Some fiscal arithmetic of unconventional monetary and credit policies

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Abstract

The severity of the 2008-09 global financial crisis forced policy-makers, particularly in advanced economies, to adopt a range of unconventional monetary and credit policies. Although the effectiveness of such policies in stabilizing the economy has been extensively studied, there is as yet no systematic analysis of the real costs of enacting unconventional measures. In this paper, utilizing a New Keynesian general equilibrium model with financial frictions and distortionary taxation, we provide a comparative cost-benefit analysis of two such policies; credit easing and bank capital injections. We find that the use of bank capital injections has a greater stabilizing effect on the economy, at the expense of higher costs. We also show that evaluation of unconventional policy based on lump-sum taxes overstates the benefits of policy interventions. However, our results reveal that both credit policies are welfare improving even with distortionary taxes. Bank capital injections generate higher welfare gains, under both lump-sum and variable tax rates.

Keywords: financial crises, bank equity injections, credit easing, distortionary taxes.

JEL Classification: E44; G21; H50.

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1 INTRODUCTION

The gravity of the 2008-09 global financial crisis, regarded by many as the worst since the Great Depression in the 1930s, required unconventional policy responses. This was particularly the case given that conventional monetary policy had already reached its limits with nominal interest rates at or near their zero lower bound. Such unconventional measures varied from providing liquidity to the economy as a whole to extending direct support to financial institutions.

Among most prominent examples has been the direct supply of liquidity to the non-financial sector, adopted by both the Federal Reserve (Fed) and the Bank of England (BoE). Commonly referred to as credit easing, this entailed purchases of highly rated commercial paper and providing liquidity to money market mutual funds. The Fed established several lending programmes including the Commercial Paper Funding Facility (CPFF) to provide liquidity to credit markets during the global financial crisis. Similarly, the BoE operated the Asset Purchase Facility (APF), to relax credit market conditions, purchasing 3 billion pounds of private assets. Such measures raised asset prices in both countries, resulting in an increase in the number of buyers and the resumption of trade (Fawley and Neely, 2013).

Another unconventional policy, bank capital injections, took the form of injecting capital directly into the financial sector. Examples include the US Treasury’s Capital Purchase Program (CPP) as part of its Troubled Asset Relief Program (TARP), distributing 205 billion dollars of funds to 707 institutions (see, for example, Contessi and El-Ghazaly, 2011). Likewise, the U.K. Treasury injected about 50 billion pounds of equity into British banks as part of its bank capitalization program (Mishkin, 2010).\footnote{Bank capital injections are less 'unconventional' than credit easing; 32 out of the 42 banking crises between 1970 and 2007 featured bank capitalizations (Contessi and El-Ghazaly, 2011).}
Substantial effort has been devoted towards understanding the implications of unconventional monetary and credit policies that had been adopted since 2009. It is shown that unconventional monetary and credit policies are indeed effective in dampening the scale of fluctuations in the face of financial shocks beyond what can be achieved through conventional monetary policy. For example, Gertler and Karadi (2011) show that, when banks are financially constrained due to credit market frictions, direct lending by the central bank to the private sector during a crisis can be beneficial. Both Curdia and Woodford (2010) and Del Negro et al. (2010) arrive at similar conclusions regarding credit easing by the central bank with the use of models based on financial frictions à la Bernanke et. al. (1999) in the former and à la Kiyotaki and Moore (2008) in the latter. They both find that the policy intervention eases the constraints in the financial markets, which in turn reduces the decline in investment and consumption, potentially substantially. Likewise, a number of studies explore the effectiveness of government support to financial institutions in times of crisis. For example, using an estimated New Keynesian model with a global bank, Kollmann et.al (2012) examine the effects of government support to banks as a public transfer, identifying a stabilizing effect on output, investment and consumption. Hirakata et.al (2013) also finds similar results regarding the government support to banks, by exploring the outcomes of government purchase of bank equity in a general equilibrium model featuring financial frictions.

Our paper differs from the aforementioned studies in three key aspects. First, motivated by the lack of work on the cost of unconventional policies, we compare the fiscal costs, as well as the stabilizing effects of the two policies and present a comprehensive cost-benefit assessment. The overriding focus of the existing work, as is just seen, had been the effectiveness of unconventional policies in shielding the economy from the detrimental consequences of financial shocks. Yet, implementation of these policies also entails sizable costs, with important implications for the economy’s response to the financial shocks, as is recently highlighted by Benigno (2016) and Orphanides (2016). To the best of our knowledge, this is the first
paper systematically incorporating the fiscal costs of unconventional policies and their wider implications for the economy in the wake of a financial crisis. Second, to assess the true fiscal costs of alternative policy measures, we incorporate distortionary consumption and labour taxes, enabling us to provide a more realistic assessment of alternative unconventional policy measures. This is also in sharp contrast to the existing literature exclusively utilizing lump-sum taxes. Yet, lump-sum taxes are rarely available to fiscal authorities in practice. Furthermore, analyses based on lump-sum taxes are likely to overstate the benefits of unconventional measures in the context of policy analysis. Third, in contrast to the studies that examine the implications of using credit easing or bank capital injections in isolation, we provide a comparative analysis of these two most widely adopted measures.

We build a New Keynesian DSGE model where the frictions in the financial intermediation process are as described in Gertler and Karadi (2011). These frictions create an intertemporal distortion in the economy, the credit spread, defined as the difference between the gross return to risky assets and the gross riskless return. We characterize credit easing in our model as a policy tool where the central bank increases the total credit in the economy via raising the supply of loans to non-financial firms. Bank equity injections, on the other hand, directly increase the capital of banks. We also maintain that there are efficiency costs in administering either of the two policies.

