The Role of Money in Monetary Policy at the Lower Bound*

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Abstract

In light of the current low-interest-rate environment, we reconsider the merits of strict money growth targeting (MGT) relative to conventional inflation targeting (IT) and to price level targeting (PLT). We evaluate these policies in terms of social welfare through the lens of a New Keynesian model and accounting for a zero lower bound (ZLB) constraint on the nominal interest rate. Although MGT makes monetary policy vulnerable to money demand shocks, MGT contributes to achieving price level stationarity and significantly reduces the incidence and severity of the ZLB relative to both IT and PLT. Furthermore, MGT lessens the need for fiscal expansions to supplement monetary policy in fighting recessions.

Keywords: automatic stabilizers, fiscal policy, Friedman's k-percent rule, ZLB constraint.

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In November 2018, both the Federal Reserve and the Bank of Canada launched reviews of their monetary policy frameworks, and in January 2020, ECB President Lagarde announced the ECB would also conduct a similar review. One important motivation for these reviews arose from concerns that existing strategies would prove inadequate in an environment of a lower natural rate of interest, with more frequent episodes during which policy rates will be constrained by the effective lower bound on nominal interest rates. When this constraint is binding, policy rate cuts are no longer an option to stimulate the economy after a contractionary shock, thereby worsening the decline in economic activity and causing inflation to fall below the central bank's target.

The decline in economic activity and inflation would be moderated if any fall in inflation automatically caused households and firms to expect higher inflation in the future. The rise in expected inflation would reduce real interest rates and help stimulate economic activity. Such a stabilizing movement in inflation expectations might occur if the public believed the central bank was credibly committed to compensating for periods of below-target inflation by allowing inflation to rise temporarily above the target. Thus, higher inflation expectations would serve as a form of automatic stabilizer when the central bank's ability to stimulate the economy with policy rate cuts is constrained by the lower bound on its policy rate.

A key question posed for the Fed's review was "Can the Federal Reserve best meet its statutory objectives with its existing monetary policy strategy, or should it consider strategies that aim to reverse past misses of the inflation objective?" (Clarida (2019a)). The research that has addressed this question focused on replacing the Fed's strategy of flexible inflation targeting with alternative strategies such as price level targeting, average inflation targeting, and nominal income targeting, all of which involve making up for past target misses in order to make inflation expectations move in a stabilizing fashion.[1] In August 2020, Federal Reserve Chairman Powell (2020) described the Fed's new policy strategy as a "flexible form of average inflation targeting".

Absent from the strategic policy review of the Federal Reserve was any consideration of the role of *money* in monetary policy. Friedman (1960) provided the classic argument for adopting a constant money growth rate, based on his conclusion that "long and variable lags" in the effects of monetary policy meant that attempts to employ cyclical variation in the money supply to stabilize the economy would be more likely to increase instability. He, therefore, advocated for the Federal Reserve to ensure the money supply grew at a constant rate (the k-percent money growth rule).

[1] See, for example, the discussion of these alternative strategies in Walsh (2019) and Svensson (2020).

Recently, Clarida (2019b) has argued that "the Fed's job would be (much) easier if the real world of 2019 satisfied the requirements to run Friedman's k-percent policy rule, but it does not and has not for at least 50 years, and our policy framework must and does reflect this reality". This view is consistent with a key lesson Mishkin (2001) drew from his review of the monetary targeting experiences of Canada, Germany, Switzerland, the United Kingdom, and the United States: "The instability of the relationship between monetary aggregates and goal variables (inflation and nominal income) make monetary targeting problematic".

However, in the two decades since Mishkin highlighted the potential advantages of inflation targeting over monetary targeting, the effective lower bound on policy rates has become a more pressing constraint for monetary policy. A key ingredient of "make up" policies such as price level targeting is that they induce (trend) stationarity in the price level. It is the belief that the price level will return to a long-run path that ensures inflation expectations adjust in a stabilizing way. While inflation targeting produces a non-stationary price level, credible money growth targeting could also induce (trend) stationarity in the price level, as does price-level targeting, and so ensure inflation expectations adjust in a stabilizing way. Thus, a full review of monetary strategies should include an evaluation of the performance of a target expressed in terms of a monetary aggregate. We contribute to such an evaluation by comparing the performance of flexible inflation targeting (IT), price level targeting (PLT) and strict money growth targeting (MGT) in a New Keynesian model subject to an occasionally binding zero lower bound (ZLB) on the central bank's policy interest rate.[2]

In contrast with the literature that interprets alternative policy strategies in terms of the variables appearing in a simple instrument rule, we model alternative policies in terms of *targeting rules*.[3] For our analysis, we use a basic New Keynesian model that is subject to stochastic fluctuations in the natural rate of interest and to money demand shocks. In addition to accounting for the ZLB, we employ a model-consistent measure of welfare to rank outcomes under different policies. We show that, unsurprisingly, PLT performs best in terms of social welfare. However, the ranking between IT and MGT is not a forgone conclusion. In particular, although MGT makes monetary policy vulnerable to money demand shocks, it contributes to achieving price level stationarity and,

[2] Several central banks have implemented negative interest rate policies, demonstrating that the effective lower bound is below zero. For simplicity, and given the uncertainty about the exact value of any effective lower bound, we follow the literature and treat its value as equal to zero. Our analysis remains valid with a negative effective lower bound.

