

Macroeconomics at the Zero Lower Bound: Quasi-Fiscal Monetary Policy vs. Quasi-Monetary Fiscal Policy

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Abstract

This paper assesses adjustment at the zero lower bound (ZLB) in an economy incorporating financial frictions and nominal price stickiness. We examine adjustment under recurring productivity and recurring financial-sector shocks under three alternative policies: removal of the zero lower bound (by allowing negative rates), quantitative easing policies at the ZLB (quasi-fiscal monetary policy), and the use of endogenous tax rates on consumption and labor income at the ZLB (quasi-monetary fiscal policy). Under a balanced budget rule, the quasi-monetary fiscal regime will force large swings in government spending, under both types of shocks, but is much more effective, relative to the quasi-fiscal monetary regime, at stabilizing consumption and investment during prolonged crisis periods. Our results show that QE policies closely mimic the paths that would be generated if nominal interest rates were not constrained by the zero lower bound.

Key words: zero lower bound, quantitative easing, fiscal policy

JEL Codes: E52, E62

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1 Introduction

Crisis periods, when the traditional Taylor rule is not operative, have prompted research into alternative stabilization policies. Two approaches have emerged in the literature. The focus of the first approach is on non-traditional monetary policies such as forward guidance and quantitative easing (QE). With respect to QE, the first wave, QE1, had involved the purchase of private non-performing debt from the financial sector by the central bank. The second form, as in the later QE policies in the United States, the Euro Zone and Japan, involved the purchase of long-term government bonds held by private banks and non-bank financial institutions. Such policies are essentially massive open market operations in long-term government debt. S.Damico et al. (2012) for example, estimate that the second QE or LSAP (large scale asset purchase) of the Federal Reserve, in the amount of \$600 billion, reduced long-term Treasury yields by 45 basis points.

The focus of the second approach is to consider the use of fiscal policy as a substitute for monetary policy. Correia et al. (2013) have examined the use of rules for tax-rates as substitutes for interest-rate rules when the zero lower bound is binding. They show how the use of rules for the tax rate on consumption can affect Euler equations in the same way as the interest rate when a Taylor rule is operative. A similar case can be made for a tax rate rule for the labor income tax rate in the Euler equation for the household labour-supply equation. They argue that the use of these rules can achieve the same welfare results as monetary instruments when the economy is operating at the lower bound and whether or not prices are sticky or flexible.

The closest implementation of a tax-rate based substitute for monetary policy when the interest rate is at the lower bound came during the “cash for clunkers” program in 2009. Mian and Sufi (2010) find little evidence that this program had any significant effects as a stimulus for spending or for reversing the collapse on housing prices. They point out that the policy was short-lived, and its net effect was to pull forward purchases which would have taken place in the near future. This empirical result does not mean, of course, that a better-designed quasi-monetary fiscal policy might have had more lasting effects.

In this context, as Sims (2010) has pointed out, large scale asset purchases by the central bank are quasi-fiscal policies, so that the distinction between monetary and fiscal policies in such times of prolonged crisis is not a hard and fast one. Since tax-rate rules play the same role as the interest rate in Euler equations, this policy rule becomes, in fact, a quasi-monetary fiscal policy. We are in the macroeconomic twilight zone, To paraphrase the late Rod Serling, during the last decade, macro economists have traveled to another dimension, a land of both shadows and substance, of reality and ideas.

From a modeling perspective, Gertler and Karadi (2011), have examined quantitative easing policies in models with financial frictions. These papers generally find that such policies are effective only in times of crisis.¹ None of

¹Pesaran and Smith (2014) point out that specification is a major drawback to the analysis

these papers have considered a role for fiscal policy as an alternative to QE during crisis periods. This paper compares quasi-fiscal monetary policy with quasi-monetary fiscal policy.

The analysis is based on the Gertler and Karadi (2011) model in two regimes, one in which the zero lower bound does not bind, and the second crisis regime, in which the zero lower bound is binding. Our modeling contribution is the extension of the Gertler-Karadi (GK) model, to allow the adoption of fiscal options when the economy is at the zero lower bound, following Correia et al. (2013). The model is solved using the regime-switching approach developed by Guerrieri and Iacoviello (2014). As a robustness check, we also solve the model as a full nonlinear system with the extended-path algorithm originally due to Fair and Taylor (1983). This work represents a DSGE meeting and match up of Gertler-Karadi vs. Correia, Fahri, Nicolini, and Teles.

We also adopt the Mendoza (2010) approach to analyse crisis events. The model is simulated for recurring shocks and simulated for $T=100,000$ periods. We then isolate sub-periods when the GDP is two standard deviations below its stochastic mean. This then allows us to examine the adjustment of key macroeconomic variables for five years before and five years after the crisis event. In the non-crisis regime, an optimal Taylor rule is operational for the interest rate. In the crisis regime, we first examine the case of the zero lower bound with no fiscal or monetary alternatives. Then we compare and contrast results for two alternative cases: (i) optimal quantitative easing rule (ii) optimal rules for the tax rates on consumption and wages. Like impulse response paths, the method shows the paths for the different scenarios, but the approach has the added advantage that we can also ascertain the frequency/likelihood of crisis compared to normal times.

The next section describes the model specification as well as its calibration. This section also describes the optimal rules for the tax rates for consumption and labor income and for quantitative easing. The third section contains an analysis of the simulation results for recurring productivity and financial-sector shocks. The last section concludes.

2 The Model

The model is fully described in Gertler and Karadi (2011) It is a closed economy model with households, bankers and firms. There is also a government who is responsible for monetary and fiscal policies with different behaviors under normal and crisis periods. We have modified the GK model to allow for taxes on wage income and on consumption. The model is described briefly next and the aggregate equations are reproduced here.

of these policies. These authors suggest that a simple reduced-form approach may be a better way to assess the implication of QE policies.