As is standard in similar models with financial frictions, the financial shock leads to a decrease in asset prices, triggering the financial accelerator mechanism. As a result of the fall in asset prices, banks experience a downturn in their balance sheets, raising the leverage ratios and hence, the credit spread. The rise in the spread pushes up the cost of capital which, in turn, decreases investment and asset prices further, thereby lowering the aggregate output. When the policy-maker pursues credit easing or bank capital injections, the rise in the credit spread is curtailed, hence is the cost of capital, containing the fall in investment and thus in aggregate output. Since bank capital injections result in a direct increase in banks’ net worth, they induce a much lower increase in the leverage ratio and thus in the
spread compared to that with credit easing. However, bank capital injections are also more expensive due to the excess return on assets that the central bank can draw upon in times of financial crisis with credit easing, unlike with capital injections.

Since both the benefits and the costs from pursuing bank capital injections are higher than those from credit easing it is important to examine the welfare outcomes associated with each policy. Our welfare analysis reveals that bank capital injections are more effective in mitigating the negative effects of financial shocks to the economy, resulting in more favourable outcomes with both lump-sum and distortionary taxes. We also find that, working with lump-sum taxes overstates the welfare gains from pursuing credit market interventions. Yet, we show that even under distortionary taxation, the benefits from using credit policies still outweigh the fiscal costs resulting in positive welfare gains, under both credit policies with both consumption and labour taxes.

The rest of the paper is organized as follows. Section 2 sets out our benchmark model by describing the behaviour of the households, the financial sector, the production firms and the policy-makers as well as the structure of monetary, fiscal and credit policies. Section 3 presents our quantitative results. The impulse responses to a financial shock are elaborated with the use of bank capital injections or credit easing, under lump-sum, consumption or labour taxes. The welfare implications of pursuing credit policies under alternative scenarios are also presented in Section 3. Finally, Section 4 summarizes the main conclusions.

2 THE MODEL ECONOMY

Our model economy shares many features with Gertler and Karadi (2011) who incorporate financial intermediaries into an otherwise standard monetary DSGE model with nominal rigidities á la Christiano et al (2005) and Smets and Wouters (2007). Financial intermediaries face an agency problem, limiting their ability to borrow, which is at the core of the financial accelerator mechanism with a key role on the adjustment in crisis periods.
Our framework features seven types of agents: households (consisting of bankers and workers); three types of firms - capital goods producers, wholesale and retail firms; banks and the monetary and fiscal authorities.

We now turn to a detailed exploration of the behaviour of each agent.

2.1 Households

The representative household consists of a continuum of members of measure unity. The two types of members within the household are workers and bankers. Workers supply labor and earn wages while bankers manage financial intermediaries and transfer dividends back to households. Households hold their savings as deposits, which are assumed to be riskless one period securities.

A representative household maximizes expected discounted utility,

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t(C_t, C_{t-1}, L_t)$$

(1)

where $U_t = \frac{(C_t-C_{t-1})^{(1-\sigma)}(1-h_t)^{\sigma(1-\sigma)/2}}{1-\sigma}$, subject to the following budget constraint,

$$(1 + t_c^t)C_t = (1 - t_h^t)W_t h_t + \Pi_t + R_t D_{t-1} - D_t$$

(2)

where $0 < \beta < 1$ is the subjective discount factor, $E$ is the expectation operator, $C_t$ denotes consumption and $L_t$ leisure, $W_t$ the wage rate, $h_t(= 1 - L_t)$ hours worked and $D_t$ bank deposits. In equation 2 $t_c^t$ and $t_h^t$ denote the consumption and the labor income tax rate, respectively. $\Pi_t$ denotes profits accruing to the household from the ownership of banks and firms.
2.2 Banks

We follow Gertler and Karadi (2011) in our characterization of the banking sector. A representative bank’s balance sheet has the following form,

\[ Q_t s_t = n_t + d_t \]  \hspace{1cm} (3)

where \( s_t \) denotes loans to non-financial firms, \( Q_t \) their price, \( n_t \) net worth and \( d_t \) deposits.

The bank’s balance sheet implies an accumulation of net worth according to

\[ n_t = R_t n_{t-1} + (R_{k,t} - R_t)Q_{t-1}s_{t-1} \]  \hspace{1cm} (4)

where \( R_t \) is the gross risk-free return to deposits and \( R_{k,t} \) denotes the gross risky return to bank’s assets. Net worth at the end of period \( t \) is equal to the gross riskless return plus the excess return on bank’s assets.

As standard, we maintain that with probability \( 1 - \gamma \), a banker exits and becomes a worker. In addition, the same number of workers randomly become bankers. Only upon exiting, the bank pays dividends. As a result, the banker’s objective at the end of period \( t \) is to maximize expected discounted terminal net worth, \( V_t \)

\[ V_t = E_t \sum_{i=1}^{\infty} (1 - \gamma)^{i-1} \Lambda_{t,t+i} n_{t+i} \]  \hspace{1cm} (5)

where \( \Lambda_{t,t+1} = \beta \frac{U_{C,t+1}}{U_{C,t}} \) is the real stochastic discount factor over the interval \([t, t + 1]\). Given \( n_{t-1} \) at the beginning of period \( t \), net worth in period \( t \) is given by the choice of \( \{s_{t+i}\} \).

The financial friction in the banking sector is based on a moral hazard problem between the banks and the households. After a bank obtains funds, the bank’s manager may transfer a fraction, \( \Theta \) of total assets, \( Q_t s_t \) for her own benefit. In this case, the bank defaults on
its debt, shuts down and the creditors can reclaim the remaining 1−Θ fraction of funds. As households know this possibility, they limit the funds (deposits) that they lend to banks. As a result, the bankers choice of \( s_t \) at any time \( t \) is subject to the following incentive constraint,

\[
V_t \geq \Theta Q_t s_t
\]

The constraint shows that for depositors to be willing to lend to banks, the banker’s loss from diverting funds should be at least as large as her gain from diverting.