[3] See Svensson (2020) for a recent discussion of the advantages of targeting rules over instrument rules. Mertens and Williams (2020) adopt a hybrid approach by adding variables such as the price level to policy rules that respond directly to expected inflation and to the underlying shocks. Bianchi, Melosi and Rottner (2021) study policy rules that respond more aggressively to inflation when it is below target or is too far away from the target.

importantly, *significantly reduces the incidence and severity of the ZLB* relative to both PLT and IT. As a result, MGT outperforms IT in the face of aggregate demand shocks when the ZLB is occasionally binding.

Intuitively, strict MGT produces a trend stationary price level in which below trend inflation is followed by above trend inflation, and vice versa. Thus, like PLT, MGT serves to generate a rise in expected inflation after contractionary shocks that push current inflation below target. This movement in expected inflation helps mute the effects of such shocks, particularly at the ZLB. In comparison with PLT or IT, however, MGT succeeds in reducing the frequency of ZLB episodes. As we show, away from the ZLB, both IT and PLT cut the policy rate one-for-one with a fall in the natural rate of interest; MGT does not. Rather, under MGT, the policy rate does not respond directly to the natural rate but to nominal income, and it moves much less than one-for-one with nominal income. Hence, our benchmark negative aggregate demand shock, which pushes the policy rate to the ZLB under IT and PLT, does not reduce the policy rate to the ZLB under MGT. The welfare performance of PLT is very dependent on expectations moving appropriately during the much more frequent episodes at the ZLB. In contrast, MGT relies less on its credibility and ability to move expectations, because monetary policy is much less often constrained by the ZLB and can remain active even after large negative shocks to aggregate demand.

Evaluations of monetary policy strategies usually ignore the role of countercyclical fiscal policy. Yet, when monetary policy is constrained by the ZLB, fiscal policy can play an important role in ensuring macroeconomic stability. Debt to GDP ratios have risen sharply in many OECD countries as a result of COVID-19, suggesting that fiscal space for responding to future crises may potentially have shrunk. The question of whether in a low-interest-rate environment there are limits to fiscal debt is, of course, an active topic of debate; see the AEA Presidential Lecture by Blanchard (2019). However, if fiscal space has contracted, the ability of fiscal policy to compensate for any limits on monetary policy may be reduced.

We show that a reduction in fiscal space poses a more serious problem for IT than MGT. As MGT significantly reduces the incidence and duration of episodes at the ZLB, it also reduces the need for countercyclical fiscal policy. To illustrate this fiscal benefit of MGT, we introduce a simple rule for the fiscal authority to raise government purchases when GDP falls below potential. If the government fails to make up for a substantial share of the shortfalls in GDP, then IT performs worse than MGT from the perspective of society. Hence, facing concerns that fiscal space has been reduced, or that fiscal support might not be forthcoming, monetary policy strategies that not only ensure inflation expectations act as an automatic stabilizer at the ZLB but also reduce the incidence of the ZLB, both of which MGT does, are particularly desirable.

Our paper contributes to the large literature that seeks to evaluate alternative monetary policy strategies. Mishkin (2001) reviewed the history of monetary growth targeting. Following the logic of the classic instrument choice problem of Poole (1970), the perceived instability of money demand in the 1980s led major central banks to shift explicitly to the use of a short-term interest rate as their policy instrument. While conceptually distinct from the choice of target, this shift in instruments led to a de-emphasis of money, both as an instrument and as an appropriate target for monetary policy. This de-emphasis was reinforced by the development of the New Keynesian model during the 1990s, and the disappearance of monetary aggregates from mainstream monetary policy models. As a result, monetary policy design and practice have been focused on employing a short-term interest rate in support of objectives such as inflation targeting.

When the ECB was established, the analysis of monetary trends played an important part in the analysis of the risks to price stability—it was one of the ECB's two pillars. The focus on monetary analysis was a nod to the Bundesbank's success in controlling inflation based on money growth targeting prior to the creation of the euro. Beck and Wieland (2007) discussed the role of money as a pillar in ECB policy. However, Svensson (1999) argued that while the Bundesbank seemed like a money growth targeter it actually behaved as an inflation targeter "in disguise". And in practice, the influence of the monetary pillar for ECB monetary policy has decreased over time (Dybowski and Kempa (2020)). In July 2021, the ECB replaced the two-pillar strategy with a policy strategy based on an integrated framework that combines economic analysis with an analysis of financial and monetary factors.

The dominance of the New Keynesian model and the rise of inflation targeting meant that relatively little formal analysis of money growth targeting has been done over the last 20 years. Woodford (2003) (p. 298) compared an optimal interest rate policy to a policy that fixed the level (or growth rate) of the monetary aggregate. Similarly, Ireland (2000) compared a Taylor-type interest rate rule with a fixed money growth rate target, while Collard and Dellas (2005) compared an interest rate rule that was close to a random walk for the nominal rate (with just enough response to inflation to ensure determinacy) versus a fixed money growth rate policy.[4] Importantly, neither Ireland (2000)

[4]Collard and Dellas (2005) found that their interest rate rule led to more stable output and consumption in the face

nor Collard and Dellas (2005) considered the relative performance of MGT and alternatives in the face of the ZLB, which is a major focus of our assessment of alternative policies. Galí (2003), like Collard and Dellas, used a welfare metric to compare a simple Taylor rule to a money growth peg; he too did not consider the ZLB, nor did he incorporate money demand shocks into his analysis.

