Credit Spreads and Credit Policies[*]

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Abstract

How should monetary and fiscal policy react to adverse financial shocks? If monetary policy is constrained by the zero lower bound on the nominal interest rate, subsidising the interest rate on loans is the optimal policy. The subsidies can mimic movements in the interest rate and can therefore overcome the zero bound restriction. Credit subsidies are optimal irrespective of how they are financed. If debt is not state contingent, they result in a permanent increase in the level of public debt and future taxes, and in a permanent reduction in output.

Keywords: Credit policy; credit subsidies; monetary policy; zero-lower bound on nominal interest rates; banks; costly enforcement.

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1 Introduction

The 2008-2009 financial crisis and the Great Recession have exposed the limitations of standard monetary policy as a tool for macroeconomic stabilization. Even if policy rates have been cut to near-zero levels, the costs of financing for firms and households have been kept high by unusually high credit spreads. Since further downward movements in the nominal interest rate were prevented by the zero lower bound constraint, alternative tools have been deployed by various institutions. Central banks have introduced credit policies and fiscal/macroprudential interventions have been used to address the weak balance sheet conditions of financial intermediaries.

The particular combination of measures adopted in practice was partly the result of political and institutional constraints. This paper investigates whether more general policy tools would be desirable to address financial market disturbances. It studies optimal fiscal and monetary policy in environments with financial frictions and financial shocks. In particular we revisit the Ramsey literature on optimal fiscal and monetary policy, and extend it to allow for multiple interest rates—on bank deposits and bank loans—and to analyze the optimal response to shocks that weaken banks' balance sheets.

We consider a simple monetary model and extend it to include financial intermediaries. Firms must borrow to pay wages and they can only obtain loans from banks, whose intermediation activity is costly. To provide sharper results, we assume away any resource costs and focus on an efficiency cost resulting from an incentive problem, as in Gertler and Karadi (2011) or Gertler and Kiyotaki (2010). Banks must earn rents because they have an incentive to divert funds away from the lending activity. Loan rates therefore include a spread over the deposit rate, which is also the monetary policy interest rate in the model. There is also an alternative technology, that the government can use, in which the enforcement problem is solved by paying a resource cost.

We show that lending rates may in general be too high in the model. They may be too high on average, because financial intermediation entails no resource costs. They may be especially high in reaction to adverse shocks that reduce the value of banks' internal funds and produce an increase in lending spreads. Volatility in lending rates due to volatile spreads may also be undesirable.

Even if it cannot directly affect spreads, interest rate policy can be used to partially correct the distortionary effects of high and volatile lending rates. A lower policy rate induces a reduction in the deposit rate, which is the financing cost of banks. For given spreads, the reduction in the deposit rate will bring down the lending rate. Monetary policy is however constrained by the zero lower bound. Even if the policy rate were zero, lending rates may still be too high and too volatile. Other policy measures are therefore desirable.

To develop an intuition for the choice of the appropriate measure, it is useful to consider the hypothetical case in which the policy rate could be negative. If, in addition, the associated fiscal subsidy could be financed with lump-sum taxes, then optimal policy would be a version of the Friedman rule, as in the traditional Ramsey literature. In contrast to that literature, however, in our model with financial intermediation, the Friedman rule would require setting the lending rate to zero, and not the policy rate.[1] Without lump-sum taxes, it would not be possible to finance the systematic fiscal subsidy associated with a negative policy rate. However negative policy rates could remain useful in reaction to shocks, in order to smooth the effects of spreads on the financing costs of firms.

In practice policy interest rates cannot be negative–or, at least, not deeply negative. The central message of our paper is that, when monetary policy is constrained by the zero bound, the financing costs of firms can still be lowered through credit subsidies. Credit subsidies and the policy interest rate can be seen as complementary policy instruments. They have the same effect in terms of reducing the financing costs of firms. And they produce the same budgetary implications for government finances. But, because they are both subject to lower or upper bound constraints, they must be used together to make those constraints ineffective. While the policy interest rate cannot be negative, the credit subsidy cannot be higher than the spread it aims to correct. In other words, the bank lending rate cannot be lower than the deposit rate, otherwise agents would borrow money, deposit it in their bank accounts and make profits. Just as the policy rate cannot be lower than zero, otherwise it would be possible to borrow money, keep it as cash and make profits. With credit subsidies, it is possible to implement allocations that would be infeasible for monetary policy. But policy on credit subsidies also needs to be complemented by interest rate policy in order to be fully effective.

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[1] This result hinges on the assumption that financial intermediation is costless. With a positive intermediation cost, the optimal lending rate would have to include that cost.

With both interest rate policy and credit subsidies, the Friedman rule on the lending rate that achieves the first best in this model is implementable. In the model, when policy rates are set to zero, lending rates are positive and time varying, in response to changes in the balance sheet conditions of banks. Still the effective lending rates paid by borrowers can be kept smooth and very low thanks to credit subsidies.

The precise features of the allocation which can be achieved through credit subsidies depends on the financing instruments available to the government. If lump-sum taxes were feasible, credit subsidies could be used to achieve the first best allocation. Without lump-sum taxes, credit subsidies would only be used in response to shocks. We allow for state contingent debt, that, in response to large and rare financial shocks, could be understood as a confiscatory tax on wealth justified by the exceptional nature of the shock. Even if state contingent nominal debt is ruled out, it is still the case that, as in Chari, Christiano and Kehoe (1991), it could be replicated through unexpected changes in inflation. This would generate all the desirable variation in the real value of the outstanding nominal public debt.

To analyze also the policy implications of noncontingent debt, we restrict the policy makers' ability to implement changes in inflation through instantaneous price adjustments in reaction to shocks. In this case, credit taxes and subsidies are still optimal, but they have budgetary implications and the economy cannot be perfectly insulated from the consequences of financial shocks. Adverse shocks result in a permanent increase in the level of public debt, in a permanent increase in future taxes and in a permanent reduction in output.[2]

As in the original Gertler and Karadi (2011) model, policies of direct lending by the central bank could also be desirable in reaction to large tightening of banks' balance-sheet constraints. Balance sheet constraints lead to a contraction in lending through the increase in credit spreads. Replacing the missing private intermediation with central bank intermediation is intuitively appealing. The choice between direct lending and credit subsidies will in general depend on the relative size of the inefficiency cost of direct central bank intermediation vis-a-vis the financing cost for credit subsidies. The ranking between the two policies is clear in the benchmark case with lump-sum taxes. Credit subsidies are then strictly preferable for any arbitrarily small cost of central bank intermediation, since they can be used to achieve the first best allocation.

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[2]These results are consistent with those in Barro (1979) and Aiyagari et al (2002) where, in the absence of state contingent debt, innovations in fiscal conditions are spread out over time and the optimal tax rate follows essentially a random walk.

In our analysis we focus on monetary and fiscal policy, but these policies also ensure that leverage ratios in the banking sector vary appropriately across states of nature. This suggests that optimal policy could alternatively be specified also in terms of a macro-prudential instrument, such as a time-varying capital requirements that would directly mandate appropriate values for leverage ratios.

Our paper is related to the recent literature studying the effects of financial market shocks and the desirability of non-standard policy responses (see also Curdia and Woodford, 2011, De Fiore and Tristani, 2012, Eggertsson and Krugman, 2010). This literature explores various forms of direct lending by the central bank, but it does not explicitly allow for tax instruments and it does not study the optimal combination of monetary and fiscal policy in reaction to financial, or other, shocks.

Optimal fiscal policy when interest rates are at zero has been studied by Eggertsson and Woodford (2006), Schmidt (2013) and Werning (2012). These papers however rely on the new Keynesian model and therefore abstract from financial market distortions. The key benefit of fiscal policy in those models is related to the large fiscal multipliers which may arise when monetary policy is constrained by the zero bound (see Christiano, Eichenbaum and Rebelo, 2011; Eggertsson, 2011, Woodford, 2011). In contrast, in our environment the fiscal intervention is desirable to cushion the economy from the consequences of an increase in credit spreads.

Our paper is also related to the results in Correia, Farhi, Nicolini and Teles (2013), that show that consumption taxes and other taxes can be used to overcome the zero bound constraint in models with sticky prices. Our paper differs in the type of frictions and shocks which make the zero bound a restriction for monetary policy, but it confirms the result that standard tax instruments can overcome the zero bound constraint.

The paper is organized as follows. In section 2, we describe the environment. In section 3, we analyze optimal credit policies, in the first and second best, and establish the irrelevance of the zero bound constraint when credit subsidies are used. In section 4, we compute numerically the optimal response to shocks in a second best, without lump-sum taxes. We consider two cases. In the first, policy can instantaneously change the price level in response to shocks. In the second case, policy is restricted from affecting prices on impact. Section 5 contains concluding remarks.