We solve the banker’s optimization problem using backward induction. Hence, we start by guessing that \( V_t \) can be expressed in the following form,

\[
V_t = V_t(s_t, d_t) = v_{s,t} s_t - v_{d,t} d_t
\]

Eliminating \( d_t \) from equation 6 using the bank balance sheet in 3, we can obtain,

\[
V_t = V_t(s_t, n_t) = \mu_{s,t} Q_t s_t + v_{d,t} n_t
\]

Here, \( v_{s,t} \) and \( v_{d,t} \) are time-varying marginal values of loans and deposits, respectively and \( \mu_{s,t} = \frac{v_{s,t}}{Q_t} - v_{d,t} \) is the excess value of the bank’s assets over its deposits.

Defining \( \phi_t \) as the leverage ratio, the maximum ratio of a bank’s assets to its net worth that satisfies the incentive constraint, we obtain

\[
Q_t s_t = \phi_t n_t
\]

where \( \phi_t = \frac{v_{d,t}}{\Theta - \mu_{s,t}} \).

Using the solution to the banker’s optimization problem, we can determine \( v_{s,t}, v_{d,t} \) and \( \mu_{s,t} \) as
\[ v_{s,t} = E_t \Lambda_{t,t+1} \eta_{t+1} R_{k,t+1} Q_t \]

\[ v_{d,t} = E_t \Lambda_{t,t+1} \eta_{t+1} R_{t+1} \]

\[ \mu_{s,t} = E_t \Lambda_{t,t+1} \eta_{t+1} (R_{k,t+1} - R_{t+1}) \]

where \( \eta_t = (1 - \gamma) + \gamma (\mu_s \phi_t + v_{d,t}) \) is the shadow value of a unit of net worth. The difference between the gross return to loans, \( R_{k,t} \) and the gross riskless return, \( R_t \) is defined as the spread.

As the components of \( \phi_t \) are not dependent on bank specific factors, we can sum across individual banks to obtain the aggregate banking sector balance sheet,

\[ Q_t S_t = \phi_t N_t \quad (9) \]

The accumulation of aggregate net worth is given by the sum of the net worth of surviving bankers \( (N_{o,t}) \) and of new entrants \( (N_{e,t}) \),

\[ N_{o,t} = \gamma (R_{k,t} Q_{t-1} S_{t-1} - R_t D_{t-1}) \quad (10) \]

\[ N_{e,t} = \varepsilon (R_{k,t} Q_{t-1} S_{t-1}) \quad (11) \]

where \( \varepsilon \) is the fraction transferred to the new entrants.

Hence, the accumulation of net worth at the aggregate level is obtained as

\[ N_t = R_{k,t} (\gamma + \varepsilon) Q_{t-1} S_{t-1} - \gamma R_t D_{t-1} \quad (12) \]
2.3 Firms

There are three types of firms: wholesale firms, retail firms and capital producers the characteristics of which are described in the following three sub-sections.

2.3.1 Wholesale firms

Wholesale firms produce output, $Y^W_t$, using a constant returns to scale Cobb-Douglas production function that contains labour and capital as factor inputs,

$$Y^W_t = Y^W_t (A_t, h_t, K_{t-1}) = (A_t h_t)^\alpha K_{t-1}^{1-\alpha} \tag{13}$$

where $A_t$ denotes aggregate productivity and $K_{t-1}$ the end-of-period capital stock.

Firms choose labor to satisfy,

$$\frac{P^W_t}{P_t} Y^W_{h,t} = W_t \tag{14}$$

where $P^W_t$ and $P_t$ are the aggregate price indices in the wholesale and retail sectors, respectively, and where $Y^W_{h,t} = \alpha \frac{Y^W_t}{h_t}$. Profit maximization by wholesale firms yields the labour demand equation, ensuring that the marginal product of labor be equal to the real wage. It also implies that labour demand increases with an increase in output and the price of the wholesale output, while decreasing with an increase in wages.

A wholesale firm issues new securities to obtain funds from the banks, which are then used to buy new capital goods from capital producers. The number of claims issued by the firm, $S_t$ is equal to the number of units of capital needed, $K_t$ and so are their prices,

$$Q_t S_t = Q_t K_t \tag{15}$$

Through perfect competition, wholesale firms earn zero profits and they fully pay the return to capital to the banks,
Clearly, the return to capital depends on the marginal product of capital and the change in price of capital, net of depreciation, $\delta$.

### 2.3.2 Capital producers

At time $t$, capital producers convert $I_t$ of raw output into $(1 - S(X_t)) I_t$ of new capital, subject to investment costs, $S(X_t)^3$. Hence, capital accumulation is given by

$$K_t = \psi_{t+1} \left[ (1 - \delta) K_{t-1} + (1 - S(X_t)) I_t \right]$$

(17)

where $X_t = \frac{I_t}{I_{t-1}}$ and $\psi_t$ denotes the shock to the quality of capital, which follows an AR(1) process$^4$.

$$\log \psi_t = \rho_\psi (\log \psi_{t-1}) + \varepsilon_\psi$$

where $\rho_\psi$ denotes the coefficient in the autoregression and $\varepsilon_\psi$ is a white noise process with zero mean and constant variance $\sigma_{\varepsilon_\psi}^2$.

The maximization of expected discounted profits by capital producers yields

$$Q_t \left( 1 - S(X_t) - X_t S'(X_t) \right) + E_t \left[ \Lambda_{t,t+1} Q_{t+1} S'(X_{t+1}) X_{t+1}^2 \right] = 1$$

(18)

a positive relationship between investment and asset prices, widely known as the Tobin’s Q relation.

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$^3$The functional form of the investment costs is given by $S(X_t) = \phi_X X_t^2$. As is well-known, investment adjustment costs play a key role in matching the smoother investment responses observed in U.S. business cycles. See, for example, Smets and Wouters (2007).

$^4$The shock also has an effect on the evolution of bank’s net worth. Accordingly, equation 12 should be rewritten as $N_t = R_{k,t} (\gamma + \varepsilon) \psi_{t-1} S_{t-1} - \gamma R_t D_{t-1}$. 

2.3.3 Retail firms

Retail firms produce a basket of differentiated goods for consumption. The demand for consumption is given by

\[ C_t(f) = \left( \frac{P_t(f)}{P_t} \right)^{-\zeta} C_t \quad (19) \]

where \( C_t(f) \) and \( P_t(f) \) denote consumption and the price of the final good, respectively.