Rather than examining a fixed money growth rate rule, Söderström (2005) investigated optimal discretionary policy when a measure of money growth relative to target is included in the central bank's loss function, along with the standard terms in the output gap and inflation (relative to target). He found that extending inflation targeting to incorporate an MGT objective makes discretionary policy more inertial, which improves the performance of monetary policy compared with a standard, flexible inflation-targeting regime. As we show below, the inertia and price level stationarity introduced under MGT is central to why MGT does well in the face of the ZLB.

As noted, none of these papers considers the performance of MGT when the ZLB might bind, an issue that is the main focus of our analysis. Policies such as flexible inflation targeting, average inflation targeting, price level targeting, and nominal income targeting have been analyzed accounting for the ZLB.[5] Belongia and Ireland (2018, 2019) are, to our knowledge, the only studies of money growth targeting in the face of the ZLB.[6] Belongia and Ireland (2018) examined a counterfactual simulation in which the Federal Reserve maintained a constant money growth rate once the federal funds rate reached its lower bound in December 2008. Using a structural VAR framework, they concluded that "the Fed could have successfully directed its efforts towards stabilizing money growth while the funds rate remained at its zero lower bound and, in so doing, generated more favorable economic outcomes."

Belongia and Ireland (2019) estimated a New Keynesian model over the period from 1983 to 2019, thus including the 2008 to 2015 period during which the funds rate was at the ZLB. They then replaced the estimated interest rate rule with a money growth rule in which money growth responds negatively and gradually to the output gap. Overall, they found this money growth rate rule performed well, even in the face of money demand shocks. However, they did not provide a welfare ranking of the alternative rules they considered. They impose the ZLB only when analyzing

of money demand shocks; however, MGT did best in the face of money demand shocks when household welfare, rather than output volatility, was used to rank alternative policies. In their baseline calibration, money and consumption are substitutes, while money and leisure are complements. Thus, in response to a positive money demand shock under MGT, the interest rate rises and consumption falls, but leisure rises, muting the negative effects on household welfare.

[5] See, for example, Adam and Billi (2006, 2007), Billi (2011, 2017), and Budianto, Nakata and Schmidt (2020).

[6] See also Belongia and Ireland (2017).

the performance of the estimated interest rate rule, while allowing for negative nominal interest rates under the MGT regimes.

None of the aforementioned papers considers the role of fiscal policy as an additional stabilization tool when monetary policy is constrained by the ZLB. And none considers endogenous fiscal policy rules that could act as an automatic stabilizer at the ZLB. In their study of fiscal automatic stabilizers, McKay and Reis (2016) concluded that fiscal automatic stabilizers in the U.S. economy have had "little effect on the volatility of aggregate output fluctuations" but can play a more important role when the ZLB constrains monetary policy. The evidence on the declining neutral rate of interest and the possibility of more frequent ZLB episodes led Blanchard and Summers (2017) to argue that these developments increase the scope for using fiscal policy.

To capture the type of asymmetric automatic stabilizers advocated by Eichenbaum (2019) and Blanchard and Summers (2020), we adopt a fiscal rule that operates only when the output gap is negative. In contrast to money-financed fiscal policy, as analyzed for example by English et al. (2017) and Galí (2020), the fiscal policy we study does not involve monetary financing of a fiscal expansion. We thus do not consider monetary and fiscal policies that directly raise issues of policy coordination nor threaten central bank independence. Instead, we focus on how alternative targeting regimes may affect the need for countercyclical fiscal policies at the ZLB.

The rest of the paper is organized as follows. In Section 1, we set up a simple New Keynesian model, and describe our characterization of flexible inflation targeting, strict price level targeting, and strict money growth targeting, as well as the calibration of the model. Our main results are reported in Section 2. A rule for fiscal policy is introduced in Section 3. Conclusions are summarized in Section 4. Some model extensions and robustness checks are provided in the Appendix.

1 The Model

We carry out our analysis using a version of the New Keynesian model with staggered price setting à la Calvo, augmented with a ZLB constraint on the short-term nominal interest rate. In the scenarios considered, the conduct of monetary policy is described by three alternative targeting rules—specifically, flexible inflation targeting, strict price level targeting, and strict money growth targeting. Next, we introduce the equations describing the model's equilibrium, and the targeting rules. We then estimate a stable money demand relationship in U.S. data to calibrate its parameters and the volatility of money demand shocks, and rely on a standard calibration of the rest of the model as a baseline for our analysis.

1.1 Private Sector

The behavior of the private sector is described by the equilibrium conditions introduced in this section, which correspond to the closed-economy New Keynesian model with staggered price setting, flexible wages, and without capital accumulation. Government purchases are financed through lump-sum taxes. All equations are log-linearized around a steady state with zero government purchases and zero price inflation, and with a subsidy that exactly offsets the steady-state distortions resulting from price markups. Derivations can be found in Galí (2015) chapter 3, Walsh (2017) chapter 8, and Galí (2020).

The supply side of the economy is described by a New Keynesian Phillips curve representing the dynamics of inflation:

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa \tilde{y}_t, \tag{1}$$

where $\pi_t \equiv \Delta p_t = p_t - p_{t-1}$ is the rate of price inflation between periods $t-1$ and t, and where $p_t \equiv \log P_t$ is the (log) price level. The parameter β denotes the household's discount factor. $\tilde{y}_t \equiv \hat{y}_t - \hat{y}_t^n$ denotes the output gap, where $\hat{y}_t \equiv \log(Y_t/Y)$ denotes (log) output in deviation from steady state and where $\hat{y}_t^n \equiv \log(Y_t^n/Y)$ represents the (log) natural level of output, i.e. its equilibrium level in the absence of nominal rigidities, in deviation from steady state.