2.1 Households

The household sector consumes C_t , which is subjected to a consumption tax $(1+\tau^c)$, provides labour services L_t at wage $(1-\tau_t^w)W_t$ and lends B_t^h to financial intermediaries which earns a gross rate of R_t . The tax rates on consumption and wages are τ_t^c, τ_t^w respectively and these are set to zero in normal times. The household maximizes the intertemporal welfare function (1) with utility function defined in (2) subject to the budget equation (3).

$$\max E_t \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \quad (1)$$

$$U(C_t, L_t) = \ln(C_t - hC_{t-1}) - \chi \frac{L_t^{1+\varphi}}{1+\varphi} \quad (2)$$

$$(1 + \tau_t^c)C_t = (1 - \tau_t^w)W_t L_t + \Pi_t + R_{t-1}B_t^h - B_{t+1}^h \quad (3)$$

where β ($0 < \beta < 1$) is a discount factor, h ($h > 0$) is a habit persistence coefficient, χ ($\chi > 0$) is the disutility of labor, and φ ($\varphi > 0$) is the Frisch labor-supply elasticity. Π_t is net profits from ownership of financial and non-financial firms. The Euler equations are below where ϱ_t is the marginal utility of consumption.

$$\varrho_t(1 + \tau_t^c) = (C_t - hC_{t-1})^{-1} - \beta h E_t (C_{t+1} - hC_t)^{-1} \quad (4)$$

$$\chi L_t^\varphi = \varrho_t(1 - \tau_t^w)W_t \quad (5)$$

$$1 = \beta E_t R_{t+1} \frac{\varrho_{t+1}}{\varrho_t} = \beta E_t R_{t+1} \Lambda_{t,t+1} \quad (6)$$

2.2 Firms

The production sector contains 3 types of firms. The firms producing intermediate goods combines labour L_t and effective capital K_t (that is capital which is subjected to both a utilization rate U_t and a quality factor ξ_t) to produce intermediate output Y_t . The utilization rate is like a depreciation rate that varies over time. The production function is described in (7) where A_t is a productivity term and α is a share parameter.

$$Y_t = A_t (U_t \xi_t K_t)^\alpha L_t^{1-\alpha} \quad (7)$$

$$K_{t+1} = (1 - U_t) \xi_t K_t + I_t = \xi_t K_t + I_t^n \quad (8)$$

$$I_t = I_t^n + U_t \xi_t K_t \quad (9)$$

The law of motion of capital (8) is made up of existing effective capital and new capital I_t^n which, in turn is equal to gross investment I_t less the replacement of utilized capital (equation (9)). These firms borrow S_t at price Q_t to pay for capital (10), incurring a gross cost R_{t+1}^k to be paid the following period.

$$Q_t S_t = Q_t S_t^b + Q_t S_t^g = Q_t K_{t+1} \quad (10)$$

In normal times, governments do not purchase these assets, $S_t^g = 0$, so all lending is undertaken by the banks, S_t^b . Maximizing profits with respect to labour, utilization and capital, yields the equations below:

$$W_t = P_t^m (1 - \alpha) \frac{Y_t}{L_t} \quad (11)$$

$$U_t \xi_t K_t = P_t^m (\alpha) \frac{Y_t}{U_t} \quad (12)$$

$$R_{t+1}^k Q_t = P_{t+1}^m (\alpha) \frac{Y_{t+1}}{K_{t+1}} + \xi_{t+1} (Q_{t+1} - U_{t+1}) \quad (13)$$

The intermediate goods are sold to capital-producing and retail firms. An adjustment cost Θ_t is incurred in the production process so maximizing profits with respect to investment yields equation (14) below.

$$\Theta_t = \left(\frac{(I_\tau + I^s)}{(I_{\tau-1} + I^s)} - 1 \right)^2 (I_\tau + I^s) \quad (14)$$

$$Q_t = 1 + \left(\frac{(I_\tau + I^s)}{(I_{\tau-1} + I^s)} - 1 \right) (I_\tau + I^s) + \frac{1}{2} \left(\frac{(I_\tau + I^s)}{(I_{\tau-1} + I^s)} - 1 \right)^2 \quad (15)$$

$$- E_t \beta \Lambda_{t,t+1} \frac{1}{2} \left(\frac{(I_{\tau+1} + I^s)}{(I_\tau + I^s)} - 1 \right) \frac{(I_{\tau+1} + I^s)^2}{(I_\tau + I^s)^2} \quad (16)$$

The retail firms package the intermediate products into final retail goods. The resource constraint is (17), which shows output being used for consumption C_t , investment I_t , government expenditure G_t , plus expended in building capital and government intermediation with parameter τ (only in effect during crisis when the government engages in quantitative easing).

$$Y_t = C_t + I_t + G_t + \Theta + \tau \psi_t Q_t K_{t+1} \quad (17)$$

The marginal cost is P_t^m and the final price is determined according to the Calvo (1983) staggered price system. The retailer choose the optimal price P_t^* by maximizing the expected discounted profits subject to the demand for its product $(P_t^i/P_t)^{-\varepsilon} Y_t$:

$$Max E_t \sum_{\iota=0}^{\infty} \gamma^\tau \beta^\tau \Lambda_{t,t+\tau} \left(\frac{P_t^*}{P_{t+\tau}} \prod_{k=1}^{\tau} (1 + \pi_{t+k-1})^{\gamma_p} - P_{t+\tau}^m \right) \left(\frac{P_t^*}{P_{t+\iota}} \right)^{-\varepsilon} Y_{t+\iota} \quad (18)$$

where ε is the elasticity of substitution and where the probability that a firm will adjust its price is $(1 - \gamma)$. Solving for P_t^* yields the equation (19) and the evolution of the aggregate price level is given in equation (20). The firms that do not optimize are assumed to follow an indexation rule governed by the

parameter γ_p .