In aggregate, demand for investment, government expenditures and hence the final/retail output has the same functional form as consumption,

\[ Y_t(f) = \left( \frac{P_t(f)}{P_t} \right)^{-\zeta} Y_t \quad (20) \]

where \( \zeta \) is the elasticity of substitution and the aggregate price index, \( P_t \) is given by

\[ P_t = \left( \int_0^1 P_t(f)^{1-\zeta} \, df \right)^{1/(1-\zeta)}. \]

We assume that retail firms modify the wholesale output \( Y_t^W \) at a cost of \( c \). Hence, the relationship between the retail and the wholesale sector is given by,

\[ Y_t = \frac{(1 - c)Y_t^W}{\Delta_t} \]

where \( \Delta_t = \int_0^1 \left( \frac{P_t(f)}{P_t} \right)^{-\zeta} df \) is a measure of price dispersion across retail firms which set their prices \( \text{à la} \) Calvo(1983).

Following Benigno and Woodford (2005), it is straightforward to show that the real marginal cost, \( MC_t \), for the retail sector can be expressed as

\[ MC_t = \frac{P_t^W}{P_t} \quad (21) \]
2.4 Monetary policy

We adopt a standard formulation for monetary policy. The central bank sets the gross nominal interest rate, $R_{n,t}$ in period $t$ to pay out interest in period $t+1$.

Monetary policy is conducted using a simple Taylor rule,

$$\log \left( \frac{R_{n,t}}{R_{n}} \right) = \rho_{\pi} \log \left( \frac{\Pi_{t}}{\Pi} \right) + \rho_{y} \log \left( \frac{Y_{t}}{Y} \right)$$

(22)

where the steady-state nominal interest rate, inflation and output are given by $R_{n}$, $\Pi$ and $Y$, respectively.

2.5 Credit policies

2.5.1 Credit easing

To model credit easing (henceforth CE), we follow Gertler and Karadi (2011) and maintain that the central bank can directly supply private securities (loans) to non-financial firms at the market lending rate, $R_{k,t+1}$. Unlike private financial intermediaries, the central bank is not balance sheet constrained and it can utilize the excess return on assets in times of financial distress. However, it faces an efficiency cost, $\tau^{e}$, per unit of credit supplied to the market.

Under CE, loans to non-financial firms at the aggregate level are now given by the sum of privately intermediated securities, $S_{t}^{p}$ and the securities that are intermediated via the central bank, $S_{t}^{g}$,

$$Q_{t}S_{t} = Q_{t}(S_{t}^{p} + S_{t}^{g})$$

(23)

As in Gertler and Karadi (2011), we assume that the securities intermediated by the central bank are given by a fraction of total loans,
Accordingly, equation 9 must be rewritten as,

\[ Q_tS_t = \phi_tN_t + \varphi_tQ_tS_t \]  \hspace{1cm} (25)

2.5.2 Equity injections

To formalize the policy of direct support to financial institutions, bank equity injections (henceforth \( BCI \)), we maintain that the fiscal authority can support the central bank by injecting equity into the banking sector and finance these injections by issuing government bonds. We also maintain that a unit of equity injected by the government, \( N^g_t \) has the same return as a unit of private equity, \( N_t \); that is, the government does not earn a premium on bank equity (implications of relaxing this assumption are explored as part of our sensitivity analysis in Section 3). In addition, the surviving bankers pay back the return to government equity the following period\(^5\). As given in equation 4, the return to a unit of private bank equity, \( N_{t-1} \) is \( R_t \). Accordingly, in the presence of \( BCI \)s, the accumulation of net worth is given by the following modified version of equation 12

\[ N_t = R_{k,t} (\gamma + \varepsilon) Q_{t-1}S_{t-1} - \gamma R_tD_{t-1} + N^g_t - \gamma R_tN^g_{t-1} \]  \hspace{1cm} (26)

where the last two terms correspond to the increase in bank net worth with the injection, net of repayments. Since the bank needs to repay the return on the capital injected by the government, it takes time for bank net worth to rebuild and the exit from the credit policy lasts long. As with \( CE \), we maintain that government equity is a fraction of total bank equity,

\(^5\)Even though very few of the CPFF beneficiaries have failed in the period between 2008 and 2010, not all have survived. (Contessi and El-Ghazaly, 2011).
\[ N_t^g = \Upsilon_t N_t \] (27)

and there are efficiency costs relating to government equity injections, which are given by \( \tau^N \) per unit of equity supplied.

In contrast to the studies that examine the implications of using credit easing or bank capital injections, we provide a comparative analysis of these two most widely adopted measures.

Securities intermediated by the central bank and capital injected by the government are determined as a fraction of total loans and total bank net worth, respectively. These fractions are given by \( \varphi_t \) and \( \Upsilon_t \), and they respond to the deviations of the credit spread from its steady-state value,

\[
\varphi_t = \rho_\varphi \left[ (R_{k,t} - R_t) - (R_k - R) \right]
\]

\[
\Upsilon_t = \rho_\Upsilon \left[ (R_{k,t} - R_t) - (R_k - R) \right]
\]

### 2.6 Fiscal policy

We assume that in normal times the government keeps a balanced budget where government spending, \( G_t \), is financed by tax revenues; hence no bonds are issued. In contrast, in times of crisis, when the policy makers pursue credit policies, government issues bonds, \( B^g_{t-1} \), which are perfect substitutes for deposits, to finance total government intermediated assets, given by the sum of the fraction of loans intermediated by the central bank, \( \varphi_{t-1} Q_{t-1} S_{t-1} \) and the fraction of bank capital injected by the government, \( \Upsilon_{t-1} N_{t-1} \).

