varepsilon_t - 1}{\varepsilon_t}} dj \right)^{\frac{\varepsilon_t}{\varepsilon_t - 1}} \quad (2)$$

where:

· $C_t(i, j)$ denotes consumption of good j by i[th] household

· ε is exogenous goods substitution elasticity.

Households optimize so that consumption basket's price is set by equation:

$$P_t = \int_0^1 (P_t(j)^{1-\varepsilon_t} dj)^{\frac{1}{1-\varepsilon_t}} \quad (3)$$

where:

· $P_t(j)$ denotes the price of good j.

Households supply labor in a competitive market where they face the idiosyncratic risk of becoming unemployed. Employed agents work for an hourly wage and can choose how long they want to work, whereas unemployed ones receive unemployment benefits.

It is assumed that labor market flow rates are constant, and as a result, the unemployment level is also constant and can be written as:

$$u = \frac{p^{EU}}{p^{EU} + p^{UE}} \quad (4)$$

where:

· p^{EU} is the unemployment inflow rate

· p^{UE} is the unemployment outflow rate.

Households store their wealth in banks and the mutual fund in order to mitigate the drop in consumption upon losing their job. The first option allows agents to withdraw money at any time, so those assets are fully liquid and are (in equilibrium) used up entirely within a time period when the agent becomes unemployed. This outcome results from relatively high unemployment outflow rate. On the other hand, wealth in the mutual fund is only partially liquid, and households receive a payout in every period, which for the unemployed agents is higher than for the employed.

While agents can hold positive deposits, they are forbidden from borrowing liquid assets, therefore:

$$D_t(i) \geq 0 \tag{5}$$

where:

· $D_t(i)$ denotes the amount of deposits held by the i[th] agent.

And the difference in mutual fund's payouts is:

$$\mu_t \equiv X_t^U - X_t^E \tag{6}$$

where:

· μ is mutual fund liquidation coefficient under unemployment, which is constant over time

· X_t^U denotes mutual fund payout for unemployed

· X_t^E denotes mutual fund payout for employed.

Households face the problem of maximization of their expected utility, which consists of Constant Relative Risk Aversion function for utility from consumption and disutility from labor characterized by constant Frisch elasticity:

$$U(C,N) = \frac{C_t^{1-\sigma} - 1}{1-\sigma} - \frac{\kappa_0}{1+\kappa_1} N_t^{1+\kappa_1} \tag{7}$$

where:

· σ is the relative risk aversion coefficient (which is greater than 0)

· κ_1 is the inverse Frisch elasticity (which is greater than 0)

· κ_0 stands for the disutility from labor

Subject to the following budget constraint:

$$C_t(i) + D_t(i) = w_t N_t(i) + \frac{R_{t-1}}{\Pi_t} D_{t-1}(i) + X_t(i) + \Theta_t(i) - T_t(i) \tag{8}$$

where:

· w_t denotes real hourly wage

· R_t denotes nominal interest rate set by the central bank

· Π_t denotes the gross inflation rate.

· $X_t(i)$ denotes i[th] household's payout from the mutual fund, which is equal to X_t^U or X_t^E

· $\Theta_t(i)$ denotes unemployment benefit(equal to Θ^U) if the household is employed or the unemployment insurance contribution for if the household is employed (equal to $-\frac{u}{u-1}\Theta^U$)

· $T_t(i)$ denotes lump-sum tax, which might potentially differ between employed (T_t^E) and unemployed (T_t^U) agents.

To facilitate the model's solution, households are divided into a finite number of cohorts according to their employment histories because all agents with the same duration of their most recent employment spell act in the same manner. There is a single cohort for newly unemployed, another for those who are unemployed for longer than one period, and 75 separate cohorts for employed. Every agent employed for more than 75 periods behaves identically. Solving the households' problem leads to the following Euler equations for the k^{th} cohort (for K^{th} cohort k=k+1=K):

$$\left[C_t^E(k)\right]^{-\sigma} = \beta E_t\left[\frac{R_t}{\Pi_{t+1}}\left[p^{EU}(C_{t+1}^{EU}(k+1))^{-\sigma} + (1-p^{EU})(C_{t+1}^{E}(k+1))^{-\sigma}\right]\right] \quad (9)$$

where:

· $C_t^E(k)$ denotes the consumption of employed agents

· $C_t^{EU}(k)$ denotes the consumption of newly unemployed agents.