The natural (flexible-price) level of output is given by $\hat{y}_t^n \equiv \Gamma \hat{g}_t$, where $\Gamma \equiv \frac{\sigma(1-\alpha)}{\alpha+\varphi+\sigma(1-\alpha)}$ and where $\hat{g}_t \equiv (G_t - G)/Y$ denotes (real) government purchases expressed as a fraction of steady state output. The parameters α, σ, and φ denote the degree of decreasing returns to labor in production, the household's coefficient of relative risk aversion and the curvature of labor disutility, respectively. In the neighborhood of a steady state with zero government purchases ($G = 0$), the goods market equilibrium condition is given by $\hat{y}_t = \hat{c}_t + \hat{g}_t$, where $\hat{c}_t \equiv \log(C_t/C)$ denotes (log) private consumption expressed in deviation from steady state.

In addition, the slope of the Phillips curve is given by $\kappa \equiv \lambda \left(\sigma + \frac{\alpha+\varphi}{1-\alpha}\right)$, where $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)(1-\alpha)}{\theta(1-\alpha+\alpha\epsilon)}$. The parameter $\theta \in [0, 1)$ denotes the Calvo index of price rigidity (the probability that a firm does not reset its price in a given period), while $\epsilon > 1$ denotes the elasticity of substitution among varieties of goods. In this benchmark model, there is zero trend inflation and there are no supply shocks buffeting the economy. We extend the analysis along those lines in the Appendix. Namely, Appendix A.1 provides a version of the model with a positive trend in the rate of inflation (and money growth), while Appendix A.2 considers the effects of aggregate supply (markup) shocks.

The demand side of the economy is described by the following two expressions representing, respectively, a dynamic IS equation and a money demand equation:

$$\tilde{y}_t = E_t\{\tilde{y}_{t+1}\} - \frac{1}{\sigma}\left(\hat{\imath}_t - E_t\{\pi_{t+1}\} - \hat{r}_t^n\right), \tag{2}$$

$$m_t - p_t = \hat{c}_t - \eta\hat{\imath}_t + v_t. \tag{3}$$

These equations are derived from the optimality conditions of the representative household's utility maximization problem under two assumptions. First, real money holdings (real balances) provide a "transactions service" that households value in terms of utility. The second, and related, assumption is that the household's utility function is additively separable in those real monetary balances, which ensures the disappearance of real-balance effects from both the Phillips curve and IS equation.

In these equations, $\hat{\imath}_t \equiv i_t - \rho$ denotes the short-term nominal interest rate expressed in deviation from its zero-inflation steady state, and the latter corresponds to the discount rate $\rho \equiv -\log\beta$. The short-term real interest rate is given by $\hat{\imath}_t - E_t\{\pi_{t+1}\}$. The natural rate of interest is given by $\hat{r}_t^n \equiv (1-\rho_z)\, z_t - \sigma(1-\Gamma)\, E_t\{\Delta\hat{g}_{t+1}\}$, where z_t is a preference shifter (aggregate demand shock) which is assumed to follow an exogenous $AR(1)$ process with autoregressive coefficient ρ_z and standard deviation σ_z.[7]

In the above money demand relationship, $m_t \equiv \log M_t$ denotes the household's (log) nominal money holdings, while $m_t - p_t$ denotes (log) real money holdings. Under inflation targeting, as we discuss in the next section, the price level can be non-stationary, but (3) ensures m_t and p_t are cointegrated. When calibrating the model, we note that the *inverse* velocity of circulation of the money stock is given by $m_t - p_t - \hat{c}_t$. The parameter $\eta \geq 0$ denotes the interest semi-elasticity of money demand, while v_t represents a money demand shock which is assumed to follow an exogenous $AR(1)$ process with autoregressive coefficient ρ_v and standard deviation σ_v.

A key objective of our analysis is the evaluation of monetary policy from a welfare perspective. For that purpose, we use as a welfare metric the second-order approximation of the average welfare

[7] This shock's innovation is an i.i.d. normally distributed process with zero mean and standard deviation given by $\sigma_{ez} = \sigma_z\sqrt{1-\rho_z^2}$. Furthermore, z_t is interpreted as a shock to the effective discount factor; it affects the household's marginal utility of consumption and marginal value of leisure, while leaving unaffected the marginal rate of substitution between consumption and leisure. Thus, z_t affects $\hat{r}_t^n$ but not $\hat{y}_t^n$ in the model.

loss experienced by the representative household as a consequence of fluctuations around an efficient steady state with zero inflation and zero government purchases. We express these losses as a fraction of steady state consumption. Assuming that the welfare effects of money holdings are negligible as in a "cashless limit" economy, the welfare loss can be written as[8]

$$\mathbb{L} = \frac{1}{2}\left[\frac{\epsilon}{\lambda} var\left(\pi_t\right) + \frac{\kappa}{\lambda} var\left(\tilde{y}_t\right) + \frac{\gamma\kappa}{\lambda} var\left(\hat{g}_t\right)\right], \tag{4}$$

where $\gamma \equiv \Gamma\left(1 - \Gamma + \frac{\delta}{\sigma}\right)$, and where δ denotes the curvature of utility from government purchases. The welfare loss has three components, respectively associated with the volatilities of inflation, the output gap, and government purchases. A derivation can be found in Woodford (2011).