$$\sum_{\iota=0}^{\infty} \gamma^\tau \beta^\tau \Lambda_{t,t+\tau} \left(\frac{P_t^*}{P_{t+\tau}} \prod_{k=1}^{\tau} (1 + \pi_{t+k-1})^{\gamma_p} - \frac{\varepsilon}{\varepsilon - 1} P_{t+\tau}^m \right) \left(\frac{P_t^*}{P_{t+\iota}} \right)^{-\varepsilon} Y_{t+\iota} \quad (19)$$

$$P_t = \left[(1 - \gamma) (P_t^*)^{1-\varepsilon} + \gamma \Pi_{t-1}^{\gamma_p} (P_{t-1})^{1-\varepsilon} \right]^{1/(1-\varepsilon)} \quad (20)$$

2.3 Financial intermediaries

The financial intermediaries borrow from households B_{t+1}^h and pay a gross rate R_{t+1} . They also lend a total of $Q_t S_t^b$ which yields a gross return of R_{t+1}^k . Their balance sheet position is in (21) where N_t is current net worth and the law of motion for bank's equity capital is shown in (22).

$$N_t = Q_t S_t^b - B_t \quad (21)$$

$$N_{t+1} = R_t^k Q_t S_t^b - R_t B_t = (R_t^k - R_t) Q_t S_t^b + R_t N_t \quad (22)$$

The banks objective is to maximize expected terminal wealth V_t , where θ is the probability of staying as a banker. The aggregate form is shown in (23).

$$\max V_t = E_t \sum_{\iota=0}^{\infty} (1 - \theta) \theta^\iota \beta^{\iota+1} \Lambda_{t,t+\iota+1} ((R_t^k - R_t) Q_t S_t^b + R_t N_t)$$

$$V_t = v_t Q_t S_t^b + \eta_t N_t \quad (23)$$

$$v_t = E_t \left[(1 - \theta) \beta \Lambda_{t,t+1} (R_t^k - R_t) + \beta \Lambda_{t,t+1} \theta \left(\frac{Q_{t+1} S_{t+1}^b}{Q_t S_t^b} \right) v_{t+1} \right]$$

$$\eta_t = E_t \left[(1 - \theta) + \beta \Lambda_{t,t+1} \theta \left(\frac{N_{t+1}}{N_t} \right) \eta_{t+1} \right]$$

The terminal wealth variable is important because households will only lend if the terminal value exceeds a fraction λ of total lending: $V \geq \lambda Q S^b$. Substituting the condition when the constraint holds into (23) gives the expression for the net worth of surviving banks N_t^e as (24). Banks are assumed to survive with probability θ and households are also willing to lend $\omega/(1-\theta) Q_t S_{t-1}^b$ to start new banks. The net worth of new banks N_t^n is (25). The expression for aggregate net worth is in (27) below.

$$N_t^e = [(R_t^k - R_t) \phi_{t-1} + R_t] N_{t-1} \quad (24)$$

$$N_t^n = \frac{\omega}{(1 - \theta)} Q_t S_{t-1}^b \quad (25)$$

$$N_t = \theta N_t^e + (1 - \theta) N_t^n \quad (26)$$

$$N_t = \theta [(R_t^k - R_t) \phi_{t-1} + R_t] N_{t-1} + \omega Q_t S_{t-1}^b \quad (27)$$

2.4 Resource Constraints and Optimal Policies

In normal times, the monetary authorities adopt a Taylor rule (28) where π_t is the inflation rate and g_t is the deviation of output from potential output. The zero lower bound (ZLB) is enforced to prevent the interest rates from going negative. Interest rates are also assumed to follow the Fisher rule (30).

$$\text{normal} : i_t = (1 - \rho) [i + \kappa^\pi \pi_t + \kappa^y \log(Y_t/Y_t^*)] + \rho i_{t-1} \quad (28)$$

$$\text{ZLB} : i_t = 0; \rho = 0 \quad (29)$$

$$1 + i_t = R_{t+1} \frac{E_t P_{t+1}}{P_t} \quad (30)$$

The budget is balanced during normal times ($\tau_t^w = \tau_t^c = S_t^g = 0$), equation (31) and $B_t^g = 0$. During crisis periods, under QE, the government buys private sector debt $\psi_t Q_t K_t$ where ψ_t is a function of the risk premium (36). The alternative is to change tax rates. In all cases we assume that G adjusts to ensure a balanced budget.

$$B_t^g = R_{t-1} B_{t-1}^g + G_t - \tau_t^w W_t L_t - \tau_t^c P_t C_t - R_{t-1}^k Q_{t-1} S_{t-1}^g + Q_t S_t^g \quad (31)$$

$$\text{normal} : G_t = 0 \quad (32)$$

$$\text{QE} : G_t = R_{t-1}^k Q_{t-1} S_{t-1}^g - Q_t S_t^g \quad (33)$$

$$\text{tax regime} : G_t = \tau_t^w W_t L_t + \tau_t^c P_t C_t \quad (34)$$

$$Q_t S_t^g = \psi_t Q_t K_t \quad (35)$$

$$\psi_t = \psi + \nu E_t \left[(R_t^k - R_t) - (\overline{R^k} - \overline{R}) \right] \quad (36)$$

We use the same parameters for the Taylor rule and the QE rule as in Gertler and Karadi (2011). During crisis, the tax rate rules, are similar to the rule for ψ_t

$$\tau_t^c = \nu^c E_t \left[(R_t^k - R_t) - (\overline{R^k} - \overline{R}) \right]$$

$$\tau_t^w = \nu^w E_t \left[(R_t^k - R_t) - (\overline{R^k} - \overline{R}) \right]$$

Following GK, we do not assume a smoothing parameter for the tax rates. In other words, we assume that in a time of crisis, the central bank can move quickly, and abandon smoothing behavior.

We estimate the optimal coefficients for these rules based on optimization of welfare, subject to a penalty on the change in these tax rates. The optimal tax rate coefficients, given the calibration of GK, have the following values: $\nu^c = 16.075$, $\nu^w = 20.946$. GK use a coefficient of $\nu = 10.0$ for the quantitative easing reaction to the spread.