Additionally employed agents consumption labor choice is given by:

$$w_t\left[C_t^E(k)\right]^{-\sigma} = \kappa_0\left[N^E(k)\right]^{\kappa_1} \quad (10)$$

where:

· $N^E(k)$ denotes hours worked by employed agents.

Budget constraint of newly unemployed simplifies to:

$$C_t^{EU}(k) = \frac{R_{t-1}}{\Pi_t} D_{t-1}{}^{E}(k-1) + X_t{}^{U} + \Theta_t{}^{U} - T_t^{U} \tag{11}$$

where:

· $D^E(k)$ denotes deposits of employed agents.

And budget constraint of those who are unemployed for longer than one period to:

$$C_t^{UU} = X_t{}^{U} + \Theta_t{}^{U} - T_t^{U} \tag{12}$$

where:

· $C_t^{UU}(k)$ denotes consumption of agents unemployed for longer than one period.

3.2 Firms

There is a variety of consumption goods, each produced by a different, monopolistically competitive firm. In the production process, firms use only labor, so they produce goods according to the following function:

$$Y_t(j) = A_t N_t(j) \tag{13}$$

where:

· $Y_t(j)$ denotes the firm's output (and $Y_t = \int_0^1 Y_t(j)dj$ stands for aggregate output)

· A_t denotes exogenously determined Total Factor Productivity, which is prone to stochastic shocks.

They adjust prices of their goods according to Rotemberg's (1982) scheme, which states they avoid significant price changes because, through them, firms lose the loyalty of consumers:

$$Adj_t(j) = \phi\left(\frac{P_t(j) - P_{t-1}(j)}{P_{t-1}(j)}\right)^2 Y_t \tag{14}$$

where:

· $Adj_t(j)$ denotes the cost of the firm's price adjustment in real terms

· ϕ is the cost of the price adjustment parameter.

This can be rewritten in aggregate terms as:

$$Adj_t = \int_0^1 Adj_t(j)dj = \phi(\Pi_t - 1)^2 Y_t \quad (15)$$

Therefore aggregate dividends satisfy:

$$Div_t = Y_t - w_t N_t - Adj_t \quad (16)$$

From equations 3, 9, 11, and 12 comes the relation widely known as the New Keynesian Phillips Curve:

$$1 + \varepsilon_t \left[\left(\frac{w_t}{A_t} \right) - 1 \right] = \phi(\Pi_t - 1)\Pi_t - \phi\beta E_t \frac{Y_{t+1}}{Y_t} (\Pi_{t+1} - 1)\Pi_{t+1} \quad (17)$$

where:

· ε_t is a stochastic markup.

3.3 Mutual funds

There is a single representative mutual fund that owns both firms' shares and the government bonds, purchases of which are financed by wealth stored there by households. Its budget constraint is:

$$uX_t^U + (1-u)X_t^E = Div_t + (1+\rho q_t)\frac{B_{t-1}^m}{\Pi_t} - q_t B_t^m \quad (18)$$

where:

· ρ stays for the decay of government bonds, and it satisfies inequality $0 \leq \rho \leq \beta^{-1}$

· B_t^m denotes the amount of government bonds owned by mutual fund

· q_t denotes the price of government bonds from period t; it is determined as follows:

$$q_t = \beta E_t \frac{1 + \rho q_{t+1}}{\Pi_{t+1}} \quad (19)$$

3.4 Banks

Banks play the role of financial intermediaries, among which there is perfect competition. They gather deposits from the households in exchange for the nominal interest rate R_t and hold them as reserves in the central bank, which also pays the nominal rate R_t. Their consolidated balance sheet can be written as:

$$\int_0^1 D_t(i)di = M_t \tag{20}$$

where:

· $D_t(i)$ denotes the amount of deposits held by the i^{th} agent

· M_t denotes real reserves held in the central bank.

3.5 Government

The government finances its spending by issuing bonds and receiving lump-sum taxes and seigniorage transfers from the central bank. Its budget constraint is given by the equation:

$$G_t = q_t B_t - (1 - \rho q_t)\frac{B_{t-1}}{\Pi_t} + uT_t^U + (1-u)T_t^E + T_t^{cb} \tag{21}$$

where:

· G_t denotes exogenously determined government expenditures, which are prone to the stochastic shocks

· B_t denotes target for long-time government debt given in the real terms (equal to $B_t^m + B_t^{cb}$), it is held constant over time so time subscript might be omitted

· T_t^{cb} denotes transfer from the central bank due to seigniorage.