We initially assume (real) government purchases remain unchanged over time as a fraction of output, irrespective of the state of the economy. That is, we impose $\hat{g}_t = 0$ for all $t = 0, 1, 2 \ldots$, which implies $\hat{c}_t = \hat{y}_t = \tilde{y}_t$ for all $t = 0, 1, 2 \ldots$. This allows us to focus on the role of money in monetary policy in isolation from other policy areas, such as fiscal policy. In Section 3, however, we will introduce an explicit role for government purchases to be employed as an additional stabilization tool alongside monetary policy by allowing $\hat{g}_t$ to vary in a specific way in response to the state of the economy. We next close the model with a description of monetary policy.

1.2 Monetary Policy

In our analysis, we consider three alternative monetary policy regimes that take the form of targeting rules—that is, flexible inflation targeting (IT), strict price level targeting (PLT), and strict money growth targeting (MGT). In all of them, the central bank employs as its policy instrument the short-term nominal interest rate unless the ZLB constraint is binding. Output, inflation, and the stock of money in circulation are then determined by the equilibrium conditions together with the central bank's targeting rule. When we calibrate the model, we adopt a narrow transactions-based interpretation of money implying that control over the central bank's balance sheet allows policy to continue to control m_t even when the ZLB is binding. For all regimes, we ignore any control errors in their implementation. The policy regimes differ crucially in the central bank's choice of targets to

[8] Equation (4) is derived under the usual assumption in the optimal monetary policy literature that, even if money is valued and held by households, the welfare effects of the transactions service provided by real monetary balances are negligible in relation to the size of the economy. For a discussion of the "cashless limit" economy in an MIU (money in the utility function) model, see Woodford (2003). In Appendix A.3 we consider a welfare metric with nonnegligible consequences from money holdings.

pursue and in the implications for price level and output stability, as described next.

The first regime we consider (IT) corresponds to a typical notion of *flexible inflation targeting* (or dual mandate) under optimal discretion, in which the central bank not only aims to stabilize inflation around a target but also assigns some weight to stabilizing the output gap. The weight is assumed "optimal" in the model from a welfare perspective, given the above welfare metric (4) and assuming the central bank does not aim to stabilize $\hat{g}_t$. Such a regime corresponds to the complementary slackness condition

$$\Big(\underbrace{\pi_t + \frac{1}{\epsilon}\tilde{y}_t}_{\leq 0}\Big)\Big(\underbrace{\hat{\imath}_t + \rho}_{\geq 0}\Big) = 0, \tag{5}$$

for all $t = 0, 1, 2 \ldots$. The central bank conducts policy to achieve $\pi_t + (1/\epsilon)\tilde{y}_t = 0$ to the extent feasible, i.e. as long as the ZLB is not binding, $i_t > 0$ (and $\hat{\imath}_t > -\rho$). However, the ZLB may prevent the central bank from attaining its dual mandate. If the ZLB binds, $i_t = 0$ (and $\hat{\imath}_t = -\rho$), the condition relating inflation to the output gap may not be satisfied, and $\pi_t + (1/\epsilon)\tilde{y}_t < 0$. In this regime the price level is not pinned down by policy, so the price level can be non-stationary. We interpret this regime as a stylized representation of the one prevailing in many advanced economies with formal inflation targets. For a discussion of optimal discretionary monetary policy under the ZLB constraint, see Eggertsson and Woodford (2003), Adam and Billi (2007), and Nakov (2008).

The second regime (PLT) is a description of *strict price level targeting*, where with respect to the previous regime the central bank aims to stabilize a single target, rather than pursue a dual mandate. Specifically, this regime corresponds to a version of optimal discretionary monetary policy in which the central bank sets $i_t \geq 0$ to minimize a loss function $(p_t - \bar{p})^2$, where $\bar{p}$ is the constant price-level target. It, thus, corresponds to the complementary slackness condition

$$\Big(\underbrace{p_t - \bar{p}}_{\leq 0}\Big)\Big(\underbrace{\hat{\imath}_t + \rho}_{\geq 0}\Big) = 0, \tag{6}$$

for all $t = 0, 1, 2 \ldots$. In this regime, the central bank conducts policy to achieve $p_t = \bar{p}$ as long as the ZLB does not bind, $i_t > 0$. But if the ZLB binds, $i_t = 0$, the price level may fall below target, $p_t < \bar{p}$. This regime implies that, in contrast to the previous one, the price level is (trend) stationary; that is, policy ensures p_t returns to $\bar{p}$. We normalize $\bar{p}$ to equal zero in our analysis below. Positive trend inflation is considered in Appendix A.1.

In both of the regimes just introduced—that is, under the inflation target or price level target—

money holdings adjust endogenously to support the interest rate as necessary to stabilize inflation and output, with real money balances determined by money demand, that is, by equation (3). As a consequence, in those regimes, equation (3) is "redundant" in the set of equilibrium conditions for the determination of inflation, output and the nominal interest rate, and therefore the stock of money in the economy does not play any role in the conduct of monetary policy. We next introduce a regime with a *direct* role for money in the conduct of monetary policy.