2.5 Calibrated Parameters

We follow GK, Table 1, for the calibration of the model. The only difference is that the steady state of G is fixed and financed by a lump-sum tax, for the base simulation and for the case of the non-binding zero lower bound. Government spending will increase or decrease endogenously, if there are changes in the tax rates above or below their steady state values of zero in the base of the quasi-monetary fiscal policy. In the case of the optimal quantitative easing policy, we assume that the central bank transfers its revenue to the fiscal authority, which in turn uses this revenue to finance government spending additional government spending relative to the steady-state value.

3 Simulation Results

Four simulations are considered: (1) a base scenario, with the zero lower bound occasionally binding, denoted ZLB; (2) a flexible interest rate scenario, with no zero lower bound, denoted NZLB; (3) a scenario with the zero lower bound occasionally binding coupled with quantitative easing, denoted as QE; (4) the zero lower bound occasionally binding with the optimal tax rate rules in place, denoted as FR for Fiscal Regime. The simulations were also conducted for 2 types of shocks - a negative real shock to production and a negative financial shock to bank's net worth.

Results are presented in both pictorial and tabular form. The figures show the dynamic adjustments. Following Mendoza (2010) we use a crisis-event analysis rather than impulse responses since we are interested in the dynamic behaviour pre-, during and post- crisis where the crisis events have been generated by a sequence of adverse shocks. We identify the episodes when GDP falls two standard-deviations below its stochastic mean, and trace the adjustment of each variable for five periods before and five periods after this low point. We normalize each variable at an index of 1 for the period $t^* - 4$ (where t^* is the time of the crisis).

The tables present the mean, standard,deviations, and the min-max values of key variables, including welfare from the 4 scenarios. The variables are GDP (Y), consumption (C), investment (I), the wage rate (W), share price Q , gross inflation, Π ,the spread between return on capital and risk-free deposits, $(R_t^k - R_t)$, banking sector net worth, N , the quantitative easing parameter, ψ_t ,welfare, and the percentage of crisis episodes in the total simulation.

3.1 Productivity Shocks

In this set of simulation experiments, we are concerned with real shocks; in particular negative shocks in the productivity parameter A_t , when it follows the auto-regressive stochastic process:

In this set of simulation experiments, the logarithm of the productivity pa-

parameter, has the following stochastic process:

$$\ln(A_t) = \rho_A \ln(A_{t=1}) + \epsilon_t$$

$$\epsilon_t \sim N(0, \sigma_A^2)$$

Following GK, we set $\rho_A = .95$, $\sigma_A = .01$. This is the only stochastic shock process driving the model in this experiment.

3.1.1 Stochastic Properties: Productivity Shocks

In Table 1 we present the mean and standard deviations (as a proportion of the standard deviation of GDP) of key variables in the model, GDP (Y), consumption (C), investment (I), the wage level (W), Q , Gross inflation (Π), the spread between the return on assets and the risk free rate, $(R_t^k - R_t)$, banking sector net worth, (N), government spending (G), the tax rates, τ^c, τ^w , Welfare, and the percentage of crisis events taking place.

Table 1

Stochastic Mean and Srd dev (%Y): Simulated Data for Productivity Shock								
Variable	ZLB		NZLB		QE		FR	
	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev
Y	0.692	1	0.694	1	0.708	1	0.668	1
C	0.434	0.762	0.436	0.764	0.434	0.736	0.447	0.148
I	0.080	0.453	0.080	0.444	0.082	0.371	0.078	0.088
W	1.379	2.731	1.385	2.722	1.386	2.724	1.385	2.373
Q	1.000	0.474	1.000	0.458	1.000	0.312	0.999	0.526
Π	1.000	0.131	1.000	0.131	1.000	0.120	0.999	0.222
$(R_t^k - R_t)$	0.023	0.102	0.023	0.093	0.023	0.228	0.020	0.674
N	3.734	1.651	3.741	1.790	2.956	1.613	3.688	3.896
ψ	-	-	-	-	0.226	0.339	-	-
G	0.178	-	0.178	-	0.193	0.057	0.144	1.066
τ^c	-	-	-	-	-	-	-0.011	1.217
τ^w	-	-	-	-	-	-	-0.014	1.575
<i>Welfare</i>	-318.264	45.243	-318.166	45.908	-320.422	45.406	-313.752	4.562
<i>% Crisis</i>	0.066		0.048		0.040		0.050	

For the four simulated data sets, over good times and bad, we see that the welfare is reduced when the ZLB is binding relative to when the constraint is not binding. Table 1 also shows that the QE regime, while having a lower welfare than the ZLB regime with no other policy in place, actually reduces the number of crisis events. This result shows that the introduction of the QE regime, once the interest rate is at the zero lower bound, at times prevents a downturn from turning into a crisis. Table 1 also shows that the use of an activist tax-rate policy increases welfare relative to the other regimes.

For the volatility measure, as seen in Table 1, the fiscal regime greatly reduces the volatility of consumption and investment relative to the other regimes.

However, the FR regime drastically increases the volatility of G relative to the QE regime, as well as the volatility of the spread.

To analyze further the differences in volatility across regimes, Table 2 shows the minimum and maximum values of the key variables across regimes.

Variable	ZLB		NZLB		QE		FR	
	Min	Max	Min	Max	Min	Max	Min	Max
Y	0.612	0.768	0.613	0.776	0.626	0.781	0.577	0.780
C	0.382	0.487	0.368	0.489	0.367	0.482	0.438	0.465
I	0.052	0.129	0.047	0.129	0.053	0.120	0.070	0.087
W/P_m	1.187	1.604	1.145	1.623	1.145	1.609	1.145	1.610
Q	0.962	1.038	0.957	1.040	0.971	1.027	0.925	1.026
Π	0.990	1.010	0.991	1.012	0.984	1.012	0.973	1.025
$\ln(R_t^k - \log R_t)$	0.012	0.030	0.014	0.031	-0.006	0.042	-0.064	0.089
N	3.591	3.886	3.593	3.968	2.856	3.170	3.357	4.144
ψ	-	-	-	-	0.193	0.251	-	-
G	0.178	0.178	0.178	0.178	0.188	0.197	0.034	0.261
τ^c	-	-	-	-	-	-	-0.153	0.104
τ^w	-	-	-	-	-	-	-0.199	0.135
<i>Welfare</i>	-321.886	-314.670	-322.477	-314.545	-324.659	-316.919	-314.251	-313.218

Table 2 shows that while the FR regime greatly stabilizes welfare, the tax rates vary quite a bit, as does government spending. While G never becomes negative, the tax rates often become negative, or subsidies. The strong fiscal results should not be surprising, since the volatilities of the tax-rate coefficients are much larger than the corresponding volatility of the QE coefficient ψ .