3.6 Central bank

The central bank has its budget constraint given by:

$$T_t^{cb} + \frac{R_{t-1}}{\Pi_t} M_{t-1} + q_t B_t^{cb} = M_t + (1 + \rho q_t)\frac{B_{t-1}^{cb}}{\Pi_t} \tag{22}$$

where:

· B_t^{cb} denotes the amount of government bonds owned by the central bank.

It conducts monetary policy in one of the following ways:

· First, it can set nominal interest rate R_t in accordance with the following Taylor rule:

$$\hat{R}_t = \hat{\Pi}_t^{\xi_\Pi^R} \hat{Y}_t^{\xi_Y^R} z_t^R \tag{23}$$

where:

· $\hat{R}_t = \frac{R_t}{\overline{R}}$, interest rate relative to its value in steady-state ($\overline{R}$)

· $\hat{\Pi}_t = \frac{\Pi_t}{\overline{\Pi}}$, inflation relative to its value in steady-state ($\overline{\Pi}$)

· $\hat{Y}_t = \frac{Y_t}{\overline{Y}}$, output relative to its value in steady-state ($\overline{Y}$)

· ξ_{Π}^{R} denotes inflation stabilization policy coefficient for the interest rate rule

· ξ_{Y}^{R} denotes output stabilization policy coefficient for the interest rate rule

· z_t^R denotes shock to the exogenous policy rule.

Under the conventional policy, real reserves are assumed to be constant, the central bank does not hold any government debt, and there are no seigniorage transfers.

· Second, it can purchase government debt and finance it by issuing reserves (QE) the amount of which is set according to the following policy rule:

$$\hat{M}_t = \hat{\Pi}_t^{\xi_{\Pi}^{QE}} \hat{Y}_t^{\xi_{Y}^{QE}} z_t^{QE} \tag{24}$$

where:

· $\hat{M}_t = \frac{M_t}{\overline{M}}$, amount of real reserves relative to its value in steady-state ($\overline{M}$)

· ξ_{Π}^{QE} denotes inflation stabilization policy coefficient for the QE rule

· ξ_{Y}^{QE} denotes output stabilization policy coefficient for the QE rule

· z_t^{QE} denotes shock to the exogenous policy rule.

Under QE nominal interest rate is assumed to be constant due to binding effective lower bound, and there are no seigniorage transfers.

· Last but not least, it can transmit a certain amount of money directly to the government budget and finance it via reserve creation (MFFS). It is done with commitment with the government who earmarks those funds for a tax cut:

$$\hat{M}_t = T_t^{cb} \tag{25}$$

It may apply either to every household, and tax paid by employed and unemployed is equal:

$$T_t^E = T_t^U \tag{26}$$

Alternatively, the tax might be lowered only for unemployed ones, and then the height of their tax might be written as:

$$T_t^U = T_t - \frac{T_t^{cb}}{u} \tag{27}$$

The magnitude of this action is given by the following policy rule:

$$\hat{M}_t = \frac{z_t^{QE}}{100} \tag{28}$$

3.7 Shocks

Every shock in this model evolves according to the following AR(1) stochastic process:

$$\ln z_t = (1-\lambda_z)\ln \bar{z} + \lambda_z \ln z_{t-1} + \upsilon_t \tag{29}$$

where:

· z_t denotes variable which is subjected to the shock

· $\bar{z}$ denotes the steady-state value of a variable which is subjected to the shock

· λ_t is parameter standing for persistent of a shock, it may take the values from the interval [0, 1)

· υ_t is white noise; it is normally distributed with an expected value equal to zero and standard deviation σ_z.

4 Quantitative analysis

4.1 Calibration

The parameter values come from the calibration of the baseline model (Cui, Sterk 2019) and are related to the United States' economy (Table 1).

Table 1. Parameters values and targets for the steady-state

x	**Parameter**	**Value**	**Description**
Households	β	0.99	households' discount factor - corresponds to 4% annual discount rate
	σ	1	relative risk aversion coefficient
	κ_1	1	inverse Frisch elasticity of labor supply
	κ_0	11.4296	labor disutility - corresponds to 1/3 of labor supply being employed