The third regime we consider (MGT) is a description of *strict money growth targeting*, a proposal generally associated with Friedman (1960). We assume a zero money growth target, which is consistent with zero inflation in the steady state of this benchmark model economy. This regimes takes the form

$$\Delta m_t = 0, \tag{7}$$

for all $t = 0, 1, 2 \ldots$, where the central bank conducts policy to stabilize the growth of the stock of money. As in the previous regimes, the monetary policy instrument is the short-term nominal interest rate when the ZLB constraint is not binding. In this case, the money demand equation (3) can be written as[9]

$$\hat{\imath}_t = \frac{1}{\eta}\left(p_t + \hat{c}_t + v_t - \bar{m}\right), \tag{8}$$

where $m_t = \bar{m}$ is the constant level of the money stock, as implied by the target (7). Policy now responds both to nominal income $p_t + \hat{c}_t$ and to the money demand shock v_t, while in the steady state $p = \bar{m}$. Because policy ensures p_t returns to $\bar{m}$, the price level is (trend) stationary.

In contrast to the previous regimes, as the money demand equation (3) is no longer redundant, the ZLB is incorporated in the set of equilibrium conditions by replacing (3) with the complementary slackness condition

$$\Big(\underbrace{m_t - p_t - \hat{c}_t + \eta\hat{\imath}_t - v_t}_{\geq 0}\Big)\Big(\underbrace{\hat{\imath}_t + \rho}_{\geq 0}\Big) = 0, \tag{9}$$

whereby money balances may overshoot the satiation level, $m_t > p_t + \hat{c}_t + \eta\rho + v_t$, if the ZLB binds, $i_t = 0$. For this reason, the ZLB does not prevent the central bank from attaining its money growth target, although the ZLB can affect the adjustment of prices and output. In particular, given that $\Delta m_t \equiv m_t - m_{t-1}$, the zero money growth target (7) achieves $m_t = \bar{m}$ in every period t. Hence, if

[9] Equation (8) shows that under MGT the nominal interest rate $\hat{\imath}_t$ responds to the level of nominal income $p_t + \hat{c}_t$. Nominal income targeting away from the ZLB is studied by Garín, Lester and Sims (2016) and at the ZLB by Billi (2020), in an environment with price and wage rigidities. Billi and Galí (2020) analyze the effects of wage rigidities and the ZLB under the optimal monetary policy with commitment.

the ZLB binds, then condition (9) simplifies to $\bar{m} > p_t + \hat{c}_t + \eta\rho + v_t$. We will normalize $\bar{m}$ to equal zero in our analysis below.

We view the MGT regime as a modern representation of Friedman's k-percent policy rule, which takes explicitly into account the consequences of a ZLB constraint on the nominal interest rate. Equipped with these three monetary policy regimes, together with the equilibrium conditions describing the behavior of the private sector, we can study the implications of assigning a prominent role to money in the conduct of monetary policy. The model is stylized, but it contains the key elements for a meaningful analysis of the issue at hand: does the presence of a ZLB constraint provide a rationale for the central bank to stabilize money growth in the economy? We next describe the calibration of the model.

1.3 Calibration

To take the money demand relationship (3) to U.S. data, we must take a stand on the appropriate empirical counterpart to the model's money stock variable. Our focus on the money growth rate as a policy target calls for using a monetary aggregate for which a stable money demand relationship exists in the data, as implied by the model. Thus, we employ MZM (money zero maturity) as our money stock variable.

As Teles and Zhou (2005) show, MZM provides a good approximation of the transactions demand for money, because MZM includes balances that can be used for transactions immediately at zero cost. MZM is defined as M2 less small-denomination time deposits plus institutional money funds. It was initially introduced by Motley (1988) and Poole (1991) as an "appropriate" measure of the transactions demand for money since the 1980s. In fact, a number of sweeping regulatory reforms and technological innovations in the banking sector (the rapid development of electronic payments and retail sweep programs) significantly changed the way banks operate and the way people use banking services and conduct transactions. Those developments made the classification of other monetary aggregates (M1, M2, and M3) inherently arbitrary, and therefore rendered "unstable" the money demand relationships based on those aggregates.

Furthermore, to account for the fact that money may earn interest, we follow Teles and Zhou (2005) and define MZM's opportunity cost as the spread between the 3-month Treasury Bill rate and MZM's own rate; the latter is a weighted average of the returns on the different components of MZM. Hence, in the estimation the opportunity cost is determined by two separate short-term nominal interest rates taken from the data, although the model is stylized with a single nominal interest rate employed by the central bank as its policy instrument. Before proceeding with the estimation, Figure 1 plots the (log) velocity of the MZM money stock and its opportunity cost. Both series are shown as quarterly averages. As this figure illustrates, over the course of the past five decades, movements in MZM velocity have been fairly closely related to movements in the opportunity cost. We next formally estimate the stable relationship between those two variables, and the residual variation then corresponds to the money demand shock in our model.