3.1.2 Crisis Event Dynamics: Productivity Shocks

Figure 1 pictures the adjustment of GDP, consumption, the wage level and Q , for a crisis event, with recurring productivity shocks. As noted, the solid curves are for the base ZLB regime, the broken curves are for the flexible interest rate regime with no zero lower bound (NZLB), the broken and dotted curves are for the QE regime, while the dotted curve represents the fiscal regime (FR) with the endogenous tax rates.

For these variables, we see that the fall in the four variables is greatest in the ZLB regime. We also see that the NZLB and the QE regimes deliver similar results in mitigating the fall consumption, the real wage and Q . Finally Figure 3 shows that the FR regime is the most effective in dampening the

Figure 2 pictures the adjustment of the net worth and the spreads, as well as the proportionate change in the QE process (denoted by Large Scale Asset Purchases or LSAP). This figure shows that the fall in the spread and the net worth are greatest in the ZLB regime, while the NZLB and QE regimes deliver similar patterns. The lower left quadrant in Figure 2 shows that in the QE

Figure 1: Adjustment to Productivity Shocks: Real Sector

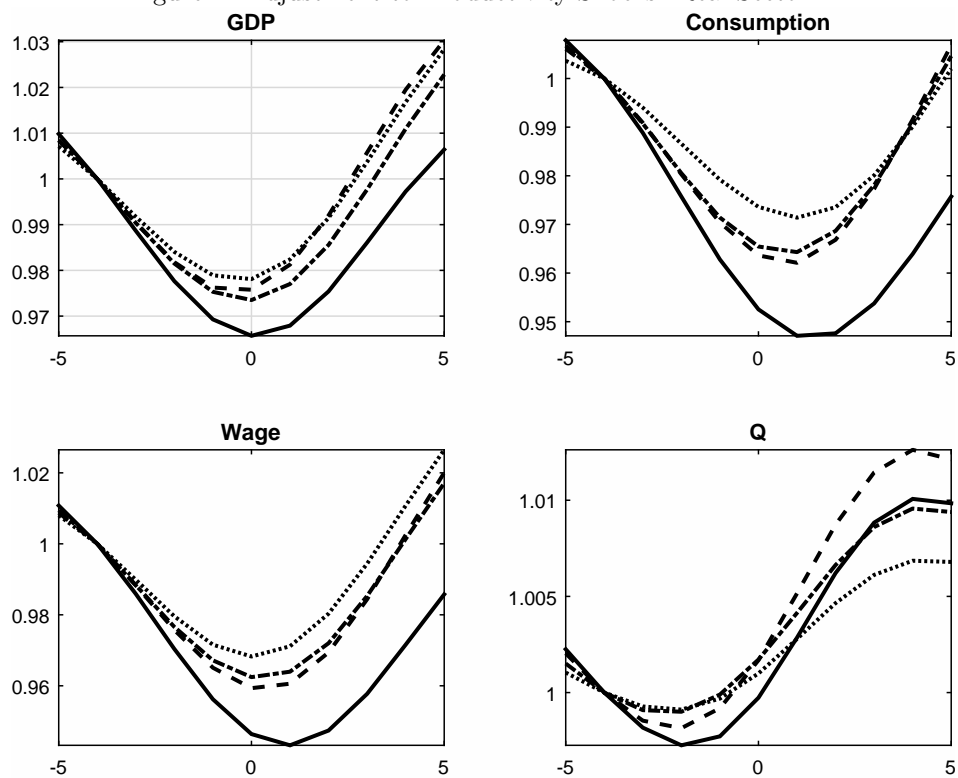
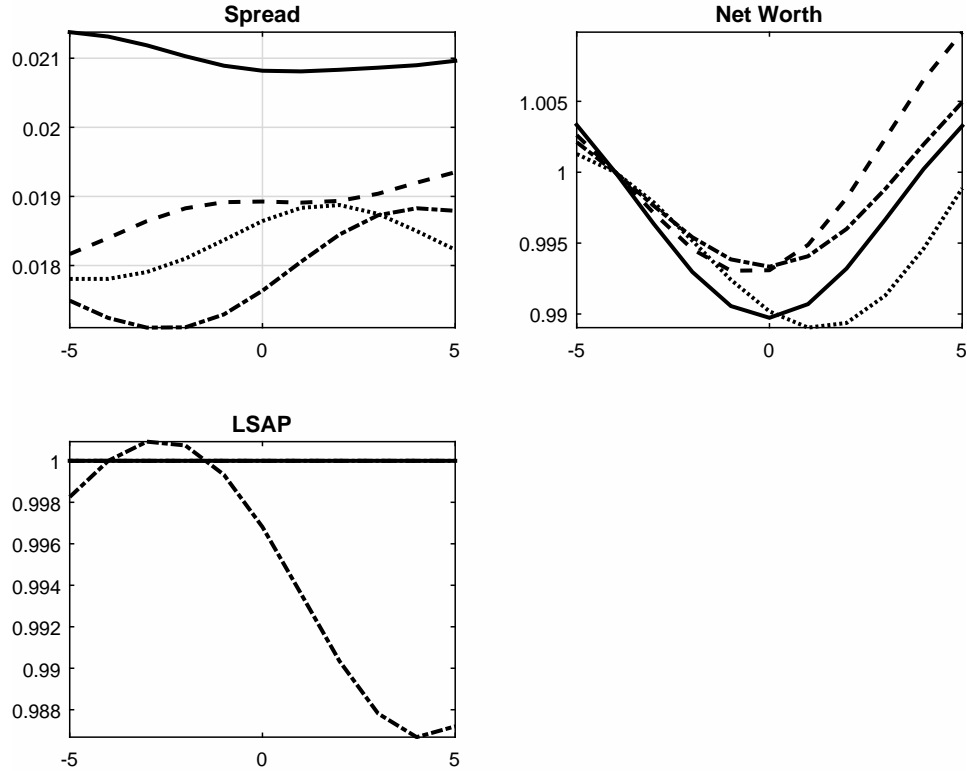