Accordingly, in crisis periods government budget constraint takes the form of
\[ G_t + (1 + \tau^S) \varphi_t Q_t S_t + (1 + \tau^N) \Upsilon_t N_t = T_t + R_{k,t} \varphi_{t-1} Q_{t-1} S_{t-1} + R_t \Upsilon_{t-1} N_{t-1} + B_t^q = R_t B_{t-1}^q \] (28)

where \( G_t \) denotes government spending; \( \tau^S \) and \( \tau^N \) efficiency costs of per unit of credit supplied via credit easing and of bank capital injections, respectively, as defined earlier; \( T_t \) is the total tax revenue in \( t \); \( B_t^g \) total government bonds outstanding in \( t \) and all else is as defined earlier.

As can be seen in equation 28, total government expenditures in period \( t \) consist of government spending and costs of supplying loans and injecting equity, \( (1 + \tau^S) \varphi_t Q_t S_t + (1 + \tau^N) \Upsilon_t N_t \). The government earns the gross risky return, \( R_{k,t} \) from the loans supplied and the gross return to net worth, \( R_t \) from the equity injected in period \( t - 1 \). The cost of these intermediations is the gross riskless return, \( R_t \) that the government pays on \( B_{t-1}^g \). Total government revenues also include the earnings from tax collection, \( T_t \). In the benchmark case \( T_t \) denotes lump-sum taxation. When the government adopts distortionary taxation, \( T_t \) denotes tax revenues from consumption taxes or labor income taxes, \( t^c_t C_t \) and \( t^h_t h_t W_t \), respectively.

Each tax rate is assumed to follow a fiscal rule with an autoregressive component as well as responding to the deviations of government debt and aggregate output from their respective steady-state values, similar to Leeper et al. (2010):

\[ t_t = \rho_t(t_{t-1} - t) + \gamma_b(B_t^q - B^q) + \gamma_y(Y_t - Y) \] (29)
3 FINANCIAL CRISIS AND POLICY EXPERIMENTS

We now turn to our analysis of how the two credit policies can be utilized to mitigate the consequences of a financial crisis which we characterize as being triggered by a five per cent negative capital quality shock, as in Gertler and Karadi (2011). This shock decreases the quality of the banks’ assets and leads to an amplified decrease in their net worth, due to high leverage. In this way, we can broadly mimic the dynamics of the global financial crisis. We begin by calibrating the model and continue with elaborating the crisis experiment.

3.1 Calibration

Given the prominence of both CE and BCI in the US policy-makers’ response to the 2008-09 global financial crisis, as documented above, we calibrate our model to the US economy. Table 1 presents parameter values used in our calibration. We start our calibration by setting the financial parameters. In line with Gertler and Karadi (2011), we choose the value of $\gamma$, the probability of bankers’ survival, to ensure an average survival of 10 years for bankers. The values of proportional transfers to the new entrants ($\varepsilon$) and the fraction of divertable bank assets ($\Theta$) are calibrated to match an economy-wide leverage ratio of 4, and an average credit spread of 100 basis points per year, based on the pre-2007 spreads between BAA corporate and government bonds. We choose conventional values for the labor share, $\alpha$ and the elasticity of substitution between goods, $\zeta$. The steady-state depreciation rate $\delta$, the habit persistence parameter $\chi$, and the price rigidity parameter $\theta$ are also set in line with the values used by Gertler and Karadi (2011). The parameters $\sigma$ (in the utility function) and $\phi_X$ (in the investment cost function) are set to reflect the empirical literature (see, for example, Batini et al., 2011). We include habit formation and investment adjustment costs in our analysis, based on the existing work showing that such real frictions improve the ability of macroeconomic models in explaining the business cycles in the US. (Schmitt-Grohe and Uribe, 2007). For calibrating the discount factor, $\beta$ and the preference parameter, $\rho$, we
Table 1. Calibrated Parameters

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Description</th>
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<tbody>
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<td><strong>Households</strong></td>
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<td>$\beta$</td>
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<td>Discount factor</td>
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<td>$\chi$</td>
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<td>Habit persistence parameter</td>
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<td>$\zeta$</td>
<td>7</td>
<td>Elasticity of substitution</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.75</td>
<td>Probability of keeping prices unchanged</td>
</tr>
<tr>
<td><strong>Banks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.975</td>
<td>Probability that bankers survive</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>0.001</td>
<td>Proportional transfer to the new entrants</td>
</tr>
<tr>
<td>$\Theta$</td>
<td>0.410</td>
<td>Fraction of bank assets that can be diverted</td>
</tr>
<tr>
<td><strong>Central Bank</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_\pi$</td>
<td>1.5</td>
<td>Inflation coefficient in the Taylor rule</td>
</tr>
<tr>
<td>$\rho_y$</td>
<td>0.5/4</td>
<td>Output gap coefficient in the Taylor rule</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t^c$</td>
<td>0.15</td>
<td>Steady-state consumption tax rate</td>
</tr>
<tr>
<td>$t^h$</td>
<td>0.15</td>
<td>Steady-state labor income tax rate</td>
</tr>
<tr>
<td>$\gamma_b$</td>
<td>0.05</td>
<td>Debt aversion coefficient in the fiscal policy rule</td>
</tr>
<tr>
<td>$\gamma_y$</td>
<td>0.4</td>
<td>Output gap coefficient in the fiscal policy rule</td>
</tr>
</tbody>
</table>

We adopt 0.35 for hours worked and 1.01 for the gross interest rate, as widely used for the US economy. We use the values of pre-2007 OECD average tax revenues (as a percentage of GDP) for setting the steady-state tax rates.\(^6\) We set the steady-state debt-to-GDP ratio to 60% in line with the level in the US before the global financial crisis. We set the fiscal policy parameters, $\gamma_b$ and $\gamma_y$ using conventional values from the literature (see for example, Leeper et. al (2010)). As in Gertler and Karadi (2011), we assume that the efficiency costs of credit

\(^6\)For the details of the tax data, see https://data.oecd.org/tax/tax-revenue.htm.
policies are equal to 10 basis points, $\tau^S = \tau^N = 0.0010$. In addition, we set the persistence parameter for the capital quality shock in our model to 0.75, following the conventional business cycle literature. The sensitivity of our results to the changes in the key parameter values is examined as part of our robustness checks.