2 A model

We use a model in which banks face an enforcement problem as in Gertler and Karadi (2011). A representative firm needs to borrow to pay for wages. A continuum of banks make those loans and borrow from the household. There is a large household that includes workers and bankers that share consumption. The preferences of the household are over consumption and labor and the technology uses labor only and is linear. Bankers can appropriate a fraction of the assets of the bank, so they must be given an incentive not to divert the assets. In equilibrium there are going to be bank profits that are accumulated as internal funds. The government consumes, raises taxes and pays for subsidies on credit, and issues money and debt.

The uncertainty in period $t \geq 0$ is described by the random variable $\gamma_t \in \Gamma_t$, where Γ_t is the set of possible events at t, and the history of its realizations up to period t is denoted by $\gamma^t \in \Gamma^t$. For simplicity we index by t the variables that are functions of γ^t.

2.1 The household

The household is composed of workers and bankers: with probability $1 - \theta$, bankers exit and become workers. They are replaced by workers that become new bankers, keeping the fractions of bankers and workers constant, respectively f and $1 - f$. Bankers and workers share consumption.

The household preferences are

$$\text{Max } E_t \sum_{t=0}^{\infty} \beta^t \left[\log C_t - \frac{\chi}{1 + \phi} N_t^{1+\varphi} \right]$$

The household starts period t with nominal wealth $\mathbb{W}_t$. At the beginning of period t, in an assets market, the household purchases $E_t Q_{t,t+1} B_{t,t+1}^g$ in state contingent nominal claims where $Q_{t,t+1}$ is the price in period t of a unit of money in period $t+1$, in some state, normalized by the probability of occurrence of the state. The household also purchases non-contingent public debt B_t^g, and deposits D_t^h. In the beginning of the following period the nominal wealth $\mathbb{W}_{t+1}$ includes the state contingent bonds $B_{t,t+1}^g$, the gross return on non-contingent public debt $R_t B_t^g$, deposits $R_t D_t^h$, and the dividends received from the banks Π_t^b.[3] It also includes the wage income $W_t N_t$, which is received in units of money in a goods/labor market at the

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[3]Since public debt and bank deposits are riskless, their yields are identical in equilibrium.

end of period t. The household pays for consumption expenditures $P_t C_t$, and lump-sum taxes T_t. The flow of funds constraints of the household are therefore

$$E_t Q_{t,t+1} B^g_{t,t+1} + B^g_t + D_t \leq \mathbb{W}_t, \tag{1}$$

$$\mathbb{W}_{t+1} = B^g_{t,t+1} + R_t B^g_t + R_t D_t + \Pi^b_t + W_t N_t - P_t C_t - T_t$$

There is also a non-Ponzi games condition on the holding of assets.

These budget constraints are written under the assumption that $R_t \geq 1$. This is the zero bound on interest rates as an equilibrium restriction. If it were not satisfied, the households would borrow an arbitrarily large amount and hold cash. Unless the profits from that activity were fully taxed this would not be an equilibrium. That arbitrage opportunity would be the only use for money by the household.

The first order conditions of the households problem include

$$-\frac{u_C(t)}{u_N(t)} = \frac{P_t}{W_t}, \tag{2}$$

$$\frac{u_C(t)}{\beta u_C(t+1)} = Q^{-1}_{t,t+1} \frac{P_t}{P_{t+1}}, \tag{3}$$

$$\frac{u_C(t)}{P_t} = R_t E_t \frac{\beta u_C(t+1)}{P_{t+1}}, \tag{4}$$

2.2 Firms

In the economy there is a representative firm endowed with a stochastic technology that transforms N_t units of labor into $Y_t = A_t N_t$ units of output. In the beginning of the period, the firm needs to borrow nominal funds S_t in order to pay the wage bill. We assume the firms hold those funds as money, that is not remunerated.[4] The borrowing constraint is

$$W_t N_t \leq S_t \tag{5}$$

The profits in each period t can be written as

$$\pi^f_t = P_t Y_t - W_t N_t - \left[R^l_t \left(1 - \tau^l_t \right) - 1 \right] S_t,$$

where P_t is the price level, R^l_t is the gross interest rate on the loans to the firms, and τ^l_t is a government subsidy on the gross loan rate.

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[4]One way to think about the timing of transactions is with an assets market in the beginning of the period where firms borrow the money and a goods/labor market at the end where they use the money to pay wages.

Using the borrowing constraint (5), we can write profits as

$$\pi_t^f = P_t Y_t - R_t^l \left(1 - \tau_t^l\right) W_t N_t.$$

Profit maximization implies

$$P_t A_t = R_t^l \left(1 - \tau_t^l\right) W_t. \tag{6}$$

which, together with the borrowing constraint (5), implies

$$A_t N_t = R_t^l \left(1 - \tau_t^l\right) \frac{S_t}{P_t}$$

It is also an equilibrium restriction that

$$R_t^l \left(1 - \tau_t^l\right) \geq R_t, \tag{7}$$

otherwise firms could make arbitrarily large profits borrowing at $R_t^l \left(1 - \tau_t^l\right)$ and holding deposits that would pay R_t. This is an upper bound constraint on the credit subsidy, similar in substance to the zero bound constraint on interest rates.

2.3 Banks

Each bank j channels funds from depositors to the firms. Because of a costly enforcement problem, banks must have rents that are accumulated as internal funds, $Z_{j,t}$.[5] This means that there are going to be positive spreads and that internal funds will have high rates of return. It also implies that there must be exit of bankers, so that internal funds can remain scarce.

The bank borrows $D_{j,t}$ from households and lends $S_{j,t}^b$. It follows that the balance sheet of the bank is described by

$$S_{j,t}^b = D_{j,t} + Z_{j,t}. \tag{8}$$

Because the equilibrium return on the internal funds is going to be higher than the alternative return R_t, profits will be kept in the bank, as internal funds, until exit. The net worth of the bank evolves according to

$$Z_{j,t+1} = \xi_{t+1} \left[R_t^l S_{j,t}^b - R_t D_{j,t} \right], \tag{9}$$

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[5] These internal funds are a balance sheet item defined as the difference between banks' assets–loans and liabilities–deposits.

where ξ_t is a shock to the value of internal funds, similar to the capital quality shock in Gertler and Karadi (2011). This can be interpreted as a shock to the value of collateral.

Combining the two conditions above, (8) and (9), we can write

$$Z_{j,t+1} = \xi_{t+1} \left[\left(R_t^l - R_t \right) S_{j,t}^b + R_t Z_{j,t} \right]$$

Bankers exit in the beginning of the period, before the assets market. At the assets market in period t, terminal wealth, $V_{j,t}$, is

$$
\begin{aligned}
V_{j,t} &= E_t \sum_{s=0}^{\infty} (1-\theta) \theta^s Q_{t,t+1+s} Z_{j,t+1+s} = \\
&\quad E_t \sum_{s=0}^{\infty} (1-\theta) \theta^s Q_{t,t+1+s} \xi_{t+1+s} \left[\left(R_{t+s}^l - R_{t+s} \right) S_{j,t+s}^b + R_{t+s} Z_{j,t+s} \right]
\end{aligned}
$$

As in Gertler and Kiyotaki (2010), bankers can appropriate a fraction λ of assets $S_{j,t}^b$. This takes place in the asset market at time t. The incentive compatibility constraint is, thus.

$$V_{j,t} \geq \lambda S_{j,t}^b.$$

Unless this condition is verified, banks won't be able to attract deposits.

As shown in appendix A, the solution of this problem implies that loans are given by

$$S_{j,t}^b = \phi_t Z_{j,t}.$$

where ϕ_t is defined as the ratio of assets to internal funds, $\phi_t \equiv \eta_t / (\lambda - \upsilon_t)$, which we refer to as leverage ratio, and

$$\upsilon_t = E_t \left\{ (1-\theta) Q_{t,t+1} R_t \xi_{t+1} \frac{(R_t^l - R_t)}{R_t} + Q_{t,t+1} \theta \frac{S_{j,t+1}^b}{S_{j,t}^b} \upsilon_{t+1} \right\}$$

and

$$\eta_t = E_t \left\{ (1-\theta) R_t Q_{t,t+1} \xi_{t+1} + Q_{t,t+1} \theta \frac{Z_{j,t+1}}{Z_{j,t}} \eta_{t+1} \right\}.$$

The total internal funds of bankers Z_t are the sum of the funds of surviving bankers Z_{et+1} and entering bankers Z_{nt+1}. Since a fraction θ of bankers survive,

$$Z_{et} = \theta \xi_t \left[\left(R_{t-1}^l - R_{t-1} \right) \phi_{t-1} + R_{t-1} \right] Z_{t-1}.$$

The remaining fraction, $1 - \theta$, die and transfer back the internal funds to the households at the end of the period. The households then transfer to the entering banks the fraction $\frac{\omega}{1-\theta}$ of these assets at t,

$$Z_{nt} = \omega \xi_t \left[\left(R_{t-1}^l - R_{t-1} \right) \phi_{t-1} + R_{t-1} \right] Z_{t-1}.$$

We can then write

$$Z_t = Z_{et} + Z_{nt} = (\theta + \omega)\,\xi_t \left[\left(R_{t-1}^l - R_{t-1}\right)\phi_{t-1} + R_{t-1}\right] Z_{t-1}. \tag{10}$$

Aggregate dividends transferred by exiting banks to households are

$$\Pi_{n,t}^b = \xi_t\,(1-\theta) \left[\left(R_{t-1}^l - R_{t-1}\right)\phi_{t-1} + R_{t-1}\right] Z_{t-1}.$$

It follows that dividends to households net of the transfer to entering banks are

$$\Pi_t^b = \xi_t\,(1-\theta-\omega) \left[\left(R_{t-1}^l - R_{t-1}\right)\phi_{t-1} + R_{t-1}\right] Z_{t-1}$$

which, using (10), can be rewritten as

$$\Pi_t^b = \left(\frac{1}{\theta + \omega} - 1\right) Z_t \tag{11}$$

2.4   The government

The government spends G_t, issues money M_t, chooses the nominal interest rate R_t, issues non-contingent debt B_t^g and contingent debt $B_{t,t+1}^g$, gives credit subsidies τ_t^l and raises lump-sum taxes T_t.