Figure 2: Adjustment to Productivity Shocks: Financial Sector



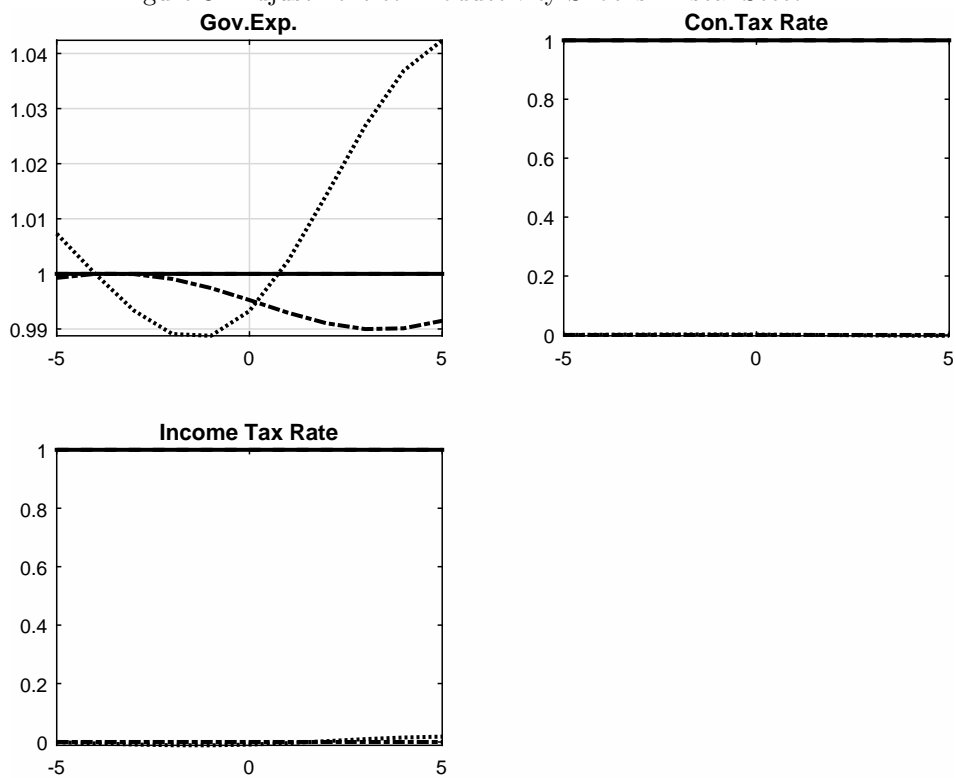
regime, the increase in large scale asset purchases is only slight at the start of the crisis.

Figure 3 pictures the fiscal sector adjustment during the crisis episode. Government spending does not change in the ZLB and NZLB regimes. For the QE regime there is a small fall in government spending. In the FR regime, by contrast, there is a large increase and then decrease in the consumption and income tax rates, with an initial fall and then increase in government spending.

This figure shows considerable adjustment in the fiscal sector under endogenous tax rates. However, this figure also indicates that at the time of the bottoming out of the crisis even, both the tax rates decrease, and the government spending levels increase at the same time. This figure shows that at the trough of the crisis there is considerable fiscal stimulus, both from the falling tax rates and increased spending by the government.

The power of the FR regime relative to the QE regime comes from the expectations of the tax rate cuts at the bottoming out of the crisis. Clearly the FR regime delivers a greater stabilizing punch in times of deep crisis.

Figure 3: Adjustment to Productivity Shocks: Fiscal Sector



3.2 Financial Shocks

In this section, we conduct the same experiments for recurring shocks to the financial sector net worth accumulation:

$$N_t^e = [(R_t^k - R_t)\phi_{t-1} + R_t] N_{t-1}[\exp(\epsilon_t^N)]$$
$$\epsilon_t^N \sim N(0, \sigma_N^2)$$

Following GK, we calibrate $\sigma_N = .01$. This is the only shock driving the dynamics of the model

3.2.1 Stochastic Properties: Financial Shocks

As in the previous section, Tables 3 and 4 present the stochastic means, the stochastic standard deviations (relative to the standard deviation of GDP) and the min-max values of the key variables of the model. The results show that welfare is highest for the FR regime. The QE regime does not reduce the frequency of the crisis episodes, as it does under recurring productivity shocks. The volatility measures show that the tax regime reduces volatility of consumption and investment, while increasing the volatility G relative to the QE régime.

Examining Table 4 we also see that the QE parameter does not vary as much as it does under the recurring productivity shocks, while the tax rates show the same magnitude of negative and positive values.