### 3.2 Policy experiments

In this section we examine the response of the model economy to the financial crisis with and without unconventional policies. In particular, we examine the behaviour of a set of macroeconomic outcomes under three policy regimes. In the first, the central bank follows a standard Taylor rule. In the second and the third, we explore the outcomes under the two credit policies, separately, as set out above. We set the total gross fiscal costs of credit policies at 10 percent of the steady-state output though the net costs of the two policies differ since the returns from the use of each credit policy are different. Given that our main focus is the fiscal implications of unconventional policies, we present a comparative analysis of costs versus benefits of the credit policies under three alternative taxes; lump-sum, consumption and labour income taxes.

#### 3.2.1 Benchmark case: lump-sum taxes

Under our benchmark scenario, as exhibited by Figure 1, we maintain that the fiscal authority has access to lump-sum taxation. The profile of crisis in this case is as follows. The shock to capital quality causes a decline in banks’ net worth, reducing asset prices, thereby triggering the financial accelerator mechanism. Since banks are leveraged, the fall in asset prices results in a further decrease in net worth, that is amplified by a factor equal to the leverage ratio. This deterioration makes it more difficult for the banks to obtain funds from households. The resulting decrease in the supply of credit and hence the rise in the spread increases the cost.

\footnote{Setting the fiscal costs at 10 percent also determines the fraction of total assets absorbed by the central bank and the fraction of capital purchased by the government under $CE$ and $BCI$, respectively.}
of capital. As a result, demand for capital falls leading to a further decline in investment and asset prices, thereby reducing aggregate output. The decrease in aggregate output depresses labour demand, marginal cost and hence, inflation. The monetary authority lowers the interest rate in response to the decrease in inflation and output. Finally, the decline in aggregate output is also reflected in the reduction in aggregate consumption.

As can be seen from the top-left panel in Figure 1, the use of both credit policies mitigate the negative effects of the financial shock. When the central bank pursues CE, the supply of credit to non-financial firms increases, which in turn, contains the increase in the spread. Hence, firms are shielded from the full force of the disruption in the financial markets caused by the deterioration in banks’ balance sheets. In contrast, BCIs directly enhance banks’ net worth. As a result, the leverage ratio dampens and bankers find it easier to acquire funds from depositors. This results in an increase in the supply of credit and a sharp reduction in the increase in the spread. Consequently, the increase in the cost of capital, the decline in investment, and in turn, the decrease in aggregate output are all curtailed. As can be seen from both the top-left and the bottom-left panels, the positive effect of pursuing BCIs on aggregate output is much greater, following from a much smaller rise in the spread compared to CE.

Figure 1 also reveals that the use of credit policies implies that government bonds need to initially increase, whereas in the absence of the policies government debt is built over time, as taxes are initially decreased to stimulate demand following the negative capital quality shock. Given that a unit of equity injected by the government has the same payout rule as a unit of private equity, the return to BCIs exactly offsets the cost from the issuance of government bonds. As a result, the government earns zero profits from bank capital injections and their efficiency costs need to be financed by a rise in taxes. In contrast, under CE, the net earnings, \((R_{k,t} - R_t)\varphi_{t-1}Q_{t-1}S_{t-1}\) are higher than the efficiency costs, reducing
the tax burden. As a result, following an initial rise, the government can lower taxes more compared to the case where no credit policy is used. To put differently, the use of BCIs yields a net increase in government outlays, in contrast to the net increase in government revenues under CE, with clear implications for real activity if taxes were distortionary.

### 3.2.2 Policy responses with distortionary taxation

We now turn to the case of distortionary taxation which enables us to conduct a more realistic comparison of alternative credit policies. Figure 2 presents the economy’s response to the same (a negative five per cent) capital quality shock, where the fiscal authority utilizes consumption taxes that are distortionary to pay for government outlays.

As can be seen from the last panel in the second row of Figure 2, compared to the case with no credit policy, BCIs bring about an increase in the consumption tax rate, while CE features an initial increase followed by a decrease. Compared to the benchmark case, this creates a change in the dynamics of consumption under the different policies: consumption decreases less under CE and more under BCI, than that under no credit policy. It is also important to note that even though the drop in output is greater than that under lump-sum taxes, as expected, both credit policies improve the output outcomes upon the Taylor rule.

Figure 3 repeats the same exercise for the case of distortionary labour taxes.

When using labour taxes, the tax rate under BCI does not increase as much as it does under consumption taxes given the smaller decline in aggregate output, and hence, hours worked under the former. Compared with the case of lump-sum taxation, labour income
taxes also result in a decrease and increase in the level of consumption under BCI and CE, respectively. However, the decrease in the level of consumption is lower than that under consumption taxes. In addition, the dynamics of hours worked also change due to the different labour tax profiles obtained with BCI and CE.

As previously mentioned, the difference in the returns to BCI and CE determines the difference in the fiscal implications of the two credit policies; a deficit forcing higher taxes in the former as opposed to a surplus, allowing for a reduction in taxes, in the latter.

In what follows, we attempt to quantify the implications of the different tax regimes under BCI and CE in a simple manner. We do this by comparing the output gains under BCI and CE relative to the case under no unconventional policy (under the Taylor rule) for the quarter in which economic activity is at its lowest. Table 2 displays the percentage increase in aggregate output attained under each credit policy regime for two cases: the benchmark scenario (lump-sum taxes) and variable tax rates. To enable comparability, we set the steady-state level of lump-sum taxes in each benchmark scenario equal to the steady-state tax revenues obtained with the use of relevant distortionary taxes.