The government flow of funds constraints are given by

$$B_t^g + E_t Q_{t,t+1} B_{t,t+1}^g + M_t \geq -\mathbb{W}_t^g, \tag{12}$$

where $-\mathbb{W}_{t+1}^g$ are government liabilities

$$-\mathbb{W}_{t+1}^g = R_t B_t^g + B_{t,t+1}^g + M_t + \tau_t^l R_t^l S_t + P_t G_t - T_t \tag{13}$$

The government flow of funds constraint can therefore be written as

$$B_t^g + E_t Q_{t,t+1} B_{t,t+1}^g + M_t \geq R_{t-1} B_{t-1}^g + B_{t-1,t}^g + M_{t-1} + \tau_{t-1}^l R_{t-1}^l S_{t-1} + P_{t-1} G_{t-1} - T_{t-1}$$

2.5   Market clearing

The market clearing condition in the goods market is

$$C_t + G_t = A_t N_t$$

and the market clearing condition for loans is

$$S_t = S_t^b.$$

2.6 Equilibrium conditions

The equilibrium conditions for the variables $\{C_t, N_t\}$, $\{\tau_t^l, R_t, Q_{t,t+1}, P_t\}$ and $\{R_t^l, \phi_t, \eta_t, \upsilon_t, S_t, Z_t\}$ are

$$-\frac{u_C(t)}{u_N(t)} = \frac{R_t^l\left(1 - \tau_t^l\right)}{A_t}, \tag{14}$$

$$C_t + G_t = A_t N_t, \tag{15}$$

$$A_t N_t = R_t^l\left(1 - \tau_t^l\right)\frac{S_t}{P_t}, \tag{16}$$

$$S_t = \phi_t Z_t, \tag{17}$$

$$\phi_t = \frac{\eta_t}{\lambda - \upsilon_t}, \tag{18}$$

$$Z_t = \xi_t\left(\theta + \omega\right)R_{t-1}\left[\left(\frac{R_{t-1}^l}{R_{t-1}} - 1\right)\phi_{t-1} + 1\right]Z_{t-1}, \tag{19}$$

$$\frac{u_C(t)}{P_t} = R_t E_t \frac{\beta u_C(t+1)}{P_{t+1}}, \tag{20}$$

$$Q_{t,t+1} = \frac{\beta u_C(t+1)P_t}{u_C(t)P_{t+1}}, \tag{21}$$

$$R_t^l\left(1 - \tau_t^l\right) \geq R_t \geq 1, \tag{22}$$

and

$$\upsilon_t = (1-\theta)E_t R_t Q_{t,t+1}\xi_{t+1}\left(\frac{R_t^l}{R_t} - 1\right) + \theta E_t R_t Q_{t,t+1}\xi_{t+1}\frac{\phi_{t+1}}{\phi_t}\left[\left(\frac{R_t^l}{R_t} - 1\right)\phi_t + 1\right]\upsilon_{t+1} \tag{23}$$

$$\eta_t = (1-\theta)E_t R_t Q_{t,t+1}\xi_{t+1} + \theta E_t R_t Q_{t,t+1}\xi_{t+1}\left[\left(\frac{R_t^l}{R_t} - 1\right)\phi_t + 1\right]\eta_{t+1} \tag{24}$$

The budget constraint of the government does not impose restrictions on the equilibrium conditions above because it can always be satisfied with lump-sum taxes, T_t.

Notice that the shock to internal funds ξ_t affects the equilibrium conditions through equations (19) and (16), and that the price level can adjust so that the equilibrium is not affected by the destruction of internal funds. This can indeed be part of optimal policy as will be seen later.

The nominal quantity of money is not neutral in this economy, the reason being that internal funds are predetermined. If it was possible to increase internal funds in every period, together with all price levels and nominal quantities by the same percentage, this would keep interest rates and allocations unchanged. However, because internal funds, Z_t, are predetermined,

increasing all nominal quantities and price levels would not be possible without changing the real allocation. Equation (19) shows that, for a given Z_{t-1}, an increase in Z_t would not be consistent with the observed levels of the policy rate R_{t-1}, the credit spread, R_{t-1}^l/R_{t-1}, and leverage, ϕ_{t-1}. The level of prices is not irrelevant in this economy.

3   Interest rate policy vs. credit subsidies

In this section we describe optimal monetary and fiscal policy under different assumptions concerning the set of instruments available to the policy maker. Our central result is that credit subsidies ought to be used in conjunction with the policy rate. Only when they are both used, are the zero bound constraint and the upper bound on the subsidy not binding constraints. They are otherwise.

3.1   Lump sum taxes and the first best

As a benchmark, we first consider the case in which lump-sum taxes are available. If credit subsidies can be used, then there is a complete set of policy instruments, in the sense that the set of implementable allocations can be characterized by the resource constraints alone, together with a constraint on nonnegative wedges that is not binding at the optimum. It follows that the first best can be implemented. If credit subsidies were not used and only interest rate policy were used in response to shocks, then because of the zero bound, there would be an additional restriction corresponding to the zero bound constraint. That constraint would be binding.

Implementable allocations   We now show that, with lump-sum taxes and credit subsidies, the set of competitive equilibrium conditions restricting the allocations for consumption and labor can be summarized by the resource constraint together with the nonnegativity of the wedge, $-\frac{u_C(t)A_t}{u_N(t)} \geq 1$. In order to show this, we take a generic, feasible allocation for consumption and labor and show that, together with the other variables, it satisfies all the other equilibrium conditions. There are multiple implementations of each allocation, so it is sufficient to do the demonstration for a particular one.[6] We choose the implementation in which the price level does not change contemporaneously in response to shocks.

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[6] We thank Joao Sousa, that first suggested the possibility of multiple implementations in the price level.

Proposition 1 *The set of implementable allocations of consumption and labor, $\{C_t, N_t\}$, is the set of feasible allocations, satisfying the resource constraints (15), with a nonnegative wedge,*

$$-\frac{u_C(t)A_t}{u_N(t)} \geq 1.$$

Proof: Take a path for consumption and labor that satisfies the resource constraints (15) and such that $-\frac{u_C(t)A_t}{u_N(t)} \geq 1$. The intratemporal condition (14) determines τ_t^l given R_t^l. The borrowing constraint (16) determines the nominal lending S_t. The leverage condition (17) determines the leverage rate ϕ_t. The incentive constraint (18) determines one of the weights, say η_t. The accumulation condition (19) determines the internal funds Z_t. The intertemporal marginal condition (20) determines P_{t+1} that was restricted to be predetermined and the condition for the state contingent prices $Q_{t,t+1}$, (21) determines those prices. The conditions for the weights, (23) and (24), determine R_t^l and the weight, υ_t. Given that the wedge is positive, it must be that $R_t^l \left(1 - \tau_t^l\right) \geq 1$, and therefore it is possible to find an R_t, such that $R_t^l \left(1 - \tau_t^l\right) \geq R_t \geq 1$, so that the zero bound constraint on the interest rate and the upper bound constraint on the subsidy are both satisfied, (22). The nominal interest rate at the zero bound would always satisfy both constraints.

As an illustration, it is useful to think of the consequences of a negative shock to the value of internal funds, ξ_t, under this implementation. Because the price level does not move on impact, the real value of internal funds moves down by the full amount of the shock. As a result, leverage and the spread have to go up. Once at the zero bound, it is not possible to further cut interest rates to counteract the effect of the spread on allocations. The subsidy, instead can be adjusted for that purpose. Because there are lump-sum taxes, they can be used to finance the subsidy.

Another implementation will have the price level adjust on impact in response to shocks. As a result, the dynamics of the financial variables and the credit subsidies would be different. In particular, in response to an i.i.d. shock to the value of internal funds, a decrease in the price level on impact would be sufficient to completely neutralize all other effects of the shock on the equilibrium.