Table 3

Stochastic Mean & St.Dev (%Y): Simulated Data for Financial Shocks								
Variable	ZLB		NZLB		QE		FR	
	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
Y	0.695	1	0.695	1	0.708	1	0.669	1
C	0.436	0.553	0.436	0.558	0.434	0.791	0.444	0.171
I	0.080	0.785	0.080	0.784	0.082	0.834	0.077	0.072
W	1.387	1.747	1.386	1.757	1.386	2.375	1.385	0.704
Q	1.000	0.657	1.000	0.622	1.000	0.538	1.000	0.523
Π	1.000	0.216	1.000	0.213	1.000	0.187	0.999	0.187
$(R_t^k - R_t)$	0.023	0.306	0.022	0.275	0.023	0.458	0.021	0.686
N	3.787	47.457	3.766	47.829	2.972	75.571	3.653	3.497
ψ	-	-	-	-	0.226	2.947	-	-
G	0.178	-	0.178	-	0.192	0.320	0.147	1.049
τ^c, τ^w	-	-	-	-	-	-	-0.007; -0.008	1.209; 1.566
$Welfare$	-318.071	54.357	-318.094	54.812	-320.369	97.472	-313.913	10.400
$\% Crisis$	0.062		0.072		0.066		0.072	

Table 4

Summary Min-Max Values for Recurring Financial Shock								
Variable	ZLB		NZLB		QE		FR	
	Min	Max	Min	Max	Min	Max	Min	Max
Y	0.684	0.705	0.686	0.708	0.704	0.715	0.575	0.749
C	0.430	0.441	0.432	0.443	0.431	0.438	0.435	0.458
I	0.072	0.091	0.072	0.092	0.078	0.088	0.072	0.085
W	1.367	1.404	1.370	1.410	1.376	1.401	1.329	1.431
Q	0.992	1.008	0.993	1.010	0.997	1.004	0.957	1.021
Π	0.998	1.003	0.998	1.003	0.999	1.002	0.979	1.012
$(R_t^k - R_t)$	0.019	0.025	0.019	0.026	0.019	0.026	-0.033	0.075
N	3.279	4.281	3.304	4.435	2.609	3.510	3.409	3.913
ψ	-	-	-	-	0.205	0.241	-	-
G	0.178	0.178	0.178	0.178	0.190	0.194	0.052	0.222
τ^c, τ^w	-	-	-	-	-	-	-0.134; -0.173	0.070; 0.091
$Welfare$	-318.689	-317.563	-318.580	-317.386	-320.812	-319.721	-314.510	-313.061

3.2.2 Crisis Event Dynamics: Financial Shocks

As in the previous section, we now turn to the dynamics before and after crisis events with recurring shocks to banking-sector net worth.

Figure 4 pictures the adjustment of GDP, Consumption, the wage, and Q under the four regimes. We see that there is a greater all in GDP and the wage under the FR regime, but an increase in consumption and Q at the time of the

Figure 4: Adjustment to Financial Shocks: Real Sector

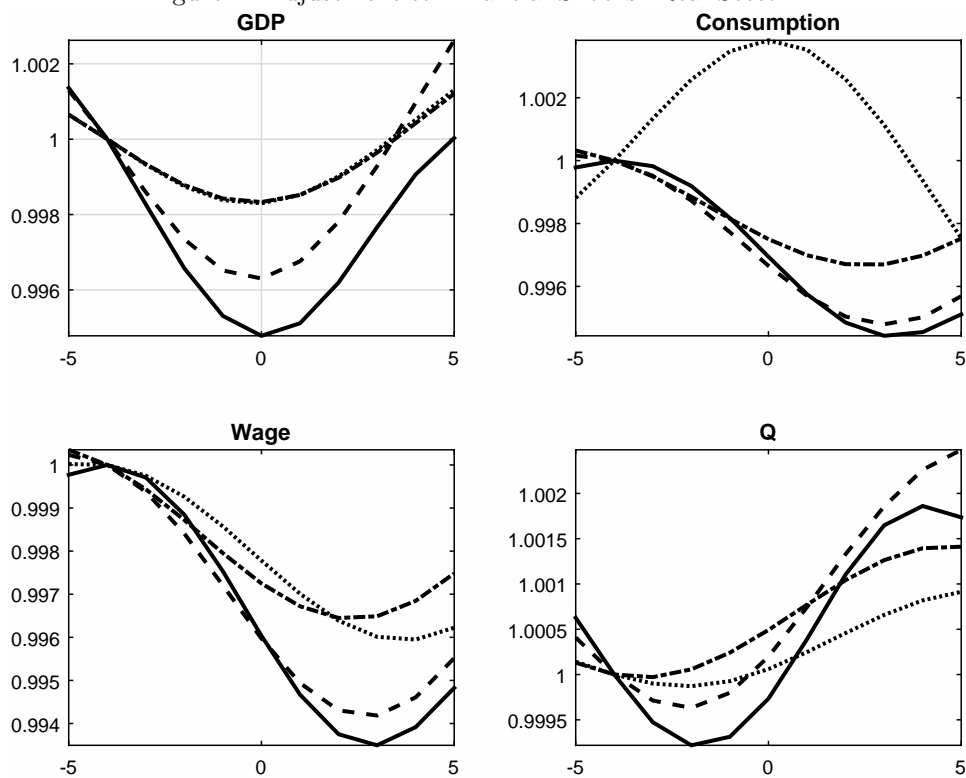
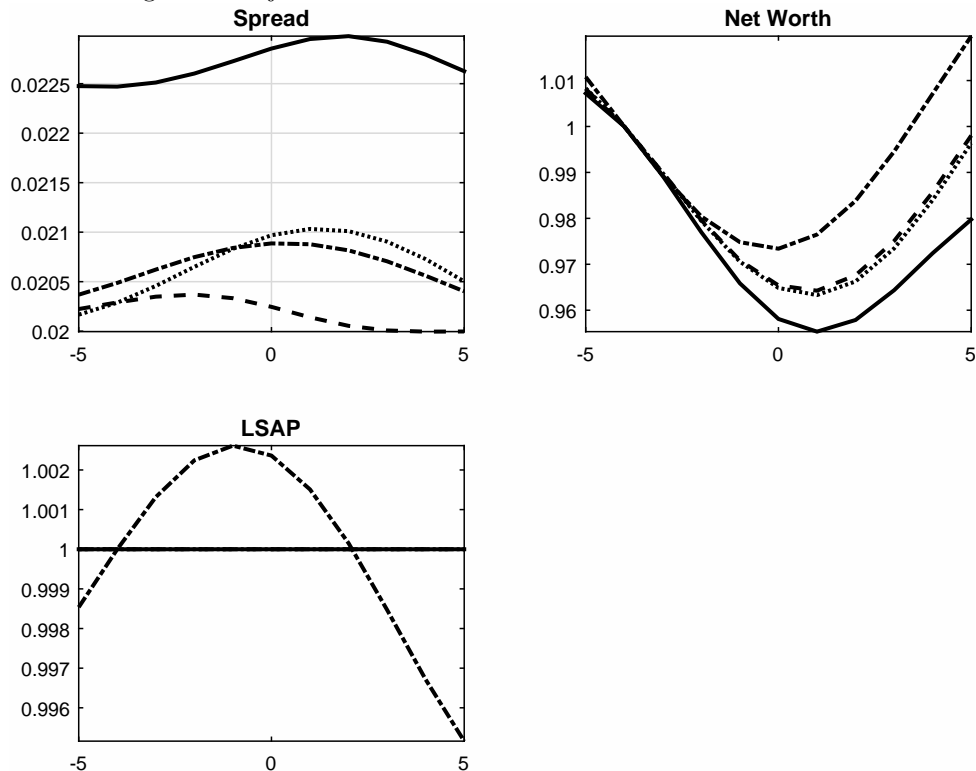