Labor market	p^{EU}	0.044	unemployment inflow rate - corresponds to 1.5% monthly rate
	p^{UE}	0.934	unemployment outflow rate - corresponds to 4.5% rate of steady-state unemployment
	Θ^{U}	0.0741	unemployment benefit - corresponds to a quarter of average real wage
Firms	ϕ	47.1	cost of price adjustment parameter - corresponds to 3 quarters average price duration
	$\bar{\varepsilon}$	9	steady-state goods' substitution elasticity - corresponds to 12.5% markup
	$\bar{A}$	1	normalized steady-state value of total factor productivity
Mutual fund	μ	0.0634	mutual fund liquidation coefficient under unemployment - corresponds to 0% real interest rate
Government	ρ	0.947	the decay of government bonds - corresponds to 4-year duration
	$\bar{G}$	0.0767	steady-state real government expenditures to annual output - corresponds to 23% of gross domestic product
	B	0.0488	the target for long-time government debt given in the real terms - corresponds to 58% of annual gross domestic product
Central bank	$\bar{M}$	0.1029	adjusted so that R=1 in steady-state
	$\bar{R}$	1	steady-state nominal interest rate
	$\bar{\Pi}$	1	inflation target is 0%
	ξ_{Π}^{R}	1.5	denotes inflation stabilization policy coefficient for the interest rate rule
	ξ_{Y}^{R}	0.75	denotes output stabilization policy coefficient for the interest rate rule
	ξ_{Π}^{QE}	-0.396	denotes inflation stabilization policy coefficient for the QE rule
	ξ_{Y}^{QE}	0.389	denotes output stabilization policy coefficient for the QE rule
	$\bar{z}^{R}$	1	normalized steady-state value of interest rate policy shock
	$\bar{z}^{QE}$	1	normalized steady-state value of QE policy shock

Source: Author, based on data from Cui, Sterk (2019)

However, some of them are worth a few words of commentary. The relative risk aversion coefficient is set to 1, which stands for a particular case when the Constant Relative Risk Aversion function for utility from consumption simplifies to the logarithmic one. Frisch elasticity is set to 1 as well, in order to match variation in hours worked from the model to the one that can be spotted in data, and it allows the model to be solved in a quasi-analytical way. Although, that is preferably not typical value nor for empirical microeconomic studies, where its value is, respectively, estimated in a range of 0-0.54, nor macroeconomic general equilibrium models, which are usually calibrated with values between 2-4. According to William B. Peterman (2016) and Raj Chetty et al. (2012), this discrepancy can be explained by inconsistency in definitions. First, samples used in estimations of micro-elasticity contain only working heads of families who are married males between 26-60 years old, while in macro, this restriction is relaxed, and the whole population is taken into account. Second, macroeconomists incorporate not only intensive margin fluctuations in hours worked by individual employees but also indivisible labor supply, which creates extensive margin fluctuations, so movements between employment and unemployment.

The QE policy coefficients' values are estimates from the Federal Reserve interventions between 2008 and 2016. Alternatively, if the central bank conveys RRT, both policy coefficients are equal to zero. Parameters associated with shocks are obtained via estimating the model on the United States' data from 2008-2016 (Table 2).

In the case of conducting MFFS policy, the shock to the policy rule is calibrated to have the same parameters values as a shock to the QE rule beside persistent parameter, because the MFFS is by definition present only for one period, hence its persistent parameter has to be equal to zero.

Table 2. Parameters values estimated from the United States within 2008-2016 and others which are related to shocks

Parameter	**Value**	**Standard error**	**t-statistic**	**Description**
λ_A	0.965	0.031	31.479	persistence of total factor productivity shock
λ_G	0.995	0.019	51.288	persistence of government expenditures shock
λ_{QE}	0.738	0.052	11.837	persistence of QE rule shock
λ_{MFFS}	0	-	-	persistence of MFFS rule shock
σ_A	0.005	0.001	4.602	standard deviation of total factor productivity shock's white noise
σ_G	0.007	0.001	6.516	standard deviation of government expenditures shock's white noise
σ_{QE}	0.158	0.032	4.890	standard deviation of QE rule shock's white noise

Source: Author, based on data from Cui, Sterk (2019).

4.2 Stabilizing inflation and output

This section is devoted to evaluating the effectiveness of QE, its subcase - RRT, and two types of MFFS: a tax cut directed to every household and a tax cut directed only to the unemployed agents and comparing them to the conventional policy. In the figures below, the responses of all variables are given in terms of percentage deviation from the steady-state, with the exception of inflation and interest rate, which are given in terms of annualized percentage points.

4.2.1 The impact of policy shocks

Before moving to the analysis of conducting policy as a response to negative shocks hitting the economy, it is worth seeing how these policies alone affect the economy around its steady state.