<table>
<thead>
<tr>
<th></th>
<th>Benchmark for Cons. Taxes</th>
<th>Variable Cons. Tax Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCI</td>
<td>31.70</td>
<td>18.90</td>
</tr>
<tr>
<td>CE</td>
<td>8.58</td>
<td>4.37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Benchmark for Lab. Inc. Taxes</th>
<th>Variable Labour Inc. Tax Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCI</td>
<td>26.24</td>
<td>14.62</td>
</tr>
<tr>
<td>CE</td>
<td>5.62</td>
<td>3.66</td>
</tr>
</tbody>
</table>

Comparing the second and the third columns, we see that the higher tax rates under BCI results in a 13 percentage point decline in aggregate output, when consumption taxes are utilized by the government. We observe that this decline is equal to 12 percentage point with labour income taxes. Inspecting rows 2 and 4 shows that the decrease in aggregate output, under CE is equal to around 4 and 2 percentage points, with consumption and labor income taxes, respectively.
The difference in the output outcomes under \( CE \) and \( BCI \) directly follows from their fiscal implications. Even though moving from lump-sum to distortionary taxes deteriorates output outcomes under both \( CE \) and \( BCI \), relative to the Taylor rule, the deterioration is significantly higher with \( BCI \). Table 2 also reveals that the use of both credit policies improve output under all scenarios with both lump-sum and variable taxation.

### 3.3 Credit policies and welfare

We now present a welfare analysis of alternative credit policies. Following Schmitt-Grohe and Uribe (2007), we calculate welfare in each scenario using a second order approximation to the utility function. First, we state the household’s utility function recursively,

\[
V_t = U_t(C_t, C_{t-1}, L_t) + \beta E_t V_{t+1}
\]  

We take a second order approximation of \( V_t \) around the steady-state and calculate the second order solution to the model. We then compute the value of \( V_t \), the welfare loss under each policy regime. While calculating the welfare losses, we use the policy parameters \((\rho_{x}, \rho_{y}, \rho_{T}, \text{and} \rho_{\phi})\) that optimize \( V_t \) in response to the capital quality shock. The welfare gains from using each alternative is then given by the difference between the values of \( V_t \) obtained under the Taylor rule only and each credit policy alternative. We then compute the fraction of the steady-state consumption required to equate welfare under the Taylor rule to the one under each credit policy alternative - the consumption equivalent \((CEQ)\).

Table 3 presents our welfare results under three scenarios: with lump-sum taxation (benchmark scenario); with consumption taxes and with labour taxes. For comparability, we set the steady-state level of lump-sum taxes equal to the steady-state tax revenues obtained with the use of the relevant distortionary taxes in two cases, as above.

Table 3. Welfare Gains with Lump-sum and Distortionary Taxes
We first observe that BCI generates higher welfare gains relative to CE, under all scenarios, consistent with the output outcomes above. It is also clear that the use of distortionary taxes reduces welfare gains under both types of unconventional policies, with both consumption and labour taxes, as expected. The decrease in welfare observed under CE is lower than the decline obtained under BCI, due to the more favourable fiscal implications of CE. Comparing the upper and lower cells in the third column suggests that the use of labour tax rate is preferred to consumption tax under both credit policies. This is firstly due to the fact that there is a smaller increase in the tax rate under the former as compared with the latter. Secondly, a rise in consumption taxes reduces consumption and hence household utility while a rise in labour taxes reduces hours worked with the opposite impact on welfare.

Overall, three observations emerge from our welfare analysis: (i) BCI s are more effective in mitigating the negative effects of financial shocks to the economy, resulting in better welfare outcomes in all cases; (ii) analysis based on lump-sum taxes overstates the welfare gains from pursuing credit market interventions; and (iii) even under distortionary taxation, the benefits from using credit policies still outweigh the fiscal costs resulting in positive welfare gains, under both credit policies with both consumption and labour taxes.

### 3.4 Sensitivity Analyses

In this section, we present a number of robustness checks. We start by examining the sensitivity of our results to the return on government equity.
3.4.1 Welfare Results and Return to Government Equity

Our initial analysis maintains that a unit of equity injected by the government, $N^g_t$, has the same return as a unit of private equity, $N_t$; that is, the government does not earn a premium on bank equity. We now assume that the government earns the return $R_{k,t}$ on equity injected, which is the same as the return that is earned from the loans supplied. Table 4 presents welfare gains generated under BCIs when banks need to pay $R_{k,t}$ on government equity, instead of $R_t$ where benchmark values are also displayed as reference points.

Table 4. Welfare Gains under BCI with Different Returns

| CEQ | Consumption Taxes | | Labour Income Taxes |
|-----|--------------------| |---------------------|
|     | BCI | CE |       | BCI | CE |
| $R_t$ | 0.0295 |     | $R_{k,t}$ | 0.0196 | 0.0102 |
|       | 0.0442 |     |       | 0.0289 | 0.0177 |

It is clear from the entries in Table 4 that even with a premium on government equity, BCIs generate higher welfare gains than CE, under both consumption and labour income taxes. Interestingly, Table 4 also reveal that when the government earns a higher return on bank capital injections, the welfare gains from this policy are lower. This is mainly due to the fact that it takes longer for banks to rebuild their net worth when they need to pay a higher return on the equity they receive.

3.4.2 Welfare Results and Efficiency Costs of Credit Policies

In our main welfare calculations, we set the efficiency costs of both credit policies at 10 basis points, $\tau^S = \tau^N = 0.0010$. Under this assumption, BCIs result in better welfare outcomes with both lump-sum and distortionary taxes. Since the efficiency costs are a significant determinant of the welfare outcomes, we now examine the magnitude of the efficiency costs
of BCIs that will equate the welfare gains obtained under this policy to that obtained under CE. Keeping the efficiency costs of CE, \( \tau^S \) at 10 basis points, we find that an efficiency cost, \( \tau^N \) of 200 basis points equates the welfare gains of BCIs to CE, with consumption taxes. With labour income taxes, the efficiency costs of BCIs that equalize the welfare outcomes are an even larger 400 basis points. The implausibility of such high efficiency costs of BCIs compared to CE reinforces our key finding that BCIs are more effective than CE in mitigating the negative effects of financial shocks to the economy.