Figure 5: Adjustment to Financial Shocks: Financial Sector

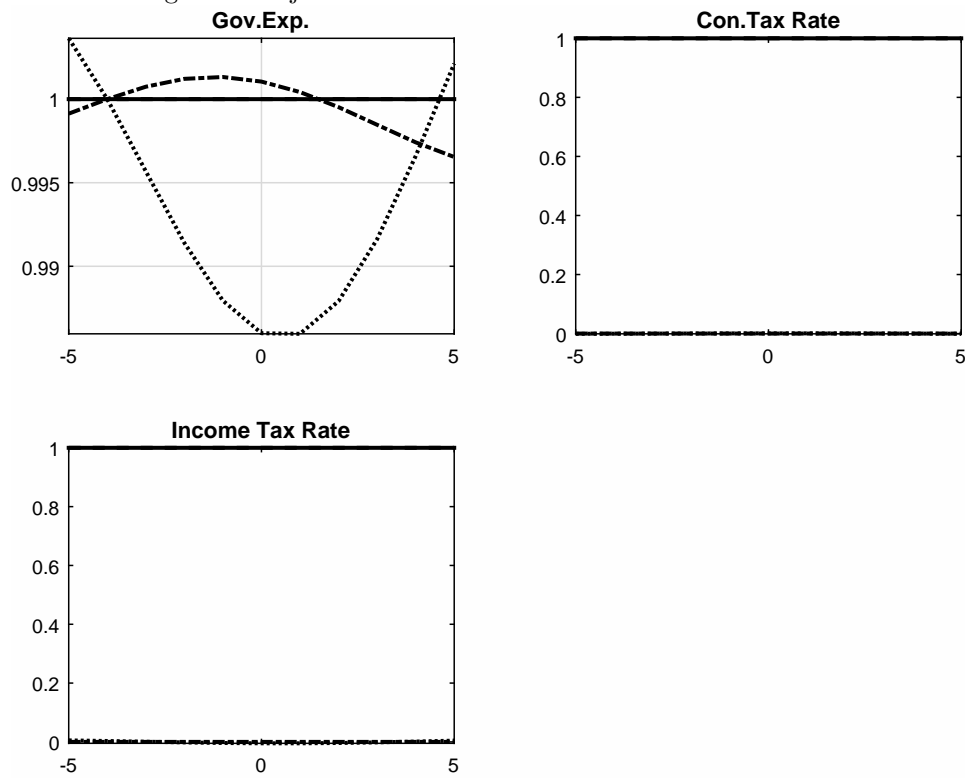


crisis. Figure 4 also shows that the QE policy closely mimics the effects of having an NZLB regime in place at the time of the crisis.

Figure 5 pictures the adjustment in the financial sector. This picture shows that the net worth actually increases both before and after the onset of the crisis under the FR regime. Under this regime the spread rises before the bottoming out of the crisis and then falls. The lower-left quadrant also shows that the QE policy, in the form of large scale asset purchases, increase before the bottoming out of the crisis and then start to fall.

Figure 6 pictures the adjustment of the fiscal variables before and after the bottoming out of the crisis event. This figure shows that there is little change in government spending under the QE regime, whereas the tax rates and government spending varying much more under the FR regime. All of the fiscal parameters as well as government spending vary in similar order of magnitudes as they did under the recurring productivity shocks. These results show that the FR regime has the power to stabilize both consumption and investment at a time of prolonged crisis, but at the cost of wide-ranging changes in tax rates and government spending.

Figure 6: Adjustment to Financial Shocks: Fiscal Sector



4 Conclusion

The results of this paper show that tax rate changes can be very effective instruments for stabilizing consumption and investment in times of prolonged crisis. However, they come at a large cost, if the government is bound by a balanced-budget rule, since the tax changes will involve large swings in government spending, which involves reducing entitlement programs.

In our model, changes in public spending did not have any feedback effects on household utility or on the productivity of investment. Our results also show that QE policies in the form of large scale asset purchases from the private sector do not entail such large swings in government spending, but these policies are less effective at stabilizing both consumption and government spending in times of prolonged crisis events than the use of fiscal instruments.

Our results raise an important question. Given that the Federal Reserve has been engaging in quasi-fiscal policy, could the Treasury have gone a bit further, with the use of quasi-monetary fiscal actions, even if the tax rate changes were kept small? Unfortunately the political discussion in the United States regarding tax rate changes was directed at deficit reduction, and not as substitutes for monetary policy in a time of crisis when the interest rate was stuck at the zero lower bound.

As we point out, in the post-crisis era, as in many episodes of the Twilight Zone series, nothing in the policy world is as it has been. While monetary and fiscal policy interact in traditional ways through the government budget constraint, we now are in the world where their interaction defies the traditional way of imagining stabilization policy.

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