We proceed to estimate equation (3) and rely on that estimate for our baseline calibration.[10] Specifically, we estimate an OLS regression of (log) MZM *inverse* velocity on the opportunity cost (quarterly rate, per unit), using quarterly data over the period 1974Q1 to 2008Q4. The estimation period ends at 2008Q4 when an extended period at the ZLB began, because the model's complementary slackness condition (9) implies the stable relationship between money velocity and the opportunity cost given by (3) need not hold when at the ZLB. This estimation of equation (3) gives

$$log(1/MZMV_t) = -\underset{(0.02)}{0.73} - \underset{(1.75)}{25.68}(TB3MS_t - MZMOWN_t)/400 + v_t, \tag{10}$$

with standard errors in parentheses and $\bar{R}^2 = 0.61$. Based on that regression, we set the interest semi-elasticity of money demand η to 26. In the analysis, however, we also report findings for alternative values of η to stress the importance of a stable money demand relationship in generating some of the results. We use the residual from the previous regression, v_t, to construct an $AR(1)$ time series model that we then estimate with OLS. This estimation gives: $v_t = 0.92v_{t-1} + \varepsilon_t$, with standard deviation of the dependent variable $SD(v_t) = 0.11$, and $\bar{R}^2 = 0.83$. Accordingly, we calibrate the process for the money demand shock to $\rho_v = 0.92$ and $\sigma_v = 0.11$.

The rest of our calibration is quite conventional and largely follows Galí (2015), reflecting the current low-interest-rate environment. In particular, we set the discount factor β to 0.995 which implies a steady-state real interest rate of 2% annualized. We set $\sigma = 1$, $\varphi = 5$ and $\alpha = 0.25$. The elasticity of substitution ϵ is set to 9, implying a steady-state price markup of 12.5%. We set $\theta = 0.75$, which is consistent with an average duration of price spells of one year. We set $\delta = 1$, which implies the marginal utility of government purchases decreases at the same rate as the marginal utility of

[10] To estimate the model's money demand relationship, we follow Galí (2015) chapters 3 and 4. As in Cochrane (2018), we include the post-1980s period and employ MZM (rather than M2) as our money stock variable. All data used are obtained from the Federal Reserve Bank of St. Louis FRED database (`https://fred.stlouisfed.org`), series MZMV, MZMOWN, and TB3MS. The MZM own rate is available starting from 1974.

private consumption, following Woodford (2011). We then calibrate the parameters of the process for the aggregate demand shock under the assumption that the monetary policy regime is *flexible inflation targeting* as described above. Specifically, we set $\rho_z = 0.9$ to generate sufficient persistence, and set $\sigma_z = 0.06$ to obtain an incidence of hitting the ZLB near 20%, reflecting the U.S. experience since 1983. Our baseline calibration is summarized in Table 1.

Next, we turn to the analysis of the model's predictions regarding the role of money in the conduct of monetary policy in the presence of a ZLB constraint.[11] We start by considering scenarios in which government purchases are not employed as an additional stabilization tool. Thus, for now, we impose $\hat{g}_t = 0$ in every period t, but we modify this assumption later in the analysis.

2 The Effects of Stabilizing Money Growth Facing the ZLB

We use the New Keynesian model—given by the above equations (1) through (9)—as a framework to analyze a strict money growth target in the presence of a ZLB constraint on the nominal interest rate. We compare the model's predictions under the money growth target to those under flexible inflation targeting and strict price level targeting. In the scenarios presented in this section, the central bank is assumed to work in isolation from other policy areas at stabilizing the economy. In particular, fiscal policy is not employed as a stabilization tool, irrespective of whether the ZLB is binding or not. Later, we will analyze how the different regimes affect the need for fiscal support at the ZLB (Section 3).

Under each policy regime, we study the impact of negative shocks to aggregate demand (z_t) that push down the natural rate of interest, and we compare the outcomes with and without a ZLB on the nominal interest rate. We also analyze the effects of negative shocks to money demand (v_t), which impact inflation and output only under the MGT regime. To rank the policy regimes, we evaluate the welfare loss experienced by a representative household using the welfare metric (4).

[11] The model outcomes are obtained with Dynare (`https://www.dynare.org`). To obtain the dynamic responses shown in the figures, we use the perfect-foresight, deterministic simulations algorithm implemented with the 'simul' command. To generate simulated equilibrium paths needed to compute the welfare losses shown in the tables, we employ the stochastic simulations algorithm (agents believe there will be no more shocks in the following periods) implemented with the 'extended_path' command. These long simulations are used to compute the variances of inflation, the output gap, and government purchases that determine the welfare losses associated with each policy regime and parameter configuration considered. Replication files are available from the authors upon request.

2.1 Effect of Shocks in the Baseline Model

The focus of the analysis is on shocks that have the potential to push the nominal interest rate to the ZLB. With and without the ZLB constraint, Figures 2 and 3 show the dynamic responses of the economy after a negative aggregate demand shock (z_t) that pushes down the natural rate of interest, and therefore warrants an expansionary monetary policy response.[12]

Without the ZLB, Figure 2 shows that in the face of a negative aggregate demand shock the nominal interest rate is cut under all three regimes, but not to the same extent. Under both inflation targeting (IT) and price-level targeting (PLT), the cut in the nominal rate is such that the real interest rate exactly shadows the natural interest rate, offsetting all effects of the shock on output and inflation. Absent a response of fiscal policy, i.e. if $\hat{g}_t = 0$ in every period t, the natural interest rate is given by $\hat{r}_t^n = (1 - \rho_z) z_t$. The nominal rate cut under IT and PLT causes a temporary expansion of the money stock, but this has no impact on the rest of the economy. In contrast, MGT fully stabilizes the money growth rate, requiring a smaller cut in the nominal rate that is insufficient to exactly shadow the natural rate. The smaller policy rate cut under MGT implies an initial increase in the real interest rate, so output and inflation fall. Yet, the MGT regime ensures the price level is stationary, and inflation eventually rises above target, serving to return the price level to its initial equilibrium level.