### 3.4.3 Welfare Results and Other Key Parameters

For the final sensitivity analysis of our results, we re-calculate the welfare gains by varying the values of the six key parameters in our model: the efficiency costs of government intermediation (keeping the assumption that the efficiency costs of BCIs and CE are equal to each other, i.e. \( \tau^S = t^N \)), bank leverage at the steady-state (\( \phi \)), habit persistence (\( \chi \)), the steady-state values for the tax rates (\( t^c \) and \( t^h \)), and the debt aversion and output gap coefficients (\( \gamma_b \) and \( \gamma_y \)) of the fiscal policy rule. Figure 4 exhibits six cases where we plot the consumption equivalent (CEQ) obtained with varying values of the relevant parameter. In each case we present two plots; the first with consumption taxes, and the second with labour taxes. In each panel, CEQs are given under BCI and CE, with lump-sum taxes (\( T \)) or the relevant variable tax rates (\( t \)), for a 1 percent negative shock to capital quality.

Insert Figure 4 here

The left pair of the first row presents the variation in the results for the two credit policies under both lump-sum and distortionary taxation across a range of values for the efficiency costs. As expected, welfare gains from credit policies fall as their efficiency costs increase. BCIs - with both lump-sum and distortionary taxes- generate higher welfare gains than credit easing at all levels of efficiency costs. In addition, use of distortionary taxes
reduces the gains from the utilization of both credit policies, compared to lump-sum taxes irrespective of the level of efficiency costs. When efficiency costs are about 100 basis points, the use of credit policies still delivers welfare gains, but the gains are quantitatively small.

The right pair of the first row plot the welfare gains across varying values of the bank leverage in the initial steady-state. An increase in the steady-state bank leverage corresponds to a decrease in the steady-state fraction of bank assets that can be diverted. This, in turn, relaxes the bank’s constraint and enables the bank to accumulate a higher level of leverage. As the leverage ratio increases, negative effects of the shocks to the economy are visibly amplified. Hence, use of credit policies results in higher gains, as shown in Figure 4. When consumption taxes are used, the welfare ranking we established above remains intact: BCI{s generate higher welfare gains than credit easing under both lump-sum and distortionary taxes. However, when labour taxes are adopted, CE with lump-sum taxes generates higher welfare gains than BCI with distortionary taxes for some values of ϕ.

The left pair on the second row display the welfare gains for different values of habit persistence. As habit persistence increases, consumption smoothing improves welfare more. Since the use of the credit policies decreases the volatility of consumption, their contributions to the increase in welfare are greater for higher values of the habit persistence parameter. In line with our main analysis, BCI yields higher welfare gains and the use of distortionary taxes reduces welfare.

The right pair on the second row present the welfare gains for different values of the steady-state consumption and labour income taxes. For comparability, the steady-state lump-sum tax level is adjusted according to each value of the tax rate considered. When BCIs are in place, our results are robust to different steady-state tax levels. With CE, use of distortionary taxes results in higher welfare gains than the use of lump-sum taxes when the steady-state labour tax rates are high - approximately beyond 20 percent.

Finally, the third row displays the welfare gains across varying values of the debt aversion and the output gap coefficients of the fiscal policy rule, respectively. The results are given
under $BCI$ and $CE$, only with variable tax rates ($t$), as changing the coefficients do not affect our welfare results with lump-sum taxes. An increase in debt aversion results in a decrease in welfare gains, whereas a rise in the output gap coefficient improves welfare outcomes, under both policies. These results indicate that in a crisis scenario, delaying government debt repayment and placing a higher emphasis on the negative impact on output yields greater welfare gains.

4 CONCLUSIONS

This paper presented an assessment of the two of the most widely adopted credit policies following the global financial crisis; credit easing through directly lending to non-financial firms and bank capital injections through injecting capital into the financial sector. In contrast to the existing work on unconventional policy that predominantly focuses on the benefits of these measures our work explicitly considers the cost of paying for each policy. Also importantly, particularly for a realistic policy evaluation, we move beyond the benchmark case of lump-sum taxation and look into the interaction between different policy measures and different tax arrangements. We conduct our analysis utilizing a New Keynesian DSGE model that contains a banking sector with financial frictions that play a key role in the amplifications of the effects of financial crises.

We examined the dynamics of a financial crisis triggered by a financial shock and find that the use of both credit easing and bank capital injections mitigates the unfavorable effects of the financial shock on the economy by containing the rise in the spread. Compared to credit easing, the use of bank capital injections impacts aggregate output more favourably, through a direct increase in banks’ net worth, thereby significantly lowering the increase in the credit spread. However, the use of equity injections also yields an increase in government outlays, as opposed to an increase in the government revenues obtained under credit easing.
Hence, when the government injects capital into banks, additional finance needs to be raised through higher taxes with additional unfavorable consequences.

Our welfare results reveal that analyses based on lump-sum rather than distortionary taxes indeed overstate the gains from pursuing credit market interventions. Interestingly, however, we also find that even in the presence of distortionary taxation, both credit easing and bank capital injections generate welfare gains as benefits from reduced volatility outweigh the fiscal cost of enacting the credit policies. Overall, bank capital injections dominate credit easing, due to the greater improvement in the spread under the former, the beneficial effects of which more than offset those of the fiscal surplus generated by the latter.

We also show that our results are robust to a wide range of variation in the parameter values. However, it is possible to envisage alternative frameworks where the assessment of the relative costs versus benefits might be different. For example, in the presence of sizable financial frictions benefits of credit policies would be substantial, while in the presence of a tax system with significant distortions, fiscal implications of unconventional policies are likely to have serious consequences. Our work, therefore, points to the key importance of quantifying fiscal implications of unconventional policies. This is especially the case given that the existing empirical work has so far exclusively focussed on the beneficial stabilizing role of these policies in the aftermath of the financial crises.

It should be noted, however, that our results rely on the assumption that the government does not default on its debt. If government bonds become subject to default risk, the policymaker would have limited ability to conduct unconventional policy and this would, in turn, affect the valuation of government bonds. We believe that incorporating the default risk for the government in assessing its role in designing post-crisis rescue programs is an important topic for further research.
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References