The first best allocation It is a corollary of Proposition 1, that the first best allocation can be achieved. Since the implementable set is the set of all feasible allocations, i.e. the ones restricted by the resource constraints (15), together with the nonnegativity constraint on the wedge, it follows that it is possible to achieve the best feasible allocation.

The first best is the solution to the maximization of households' preferences subject to the resource constraint. The efficiency conditions are given by $-\frac{u_C(t)}{u_N(t)} = \frac{1}{A_t}$ and $C_t + G_t = A_t N_t$. Comparison of the marginal condition with (14) shows that the distortion created by the financial friction shows up as a positive wedge $R_t^l \left(1 - \tau_t^l\right) - 1$. Only when policy sets this wedge to zero, is it possible to achieve the first best allocation in the distorted economy. The first best allocation therefore requires $R_t^l \left(1 - \tau_t^l\right) = 1$. This condition is reminiscent of the Friedman rule in models where money is used for transaction purposes and the nominal interest is the opportunity cost of money. The Friedman rule prescribes setting this opportunity cost to zero all times, i.e. $R_t = 1$, in order to eliminate the wedge between households' marginal rate of substitution between consumption and labor and the economy's marginal rate of transformation.

In the absence of credit subsidies, the first best allocation in our model would similarly require $R_t^l = 1$. The loan rate is the cost of obtaining loans for firms, who need funds to pay wages in advance of production. As with the case of the Friedman rule, the requirement $R_t^l = 1$ amounts to setting the cost of loans to zero, so as to eliminate the wedge between the marginal rate of substitution and the marginal rate of transformation. In order for the lending rate to be zero, and given that there must be positive credit spreads in equilibrium, the policy rate would have to be negative. The first best cannot be implemented with monetary policy alone.

Once credit subsidies are used, the first best can be achieved without setting negative interest rates. The policy rate can be zero, $R_t = 1$, the lending rate can include a spread and be strictly positive, $R_t^l > 1$, but the cost of funds for firms is still zero, $R_t^l \left(1 - \tau_t^l\right) = 1$. Since firms are not prevented from holding deposits or government debt, the rate at which they borrow including the subsidy cannot be lower than the deposit rate, $R_t^l \left(1 - \tau_t^l\right) \geq R_t$. It follows that the policy rate must indeed be zero at the optimum, $R_t = 1$.

These policy choices can be described in a particularly transparent way at the steady state, where the equilibrium spread is

$$\frac{R^l}{R} - 1 = \frac{\lambda \left(\beta - \theta - \omega\right) \left[\theta \left(1 - \beta\right) + \omega\right]}{\left(\theta + \omega\right) \beta \left(1 - \theta\right)} \tag{25}$$

which is strictly positive as long as $\beta > \theta + \omega$. Equation (25) shows that the spread is independent of policy in the steady state. Policy can only lower R^l by pushing further down the nominal rate R. If the nominal interest could be negative, $R < 1$, the Ramsey planner would be able to implement the first best with monetary policy only, setting $\tau^l = 0$. The spread

would still be positive, but the net lending rate could be zero, $R^l = 1$. The same allocation could also be achieved with an appropriate choice of credit subsidy τ^l, when the zero-lower bound on nominal interest rates is imposed, $R \geq 1$.

A particular feature of the first best equilibrium which is worth mentioning is that the dynamic response to shocks of variables other than consumption and hours is not uniquely determined. Real allocations are pinned down, but different impact movements in the initial price level could be accompanied by different values of real net worth, leverage, and credit spreads, together with different subsidies τ^l_t. Lending rates net of the subsidy would remain fixed at zero, i.e. $R^l_t \left(1 - \tau^l_t\right) = R_t = 1$. The Ramsey planner would therefore be indifferent between the various adjustment paths of spreads, net worth and leverage in reaction to shocks.

To summarize, we have so far shown that, even if lump-sum taxes were available, monetary policy alone would not achieve the first best, since that would require setting nominal interest rates below zero. Instead, if other fiscal instruments could be used, such as credit subsidies, then the zero bound constraint would not be binding and the first best would be achieved. The first best requires setting both the policy rate at its minimum level and the credit subsidy at its maximum level, resulting in zero lending rates. This is an extreme feature of this model, that takes the production of liquidity both by the government and the financial intermediaries to be costless in terms of resources.

In the next subsection, the more interesting case of distortionary taxation is analyzed.

3.2 Second best policies with distortionary taxes

Without lump-sum taxes, the budget constraint of the government, or households, must be taken into account as a restriction on the equilibrium allocations. In this subsection we derive general results for the case in which the government can issue state contingent bonds.

Implementable allocations We assume that in addition to nominal debt being state contingent, there is a tax on initial wealth l_0.[7] With state contingent debt, the households budget constraints can be written as the single constraint

$$E_0 \sum_{t=0}^{\infty} \frac{Q_t}{R_t} P_t C_t \leq E_0 \sum_{t=0}^{\infty} \frac{Q_t}{R_t} W_t N_t + E_0 \sum_{t=0}^{\infty} \frac{Q_t}{R_t} \Pi^b_t + (1 - l_0) \mathbb{W}_0.$$

---

[7]This initial tax is a lump sum tax. If initial public liabilities are positive and the tax is restricted to be less than one, then this lump sum tax can confiscate the liabilities but it cannot finance the credit subsidies/taxes or government spending.

We can then use the household and firms marginal conditions, (2), (3), and (6), and the expression for the net profits of the banks that can be written, from (11), as

$$\Pi_t^b = \left(\frac{1}{\theta + \omega} - 1 \right) \frac{S_t^b}{\phi_t},$$

to write the budget constraint, with equality, as

$$
\begin{aligned}
E_0 \sum_{t=0}^{\infty} \beta^t u_C(t) C_t &= -E_0 \sum_{t=0}^{\infty} \beta^t u_N(t) N_t - E_0 \sum_{t=0}^{\infty} \beta^t u_N(t) \left(\frac{1}{\theta + \omega} - 1 \right) \frac{N_t}{\phi_t} + \\
&\quad R_0 u_C(0) \frac{(1 - l_0) \, \mathbb{W}_0}{P_0}.
\end{aligned}
\tag{26}
$$

In this case, without lump-sum taxes, the implementable set cannot be described by the implementability condition (26) and the resource constraints, (15), together with the constraint above that the wedge be nonnegative, $-\frac{u_C(t) A_t}{u_N(t)} \geq 1$. The other competitive equilibrium conditions must also be taken into account. They impose one restriction on the leverage rate ϕ_t across all possible realizations of uncertainty at t given a history at $t-1$. This is now shown formally.

Let $\#\Gamma_t$ be the number of possible realizations of uncertainty in period t, given a history at $t-1$, γ^{t-1}, which we call the number of states. Then for a given path for $\{C_t, N_t\}$ in the implementable set, the intratemporal condition (14) in each period $t \geq 0$ and each state is satisfied by τ_t^l; the borrowing constraints (16) in each period $t \geq 0$ are satisfied with the price level in $\#\Gamma_t - 1$ states and S_t in one state, at time $t \geq 0$; the condition for the leverage (17) in each period $t \geq 0$ is satisfied with loans S_t, in $\#\Gamma_t - 1$ states, and one ϕ_t; the incentive constraint (18) in each period $t \geq 0$ is satisfied with the choice of the weight η_t; the accumulation equation (19) in each period $t \geq 0$ is satisfied with Z_t; for any level of R_t, the intertemporal condition (20) in period $t \geq 0$ can be satisfied with P_{t+1} in one state, since for each history at t there is one degree of freedom in picking the price level at $t+1$; (23) is satisfied by R_t^l.

Notice that so far we have not imposed any restriction on the policy rate, R_t. The allocation that we have just described, however, is only implementable if the after-subsidy lending rate is not lower than the deposit rate, or, in other words, if the credit subsidy does not exceed the spread. As long as the allocation has the feature that $-\frac{u_C(t) A_t}{u_N(t)} \geq 1$, which in general is satisfied at the optimum, there is an R_t, such that $R_t^l \left(1 - \tau_t^l \right) \geq R_t \geq 1$, so that the constraint on the upper bound for the subsidy, (7), is also satisfied.

We have just shown that in addition to the constraints (26) and (15) and $-\frac{u_C(t) A_t}{u_N(t)} \geq 1$ in $\{C_t, N_t\}$ and $\{\phi_t, R_0, P_0, l_0\}$ the other equilibrium conditions impose one more restriction on

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ϕ_t, per state in period $t-1$, i.e. $\#\Gamma^{t-1}$ restrictions in each period. The role of the nominal interest rate is to guarantees that the upper bound on the subsidy is satisfied.

Since at the zero bound, $R_t = 1$, the upperbound on the credit subsidy is always satisfied, it follows that the zero bound constraint on the policy rate is irrelevant.