Expansionary conventional policy lowers the nominal interest rate by one percentage point, which on impact increases inflation by 3%, output and hours worked by 0.8%, and aggregate consumption by 1%, due to a 1.2% increase in consumption of the employed and 5% decrease in consumption of the unemployed (Figure 1). All variables monotonically converge to the steady-state in about 7 quarters.

Initially, QE causes an approximately 1.25% increase in output and a comparable rise in hours worked and consumption of employed due to over 2.5% rise in the real wage. On the contrary, while on the impact, the unemployed' consumption increases by 12% due to higher unemployment benefit. It then falls to a level 5% lower than in the steady-state and then slowly converges to the steady-state value. This is a consequence of higher inflation, by 3.5 percentage point on impact, which lowers the real interest rate, thus interest income from the mutual fund. One can see that reaction for the RRT only marginally differs from QE's what is consistent with the findings of Cui and Sterk (2019). The substantially higher variation in unemployed and newly employed consumption than employed comes from tighter budget constraints.

Reaction to a widespread tax cut for most variables is similar in terms of direction, however 1.5-3 times weaker, depending on the variable. The significant difference is in the behavior of unemployment consumption. This time, it drops right on impact as the rise of inflation is more notable than one of the wages. Moreover, even though tax cut lasts for one period only, lump-sum the tax is lower for a longer time due to inflation being over the target and the government paying a lower real interest rate on its debt.

Surprisingly, the last option, tax cut only for unemployed, triggers a similar reaction to the widespread variant besides the slightly higher quicker return to steady-state values and a significant spike in unemployed consumption on impact, which is because of the fact that they, by the construction of the model, are effectively excluded from financial markets and have to consume all money form the tax cut in the initial period. Although if the unemployed were able to save, they would scatter this tax cut in time in order to smooth their consumption path.

An interesting issue that can be spotted is that the consumption of employed and unemployed agents always go in the opposite direction. The origin of this relationship lies in the fact that in the model, the primary source of income for employed is a wage, while for unemployed, its interest income from the mutual fund. As a result, any contractionary monetary policy will cause an increase in unemployment consumption due to higher real interest rates and hence, higher interest income. The other way around, any expansionary monetary policy will cause a drop in their consumption. Because of this artifact, welfare analysis is not carried out here as calculating the effect on unemployed' welfare would be biased.

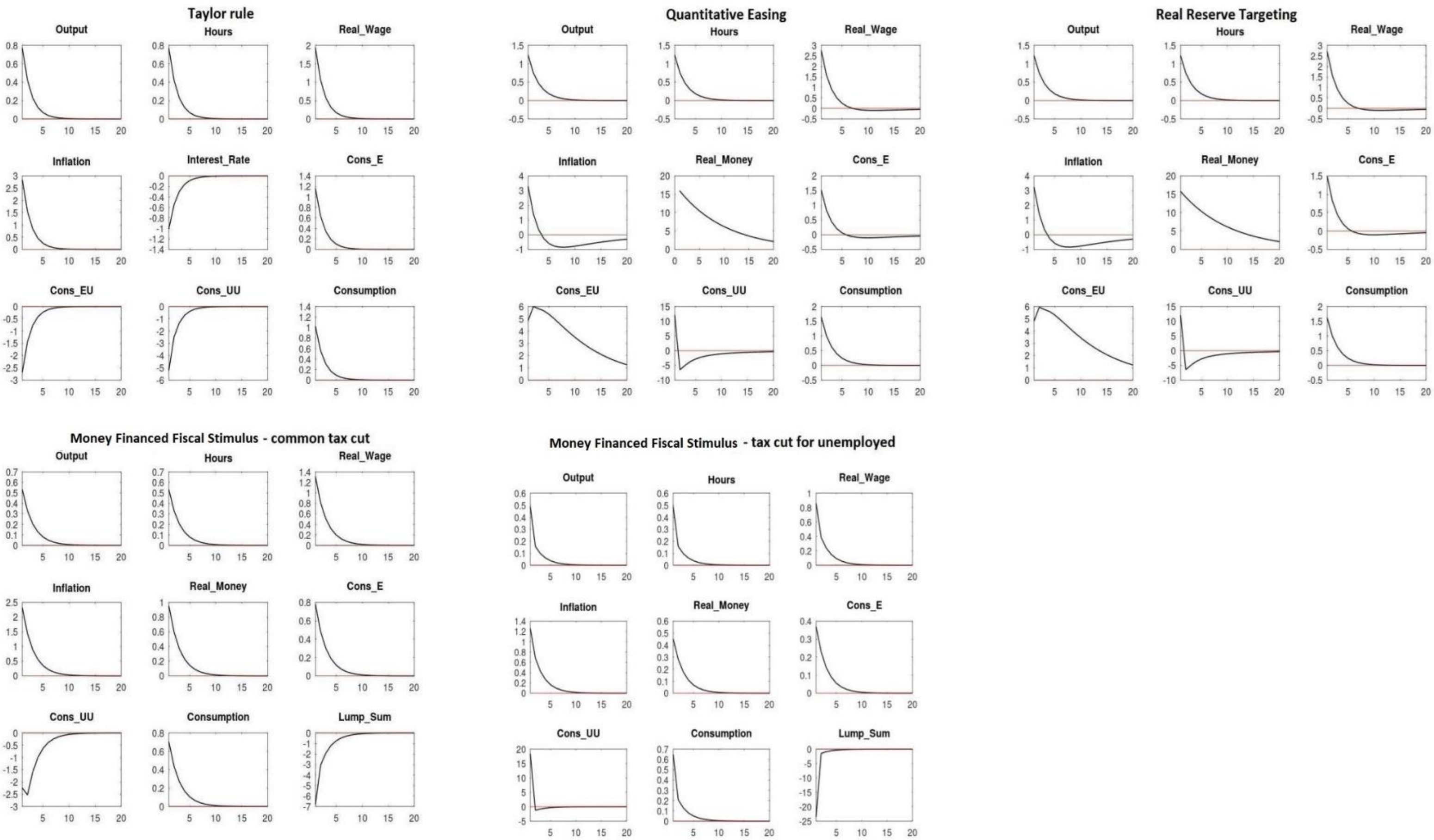
4.2.2 Reaction to the negative total factor productivity shock.