Credit subsidies as substitutes for the policy rate For a moment we abstract from the zero bound constraint on the nominal interest rates. With negative interest rates, the household could borrow and hold cash, and make arbitrarily large profits. Banks could also do the same arbitrage. We would therefore need to assume that the household and banks are prevented from exploiting these profit opportunities. Subject to these restrictions, there would be an equilibrium with negative rates, with associated (lower) lending rates and government financing. The overall set of feasible equilibria would thus be larger than in the case where the nominal interest rate is restricted to be positive. The extended set of equilibria can always be equivalently implemented with a zero policy rate and with credit subsidies. Equivalence here means that the alternative implementation will produce the same wedges and raise the same tax revenues.

In other words, starting from a path for nominal interest rates that are allowed to be negative, there is an equivalent path where the nominal interest rate is set to zero, and credit subsidies are used instead. What this means is that the zero bound constraint on interest rates is made irrelevant when credit subsidies are used.

Similarly, if we were to start with a path for credit subsidies such that the upper bound is not satisfied, there would be an equivalent path where the credit subsidy is set equal to its upper bound, and nominal interest rates are used instead. The use of both the policy rate and the credit subsidy neutralizes the effects of the upper and lower bound constraints on those policy instruments.

To be more specific, let $\{C_t, N_t\}$ and $\left\{\phi_t, \frac{R_t^l}{R_t}, \eta_t, \upsilon_t, \frac{S_t}{P_t}, \frac{Z_t}{P_t}\right\}$ be an equilibrium allocation in which the nominal interest rate is allowed to be negative. Suppose now that whenever $R_t < 1$, the path for the nominal interest rate is modified to $\widetilde{R}_t = 1$. The equilibrium allocation will remain unchanged provided there are appropriate changes in $\tau_t^l, R_t^l, Q_{t,t+1}$ and in the growth rate of nominal variables S_t, Z_t, P_t. More precisely in the equilibrium with nominal interest rate given by $\widetilde{R}_t = 1$ these variables (also denoted with a tilde) will have to be adjusted so as

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to respect the following conditions:

$$R_t^l \left(1 - \tau_t^l\right) = \widetilde{R}_t^l \left(1 - \widetilde{\tau}_t^l\right), \, t \geq 0, \tag{27}$$

so that the wedges between marginal rate of substitution and marginal rate of transformation is unchanged;

$$\frac{R_t^l}{R_t} = \frac{\widetilde{R}_t^l}{\widetilde{R}_t}, \, t \geq 0, \tag{28}$$

so that the lending spreads are unchanged; and

$$\widetilde{Q}_{t,t+1}\widetilde{R}_t = Q_{t,t+1}R_t, \, t \geq 0, \tag{29}$$

and

$$\widetilde{R}_t \frac{\widetilde{P}_t}{\widetilde{P}_{t+1}} = R_t \frac{P_t}{P_{t+1}}, \, t \geq 0,$$

so that the growth rates of the nominal variables are adjusted by the change in the nominal rates.

With an appropriate adjustment in the initial levy l_0, the change from the original path R_t to the modified path $\widetilde{R}_t$ is also revenue neutral for the government. Since Z_0 is predetermined, the initial price level, P_0, and nominal loans, S_0, must be the same in the two cases. However, because R_0 affects the value of the initial wealth in (26), the movement to $\widetilde{R}_0$ can produce effects on the initial wealth. These effects can be neutralized by an adjustment in the initial levy.

This result means that, provided credit subsidies are available, the zero bound on interest rates is not effective, which is the content of the following proposition.

Proposition 2 *When credit subsidies are used, the zero bound on the nominal interest rate is irrelevant for the implementation of allocations.*

Fiscal policies can therefore overcome the nonnegativity constraint on the nominal interest rate. As a result, allocations can be achieved which, in the absence of fiscal policy, would only be feasible if interest rates could be negative. In the next section we explore the possible practical implications of this result when the policy rate is at the zero lower bound as a result of an adverse financial shock. By setting the policy rate to zero, we also guarantee that the upper bound constraint on the credit subsidy is never binding.

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4 Credit subsidies at the zero lower bound

The Great recession following the financial crisis has led many central banks to cut policy rates to near-zero levels. This situation has opened a quest for alternative tools which would provide additional economic stimulus. Our results in section 3 show that, in an economy with financial frictions, the closest alternative tool to the nominal interest rate is a credit tax/subsidy. In this section we provide a numerical illustration of the properties of credit subsidies in reaction to adverse financial shocks in an economy where the interest rate is fixed at zero. We conclude the section with a comparison to the credit easing measures proposed in Gertler and Karadi (2011).

We focus on the case in which lump-sum taxes cannot be levied and government debt is nominal and non-contingent.

We only have five parameters to calibrate. We use standard values for utility parameters: $\beta = 0.99$ and $\varphi = 0$. Concerning the financial sector parameters, we rely on Gertler and Karadi (2011). Specifically we use the same value as in that paper for the fraction of funds that can be diverted from the bank, λ, the bankers survival probability, θ, and the proportional transfer to entering bankers, ω. In the steady state of our model, these parameters imply an annualized spread of 1.1 percent and a leverage ratio of 6. These values are roughly comparable to those in Gertler and Karadi (2011), where the annualized spread and leverage are 100 basis points and 4, respectively.

Government consumption is set to zero in the figures. We assume that the economy starts from the optimal steady state–that is, the steady state in which government debt and the fiscal subsidy are at their optimal level–and then look at impulse responses to i.i.d. shocks. The level of government debt must then be negative. The government holds positive assets in order to finance the optimal subsidy.

The impulse responses are the ones that would be obtained under commitment at an arbitrarily distant date in the future – assuming commitment is at time zero. We first abstract from fiscal policy, so that τ^l is kept constant at its optimal steady state level. The policy interest rate is set at zero, but there is still room for price level policy.[8] Since we assume no nominal rigidities, the price level can move instantaneously in reaction to shocks. Such movements have real effects, since they modify the real value of predetermined nominal variables, namely

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[8]How this price level policy is actually implemented is beyond the scope of this paper.

banks' internal funds and government debt. In the special case of an i.i.d. technological shock, both real government debt and real internal funds could be made state contingent. In order to restrict the possibility of replicating state contingent debt (or money) and because, in practice, central banks are not able to change the price level on impact in response to shocks, we also study the case in which policy is exogenously prevented from changing prices on impact after the shock.

Regardless of whether restrictions exist on price level movements, fiscal policy can improve allocations through credit subsidies and taxes.

All impulse responses are computed after solving the fully nonlinear, deterministic version of the model.

Figure 1 shows responses to a financial shock ξ_t, which causes a 1% exogenous fall in the value of banks' nominal internal funds. The shock is assumed to be serially uncorrelated. All variables are in deviation from the steady state. The nominal interest rate is at the zero bound and credit subsidies are constrained to be constant.

To understand the impulse responses, it is useful to consider first what would happen if lump-sum taxes were available. Ceteris paribus, the shock would lead to a one-to-one reduction in real internal funds $z_t \equiv Z_t/P_t$ and, for given amount of loans, an increase in banks' leverage ϕ_t. Policy could however respond through a cut in the price level equal to the size of the shock. This response would completely stabilize the real value of internal funds, leverage and output. Lump sum taxes would be used to neutralize any consequences on government finances.

When, as in figure 1, lump-sum taxes cannot be levied, a cut in the price level is no longer possible. The price cut would not only restore the initial level of internal funds, but also increase the real value of government assets—or, equivalently, increase the real value of households' liabilities. This is inconsistent with unchanged future net revenues for the government. Instead if the price level increases, that reinforces the effect of the shock on internal funds, increasing spreads and contracting economic activity. Because the subsidy rate is unchanged, and in spite of the increase in the lending rate, the expenditure with the subsidy goes down, which is consistent with the decrease in the real value of government assets that the increase in the price level induces. Because of the increase in leverage and credit spreads, banks' profits also increase and net worth can be slowly rebuilt. Along the adjustment path, lending volumes $(s_t \equiv S_t/P_t)$ and output remain below the steady state.

When only price level policy is used, the impulse responses to a net worth shock are third best. The second best responses, which coincide with the first best responses in this economy, will have allocations not vary with the net worth shock. Figure 2 shows that the first best responses are implemented when we allow for time-varying fiscal subsidies (the impulse responses of figure 1 are also reported for comparison). Following the shock, the price level falls and cushions the reduction in net worth (by almost 50% compared to the case shown in Figure 1). However lending is kept unchanged in real terms. leverage must increase and so do lending rates, but output is insulated from these financial developments through an impact increase in the credit subsidy. The increase in bank profits is such that net worth can be rebuilt in one quarter. After one quarter, prices return to steady state and so does the real value of government debt. The adjustment process is complete.

One way to understand the impulse responses with a time-varying credit subsidy in Figure 2 is to note that in this case price level policy can be used to guarantee that government bonds are state contingent, without other conflicting objectives such as guaranteeing also that real internal funds are adjusted optimally. The role of the credit subsidy is to ensure that real allocations are optimal, irrespective of the real value of banks' internal funds and leverage. Changes in the initial price level can thus be targeted to ensure that real government debt is state-contingent, and therefore ensure the necessary financing of the credit subsidy.

Figure 3 shows how this outcome is altered when government bonds cannot be made state-contingent because of an exogenous restriction that does not allow for the price level to be moved on impact.

In this case, the impulse response of output is close to the first best response, but the economy does not return to the original steady state. To reduce the recessionary consequences of the shock, leverage must increase. An increase in the subsidy τ_t^l neutralizes the effects on the real economy from the increase in lending rates. However, the increase in the credit subsidy is financed through a small, but permanent increase in real government debt. The economy settles on a new steady state, where the higher debt is financed through a slightly lower level of the subsidy. Output also falls permanently to a marginally lower level.

To gauge the potential, quantitative impact on government finances of credit subsidies, we look at the case of a financial shock of the size observed during the financial crisis of 2007-08. In our model, the destruction of 12% of the value of banks' internal funds would cause an increase in spreads by 1.5%, which is roughly the increase in the TED spreads observed in the

last quarter of 2008. We can trace the impact of this shock on all variables if we multiply by 12 the impulse responses in figure 3.[9] The optimal implementation of credit subsidies that we propose would have resulted in a permanent 1.4% increase in real government debt. While non-negligible, this increase is very small compared to that observed in most countries following the Great recession.

We wish to emphasize that the exact features of our quantitative results would be affected by changes in the model specification. The quantitative results could also change if we studied the response to shocks starting from different steady states, notably points where the government does not have enough assets to pay for the steady state level of the subsidy. In this case fiscal policy would have the additional incentive to build assets and move towards the efficient steady state. This numerical analysis should therefore be understood as merely illustrative of the merits of credit subsidies as a policy tool when the nominal interest rate is at the zero bound.

4.1 Credit subsidies vs. credit easing

While credit subsidies may be nonstandard policy instruments, they affect the economy in the same way as the nominal interest rate. Furthermore the combined use of interest rate policy and policy on credit subsidies overcomes the effects of the zero bound on interest rates as well as a similar upper bound constraint on the credit subsidies themselves. Thus, both interest rates and credit subsidies can be used to minimize the macroeconomic impact of the need to ensure the appropriate private incentives for financial intermediaries. However, once lump-sum taxes and state contingent public debt are ruled out credit subsidies have implications for public finances.

Credit easing policies instead act in a very different way from the nominal interest rate. Direct lending by the central banks directly overcomes the need to preserve the incentives of financial intermediaries. The costs of direct lending are also different. Gertler and Karadi (2011) assume a resource cost of direct lending, which can be motivated as a direct enforcement cost. Direct lending can also have budgetary implications.

To be more concrete, we can introduce credit easing in the model. We follow Gertler and Karadi and assume that the government can directly provide intermediation S_t^g to non-financial

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[9]We have also computed the nonlinear impulse responses to a 12% shock to ξ_t, but they are not significantly different from those obtained by scaling up the responses to the 1% shock.

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firms at the lending rate R_t^l. In its intermediation activity the government is not subject to the incentive constraint, but it has an intermediation cost c per unit of real lending. The aggregate deadweight cost is $c\frac{S_t^g}{P_t}$.

Government intermediation can be written as a fraction of total intermediation $S_t^g = \psi_t S_t$.[10] The government flow of funds constraints would have to be modified to include direct lending as

$$B_t^g + E_t Q_{t,t+1} B_{t,t+1}^g + M_t - \psi_t S_t \geq -\mathbb{W}_t^g, \tag{30}$$

and

$$-\mathbb{W}_{t+1}^g = R_t B_t^g + B_{t,t+1}^g + M_t + \tau_t^l R_t^l S_t + \left(c - R_t^l\right)\psi_t S_t + P_t G_t - T_t \tag{31}$$

The resource constraints would be

$$C_t + G_t + c\psi_t \frac{S_t}{P_t} = A_t N_t$$

and the market clearing condition for loans,

$$S_t = S_t^b + \psi_t S_t.$$

In the benchmark case in which lump-sum taxes are available, the first best could be achieved either without government lending, $\psi_t = 0$, or when the resource cost of that lending is zero, $c = 0$. For any arbitrarily small cost of central bank intermediation, credit subsidies would therefore be superior to direct lending policies.

In the second best, without lump-sum taxes, the ranking is no longer obvious. It will depend on the relative size of the resource cost in the case of direct central bank lending, and the deadweight cost in the case of credit subsidies.

5   Concluding remarks

We have analyzed optimal monetary and fiscal policy in a monetary model with flexible prices in which financial intermediaries are subject to an incentive problem. In this economy, the nonnegativity of the policy rate is a binding constraint to monetary policy, specially in response to a severe financial shock. The main message of the paper is that credit subsidies can play the role of the policy interest rate, and therefore they can be used to overcome the zero bound constraint on the policy rate.

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[10] Gertler and Karadi assume that policy is an arbitrary rule for ψ_t as a function of credit spreads.

Credit subsidies can be employed to shield the economy from the adverse consequences of financial shocks on credit spreads. Combined with interest rate policy, credit subsidies can implement the first best if they can be financed in a lump-sum fashion. Without lump-sum taxes, or without state contingent debt, a policy of credit subsidies is not fully effective, which would also be the case with interest rate policy alone. When debt cannot be made state contingent, the financing of the credit subsidy, or the financing of variable interest rates, is costly. There will be permanent effects on taxes, government debt, and output, which will be particularly costly in the event of large shocks.

Credit subsidies are not conventional policy, but they affect the economy in a very similar fashion to interest rate policy, except when the interest rate ought to be negative. Instead, the unconventional credit easing policies, such as the direct central bank lending to firms explored in Gertler and Karadi (2011), act in a very different way. While interest rate policy, or credit subsidies, in this economy, aim at minimizing the costs of ensuring the private incentives to the financial intermediaries, direct lending by the central banks directly overcomes the need for those incentives, presumably at a cost in terms of resources. In a benchmark with lump-sum taxation, credit subsidies would always be preferable to central bank lending. If, instead, there are relevant restrictions to the financing of credit subsidies, then there may still be a role for direct lending by the central bank.

The result that with lump-sum taxes, credit subsidies achieve the first best, as in the absence of financial frictions, is specific to this model of financial intermediation. For example, if banks were not subject to the enforcement problem we assume in this paper, but rather they would be subject to costly state verification, then the monitoring costs would always have to be paid. Credit taxes and subsidies would still be able to achieve the best allocation, but that would be a second best. The allocation without financial frictions would not be implementable.

We have presented our results in terms of the optimal combination of monetary and fiscal policy, but it should be noticed that these policy choices also have implications for bank leverage. Banks' optimizing decisions may lead to inefficiently high or low leverage in reaction to shocks. Fiscal and monetary policy instruments can ensure that leverage ratios are endogenously set optimally in equilibrium. This suggests that an alternative way to think about the nature of policy includes the macro-prudential dimension. For example, policy could mandate specific targets for capital requirements or leverage ratios, conditional on the realization of the shocks. The targets would have implications for the quantity of loans, and hence for

money, in the economy. Together with the policy interest rate and possibly the credit subsidies, macro-prudential policy would thus contribute to implement the price level and real allocations.

Appendix

Derivation of the coefficients in the leverage function   The value of a bank is

$$V_{j,t}\left(S_{j,t}^b, Z_{j,t}\right) = (1-\theta)\, E_t Q_{t,t+1} Z_{j,t+1} + E_t \sum_{s=1}^{\infty} (1-\theta)\, \theta^s Q_{t,t+1+s} Z_{j,t+1+s} =$$

$$= (1-\theta)\, E_t Q_{t,t+1} Z_{j,t+1} + E_t Q_{t,t+1} \theta V_{j,t+1}\left(S_{j,t+1}^b, Z_{j,t+1}\right)$$

The conjecture for $V_{j,t}\left(S_{j,t}^b, Z_{j,t}\right)$ is $V_{j,t}\left(S_{j,t}^b, Z_{j,t}\right) = \upsilon_t S_{j,t}^b + \eta_t Z_{j,t}$. Imposing that the incentive constraint binds gives

$$\upsilon_t S_{j,t}^b + \eta_t Z_{j,t} = \lambda S_{j,t}^b.$$

From

$$V_{j,t}\left(S_{j,t}^b, Z_{j,t}\right) = (1-\theta)\, E_t Q_{t,t+1} Z_{j,t+1} + E_t Q_{t,t+1} \theta V_{j,t+1}\left(S_{j,t+1}^b, Z_{j,t+1}\right),$$

$$Z_{j,t+1} = \xi_{t+1}\left[\left(R_t^l - R_t\right) S_{j,t}^b + R_t Z_{j,t}\right],$$

and

$$S_{j,t}^b = \frac{\eta_t}{\lambda - \upsilon_t} Z_{j,t} \equiv \phi_t Z_{j,t},$$

we have

$$\upsilon_t S_{j,t}^b + \eta_t Z_{j,t} = (1-\theta)\, E_t Q_{t,t+1} \xi_{t+1}\left[\left(R_t^l - R_t\right) S_{j,t}^b + R_t Z_{j,t}\right] +$$

$$E_t Q_{t,t+1} \theta\left[\upsilon_{t+1} \varkappa_{t,t+1} S_{j,t}^b + \eta_{t+1} \zeta_{t,t+1} Z_{j,t}\right]$$

where

$$\zeta_{t,t+1} = \xi_{t+1}\left[\left(R_t^l - R_t\right) \phi_t + R_t\right]$$

and

$$\varkappa_{t,t+1} = \frac{\phi_{t+1}}{\phi_t} \xi_{t+1}\left[\left(R_t^l - R_t\right) \phi_t + R_t\right].$$