A negative shock to the total factor productivity acts as a supply shock. Hence output and inflation move in opposite directions. (Figure 2). Initially, it has a magnitude of -0.5%. Under the conventional policy, on impact there is a slight increase in output driven by consumption, a 0.8% rise in hours worked, and a 1.2% rise in the real wage. However, it quickly falls below its steady-state level. Over shown horizon nominal interest rate is on average on a 1 percent level. Inflation initially rises by four percentage points and converges monotonically to its target.

On the other hand, if the central bank conducts QE due to the lower magnitude of increase in inflation and even drops after few periods of hours worked, output, thus, consumption also drops on impact by 0.1% and starts to return to the steady-state after sixth period. It is likely that with given coefficients balance sheet's expanse is too modest to be efficient.

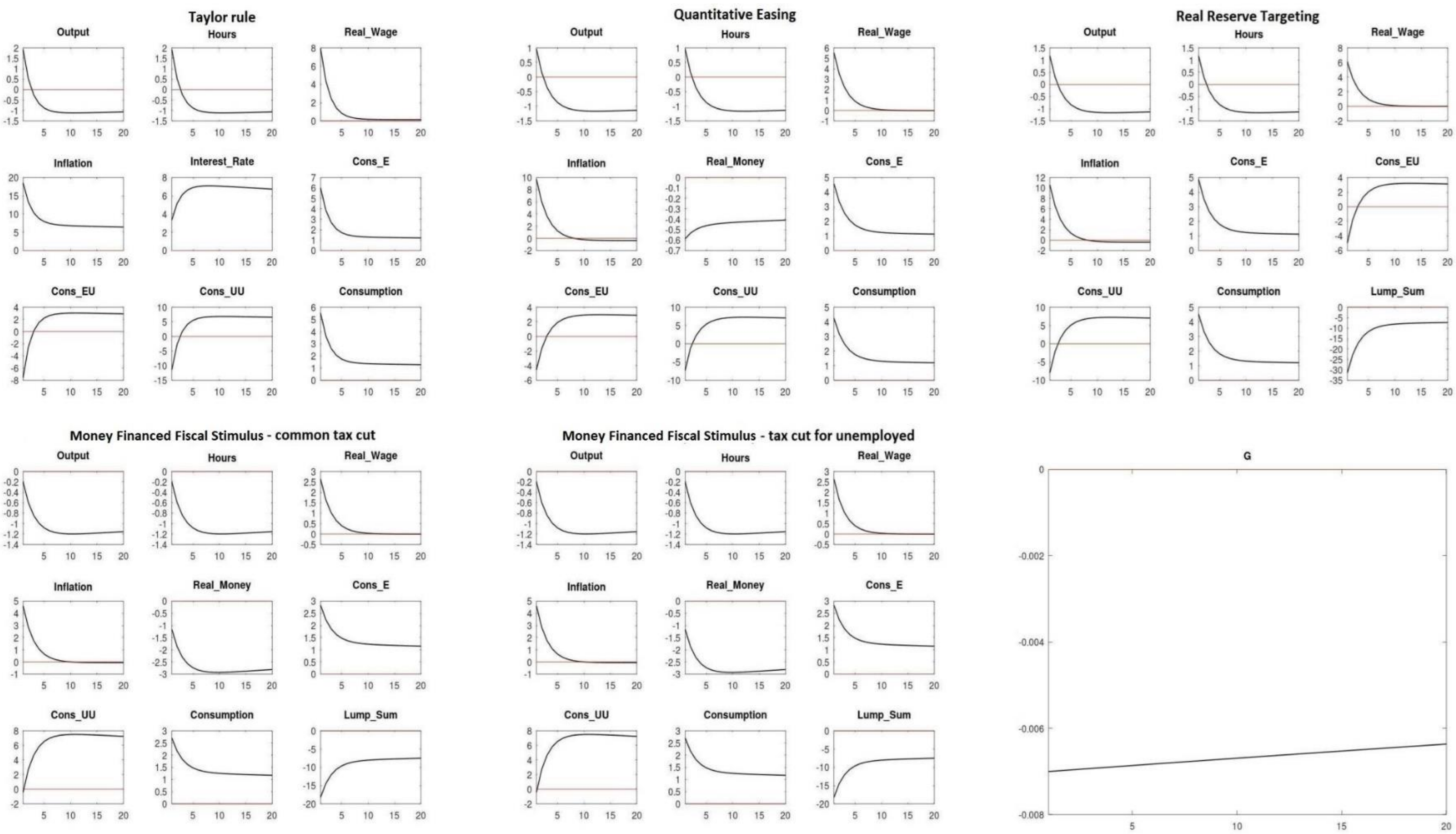
In this case, the pattern of all unconventional policies' reactions is identical. However, when a MFFS is used, the economy's reaction on impact is even weaker than in the case of QE. Also, creating reserves does not cause an increase in real money due to inflation.

Figure 1. Economy's response to the positive policy shock



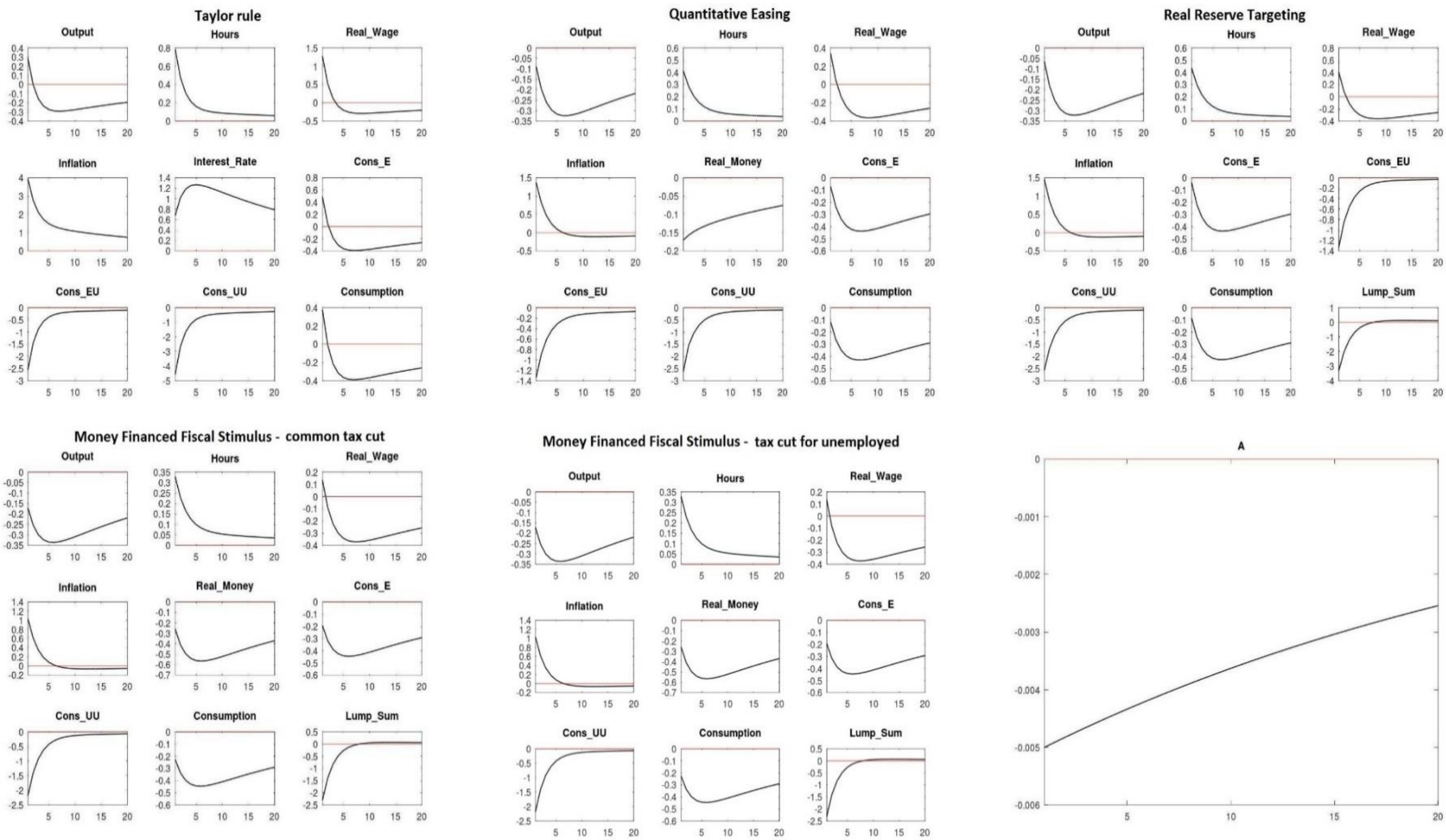
Source: Author.