It follows that

$$\upsilon_t = E_t\left\{(1-\theta)\, Q_{t,t+1} \xi_{t+1}\left(R_t^l - R_t\right) + Q_{t,t+1} \theta \varkappa_{t,t+1} \upsilon_{t+1}\right\}$$

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and

$$\eta_t = E_t \left\{ (1 - \theta) R_t Q_{t,t+1} \xi_{t+1} + Q_{t,t+1} \theta \zeta_{t,t+1} \eta_{t+1} \right\}$$

or

$$\upsilon_t = \left\{ (1 - \theta) E_t Q_{t,t+1} R_t \xi_{t+1} \frac{\left(R_t^l - R_t \right)}{R_t} + E_t Q_{t,t+1} \theta \frac{\phi_{t+1}}{\phi_t} \xi_{t+1} \left[\left(R_t^l - R_t \right) \phi_t + R_t \right] \upsilon_{t+1} \right\}$$

and

$$\eta_t = E_t \left\{ (1 - \theta) R_t Q_{t,t+1} \xi_{t+1} + Q_{t,t+1} \theta \zeta_{t,t+1} \eta_{t+1} \right\}$$

The steady state   In a steady state with constant gross inflation Π, we have $\frac{P_{t+1}}{P_t} = \frac{W_{t+1}}{W_t} = \frac{S_{t+1}}{S_t} = \frac{Z_{t+1}}{Z_t} = \Pi$. The steady state conditions, with $\psi_t = 0$ are given by

$$\frac{1}{\chi C N^\varphi} = \frac{R^l \left(1 - \tau^l \right)}{A}$$

$$C + G = AN$$

$$R \frac{\beta}{\Pi} = 1$$

$$\frac{A}{R^l \left(1 - \tau^l \right)} N = \phi \frac{Z_t}{P_t}$$

$$\Pi = (\theta + \omega) \left[\left(R^l - R \right) \phi + R \right] \tag{32}$$

where

$$\phi = \frac{\eta}{\lambda - \upsilon}$$

$$\upsilon = (1 - \theta) \frac{\beta}{\Pi} \left(R^l - R \right) + \frac{\beta}{\Pi} \theta \varkappa \upsilon \tag{33}$$

$$\eta = (1 - \theta) + \frac{\beta}{\Pi} \theta \zeta \eta \tag{34}$$

$$\varkappa = \zeta = \left(R^l - R \right) \phi + R \tag{35}$$

Manipulating the conditions (33) with (35) above, we get

$$\eta = \frac{1 - \theta}{1 - \theta \left[\left(\frac{R^l}{R} - 1 \right) \phi + 1 \right]} \tag{36}$$

and

$$\upsilon = \frac{(1 - \theta) \left(\frac{R^l}{R} - 1 \right)}{1 - \theta \left[\left(\frac{R^l}{R} - 1 \right) \phi + 1 \right]}. \tag{37}$$

It follows that

$$\phi = \frac{\eta}{\lambda - \upsilon} = \frac{1 - \theta}{\lambda \left[1 - \theta \left[1 + \left(\frac{R^l}{R} - 1 \right) \phi \right] \right] - (1 - \theta) \left(\frac{R^l}{R} - 1 \right)}$$

implying that

$$1 - \theta - (1 - \theta) \left[\lambda - \left(\frac{R^l}{R} - 1 \right) \right] \phi + \theta \lambda \left(\frac{R^l}{R} - 1 \right) \phi^2 = 0. \tag{38}$$

Notice that equation (32) can be written as

$$\frac{\beta - \omega - \theta}{\theta + \omega} = \left(\frac{R^l}{R} - 1 \right) \phi,$$

where it must be that $\frac{\beta}{\theta + \omega} > 1$, or $\beta > \theta + \omega$. This expression together with equation (38) can be used to obtain an expression for leverage

$$\phi = \frac{\beta (1 - \theta)}{\lambda [\theta (1 - \beta) + \omega]}. \tag{39}$$

The spread is given by

$$\frac{R^l}{R} - 1 = \frac{\lambda (\beta - \theta - \omega) [\theta (1 - \beta) + \omega]}{(\theta + \omega) \beta (1 - \theta)} \tag{40}$$

and is thus independent of inflation.

With lump-sum taxes, if the nominal interest could be negative, the Ramsey planner could implement the first best with monetary policy only, i.e. by setting $\tau^l = 0$. The optimal policy is to set $R^l = 1$. There is always a $R < 1$ that can satisfy the remaining equilibrium conditions, for a given P:

$$R \frac{\beta}{\Pi} = 1$$

$$AN = \phi \frac{Z}{P}$$

$$\Pi = (\theta + \omega) \left[(1 - R) \phi + R \right]$$

where

$$\phi = \frac{\beta (1 - \theta)}{\lambda [\theta (1 - \beta) + \omega]}.$$

The solution requires $R < 1$ because otherwise the bank would not be willing to lend.

As seen above, the same allocation could be achieved when the zero-lower bound on nominal interest rates is imposed, $R \geq 1$, with an appropriate choice of credit subsidy τ^l. In this case, the first-best allocation can be achieved through a combination of $R^l > 1$, $R = 1$ and τ^l such that $R^l (1 - \tau^l) = 1$. The optimal subsidy can be obtained using equation (40) and is given by

$$\frac{\tau^l}{1 - \tau^l} = \frac{\lambda (\beta - \theta - \omega) [\theta (1 - \beta) + \omega]}{(\theta + \omega) \beta (1 - \theta)} > 0.$$