Figure 2. Economy's response to the negative total factor productivity shock



Source: Author.

Figure 3. Economy’s response to the negative government expenditures shock



Source: Author

4.2.3 Reaction to the negative government expenditures shock.

In the model, a negative shock to the government expenditures causes tightening of the government’s budget constraint as the amount of issued bonds is fixed, with lower spendings, it needs less tax income. That translates to higher consumption in all cases due to the so-called crowding-in effect - reverse crowding out effect. Here the magnitude of the drop in government spendings is 0.7% (Figure 3).

When the central bank operates under Taylor rule, it substantially increases nominal interest rate from 4 percentage points on impact to the level of 7% in the 6th quarter as a reaction to stagflation, initially 18 percentage points, which falls to 8 percentage points after four quarters and stays in this region for a longer time.

Both QE and RRT cause less volatility than interest rate policy. Inflation on impact is 10 percentage points, but it converges to the acceptable level after five quarters. The increase in consumption has a comparable size, and the 1% output gap is present as well.

On the other hand, both variants of MFFS, which act almost exactly identically, generate the lowest inflation volatility among all considered policies, and under them the initial reaction of output gap is lower than QE's. However, the first few quarters increase in consumption is about two times lower, which is responsible for the initial fall of output.

Again, under all balance sheet policies, real money decreases due to inflation.

5 Concluding remarks

In the paper, I have analyzed the effectiveness of QE, its subcase RRT, and two variants of tax cuts: universal and directed to the unemployed agents, which can be considered as MFFS. The framework used in this analysis is a modified version of the New Keynesian model developed by Wei Cui and Vincent Sterk (2019). Its work is based on the difference in liquidity of assets.

There are three key findings. First, under all those regimes, capability in mitigating outcomes of total factor productivity shocks are similar across all investigated unconventional policies; however, on impact, MFFS gives slightly lower volatility of inflation and hours worked at the cost of the higher output gap and aggregate consumption volatility. Second, in the case of monetary policy and government expenditures shocks, MFFS generates the lowest volatility in the economy. Third, RRT might be the best choice when an effective lower bound is binding due to the simplicity with which it can be implemented in reality.

Nonetheless, the used model has some shortcomings which one has to be aware of. Due to its construction, the consumption of employed and unemployed agents in every situation goes in the opposite direction. Hence what seems to be optimal from the point of view of aggregate variables might have side effects on inequality. Another weakness of the model is the constant unemployment rate, which is certainly not going to happen in the case of a recession. Other problems with implementing MFFS are legal issues as cooperation between the central bank and government might be inconsistent with the principle of central bank independence. However, those issues are out of the scope of this analysis and are left for future research.

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