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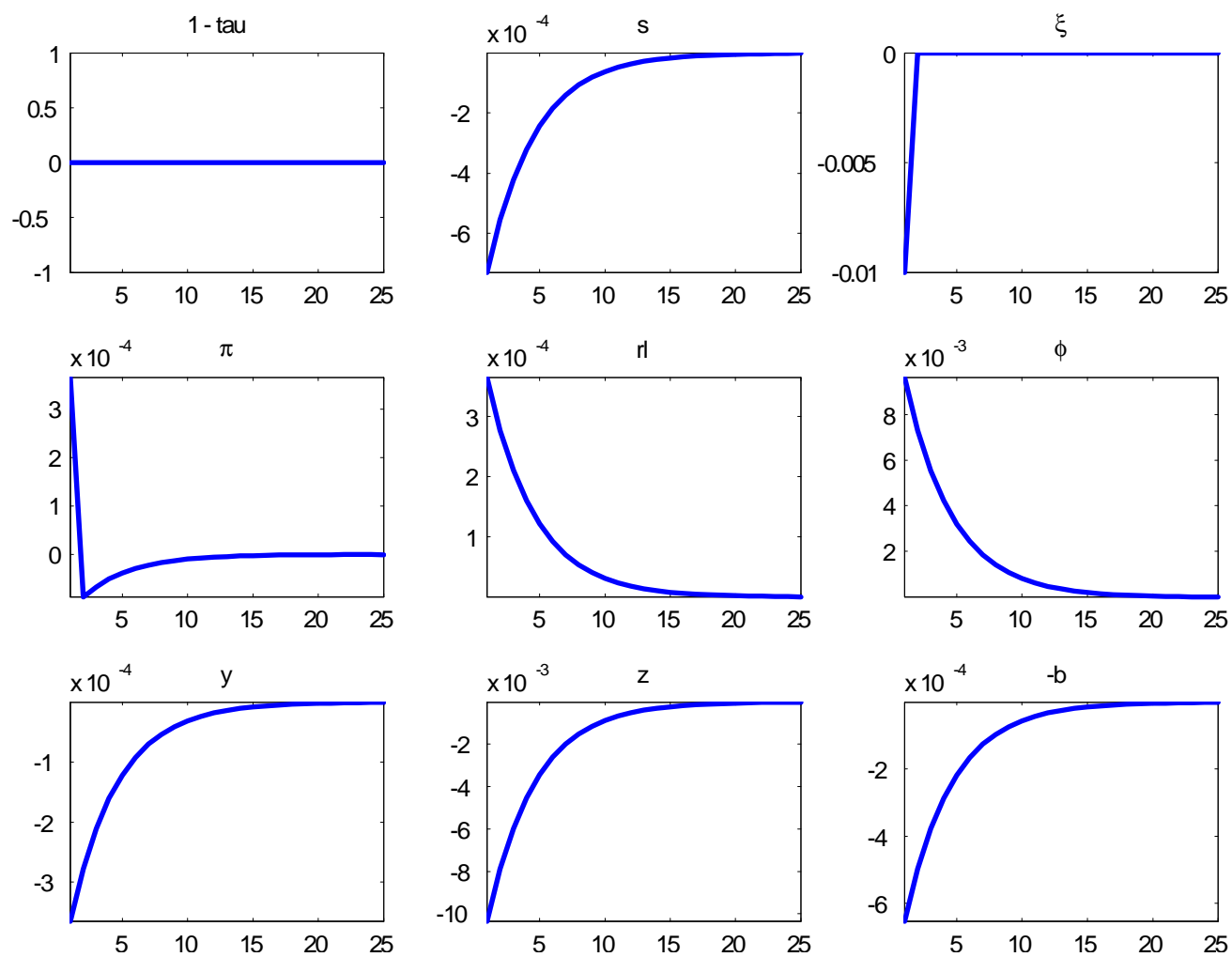
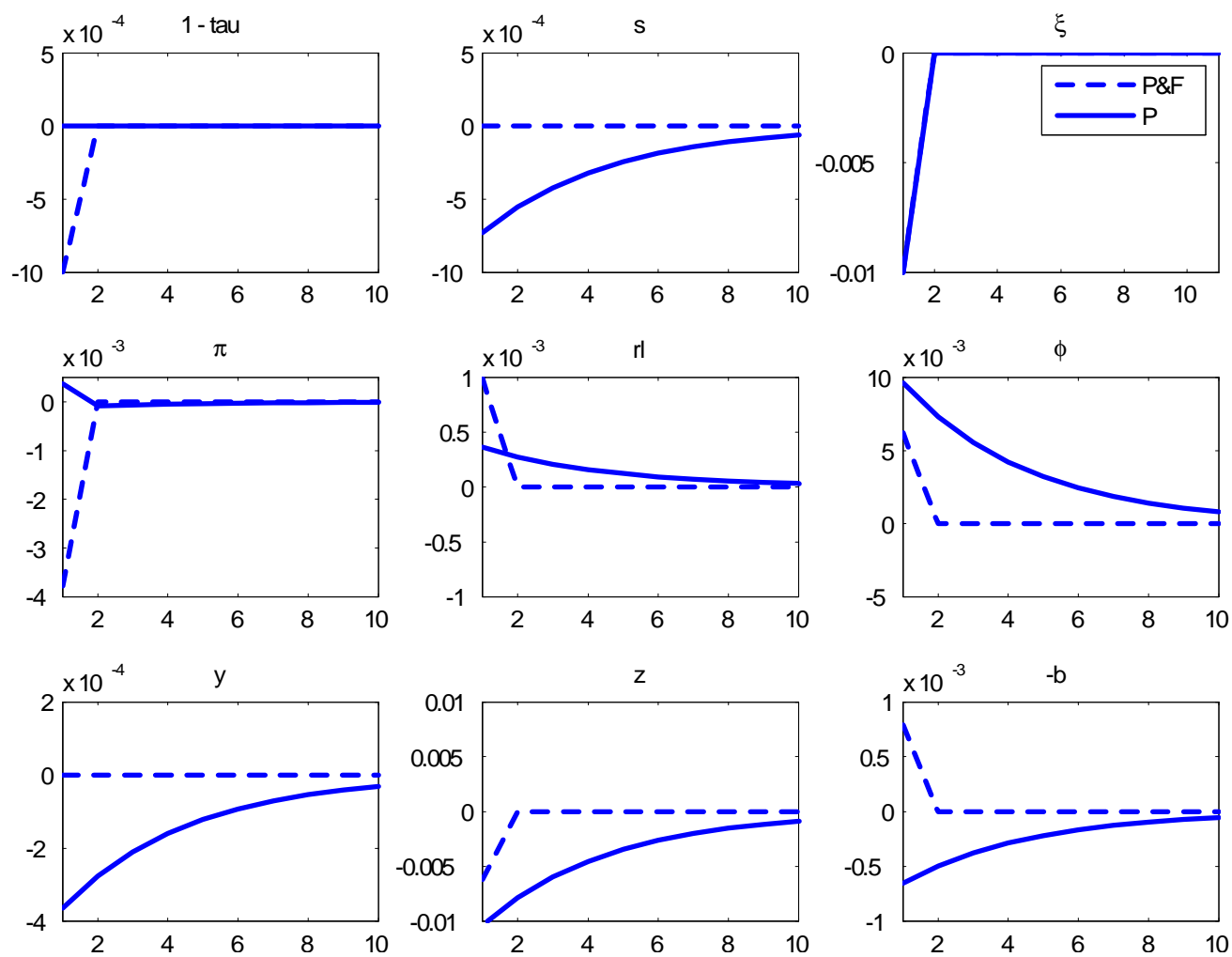Figure 1: Impulse responses to a net worth shock: optimal price level policy

Figure 2: Impulse responses to a net worth shock: optimal price level (P) vs. price level and
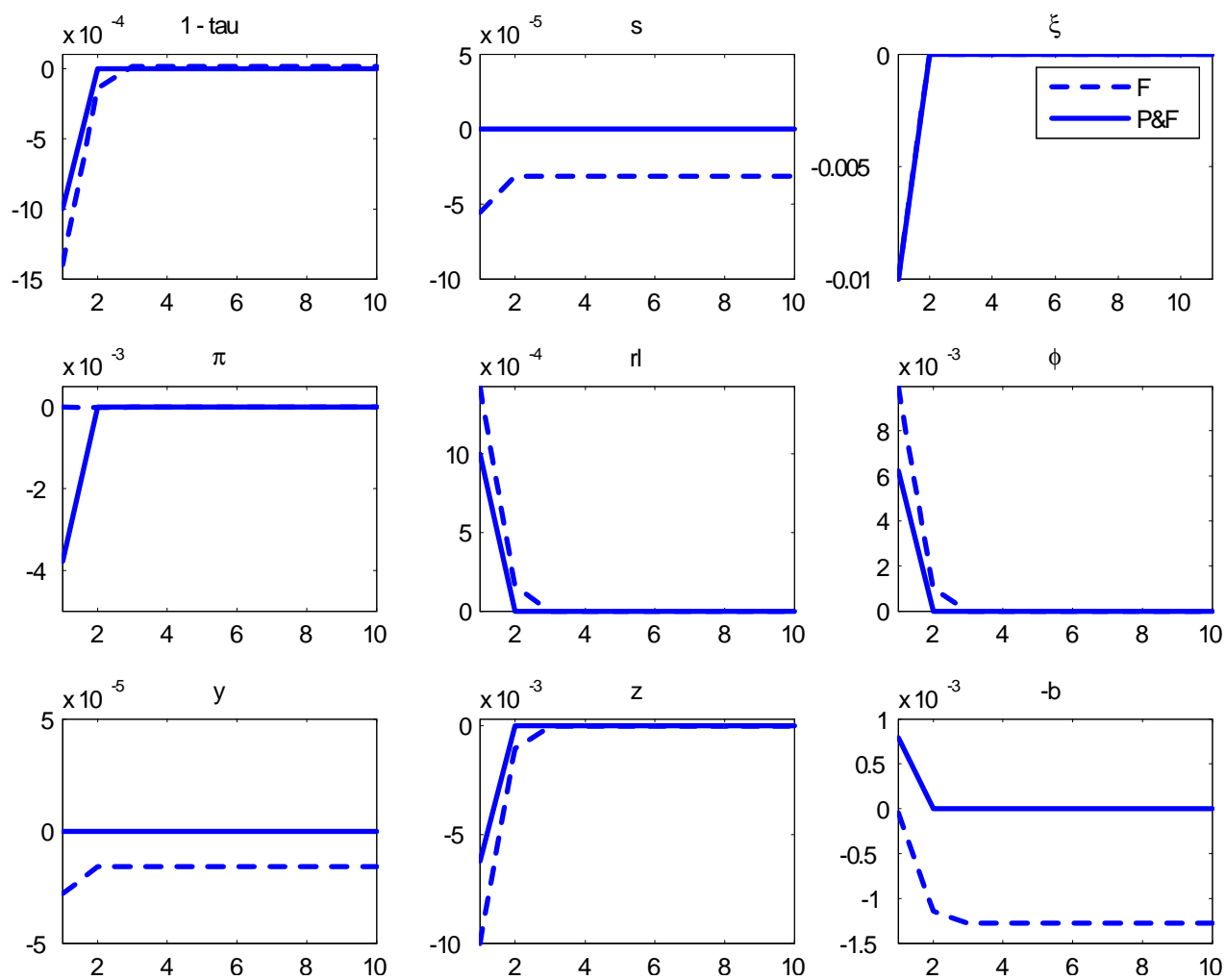
fiscal (P&F) policy

Figure 3: impulse responses to a net worth shock: optimal price level and fiscal (P&F) vs. fiscal policy (F).