With the ZLB, Figure 3 shows that facing a negative shock to aggregate demand, IT and PLT are no longer able to cut the nominal rate enough to ensure the real rate shadows perfectly the natural rate; output and inflation fall. Under IT the real rate increases, similar to MGT. Under PLT, however, the stationarity of the price level has a dampening effect in limiting the initial fall in inflation expectations, as households and firms foresee inflation will eventually overshoot the target. Hence, under PLT, the real rate falls, and therefore output and inflation fall less relative to the other regimes. Importantly, under MGT the nominal rate does not reach the ZLB—the MGT responses are thus the same in Figures 2 and 3. As discussed above when describing the model, both MGT and PLT ensure the price level is stationary, while under IT the price level can be non-stationary. Thus, during a ZLB episode, only the IT regime fails to generate the expectations of inflation needed to return the price level to its initial equilibrium level.

[12] In the various figures reporting the dynamic responses to shocks, the responses are driven by an initial impulse to z_t or v_t. The impulse to z_t is of size $2\sigma_z$, large enough to imply that under the IT regime the ZLB binds for 9 quarters. The impulse to v_t is set larger to $3\sigma_v$ so that under MGT the nominal interest rate is pushed to the ZLB. Note that growth rates and interest rates are shown in quarterly rates (not annualized).

To understand why MGT outperforms IT facing the ZLB, recall that under MGT the policy rate $\hat{\imath}_t$ responds to nominal income $p_t + \hat{c}_t$, see equation (8). Because the price level equals $p_t = \pi_t + p_{t-1}$, outcomes under MGT depend endogenously on the past price level p_{t-1}. Thus, similarly to PLT, MGT remains expansionary as long as p_{t-1} remains below its steady-state level. MGT therefore provides more stimulus to the economy than IT. The stationarity of the price level under MGT mimics some of the advantages of PLT. As a result, the fall in inflation and output is smaller under MGT than IT.[13]

Importantly, relative to PLT and IT, MGT has the benefit of reducing the incidence of the ZLB. Under MGT, as $m_t = \bar{m}$ in every period t, the money demand equation (3) implies the nominal interest rate is given by

$$i_t = \max\left\{0, \rho + \frac{1}{\eta}\left(p_t + \hat{c}_t + v_t - \bar{m}\right)\right\}. \tag{11}$$

Away from the ZLB, both IT and PLT cut the policy rate one-for-one with a fall in the natural rate of interest r_t^n, and the reduction in the nominal interest rate makes households increase their demand for money. In contrast, as discussed above, under MGT the policy rate does not respond directly to r_t^n; it reacts instead to nominal income, $p_t + \hat{c}_t$. In our estimation reported in Section 1.3, we found that money demand is relatively sensitive to its opportunity cost, so η is large in our baseline calibration. Thus, in the face of a negative aggregate demand shock, a fall in nominal income needs only a small cut in the policy rate to ensure $m_t = \bar{m}$ under MGT. The smaller reduction in the policy rate reduces the likelihood of reaching the ZLB.

Similar to PLT, MGT generates a stationary price level, which reduces the immediate impact of shocks on inflation, because inflation expectations adjust to act as a stabilizing factor. To generate a stationary price level, the rate of inflation needs to overshoot the target in the medium term, which in itself generates a welfare cost in the medium term. But the welfare cost of the over-shooting is smaller than the welfare benefit gained in the short term, when inflation is closer to target than it otherwise would have been. Put differently, under PLT and MGT, the central bank is willing to suffer a small welfare cost down the road to reap a large welfare benefit today.

A disadvantage of MGT, along the lines of Poole (1970), is that money demand shocks have the potential to destabilize the economy. In our model, such shocks have no direct impact on the

[13] Facing a much larger aggregate demand shock than the one in Figure 3, under MGT the nominal interest rate will reach the ZLB and, of course, MGT still outperforms IT in stabilizing the economy at the ZLB. This result is shown analytically for the case of a *one-period* shock to aggregate demand in an online appendix.

economy conditional on the nominal interest rate, because the stock of money is redundant for the determination of output and inflation. But under MGT, as equation (11) shows, the nominal interest rate responds to money demand shocks (v_t), with consequences for output and inflation. Figure 4 shows the dynamic responses after a negative shock to money demand, with and without the ZLB. Under IT and PLT, the money stock falls temporarily but this has no impact on the rest of the economy. In contrast, MGT cuts the nominal interest rate to stabilize money growth and therefore output and inflation rise. Under MGT when facing the ZLB, the cut in the nominal (and real) interest rate is limited, so the increase in output and inflation are more modest.[14]

The model outcomes presented so far with Figures 2 to 4—illustrating the responses of the economy after shocks to aggregate demand and money demand, under the three policy regimes—can be summarized as follows. Compared with the conventional IT regime, MGT has the advantage that inflation is more stable initially when the economy is hit by negative aggregate demand shocks, due to the stationarity of the price level. The over-shooting of inflation in the medium term generates more volatility in inflation under MGT than under IT in the medium term, but in parallel with the welfare costs, the higher volatility in the medium term is dominated by lower volatility for both inflation and output in the short term. Furthermore, relative to IT and PLT, the ZLB is much less likely to bind under MGT after aggregate demand shocks. However, in the face of money demand shocks, the MGT regime leads to volatility in the economy that is avoided under IT and PLT.

To evaluate the three policy regimes, Table 2 reports the welfare loss of a representative household (measured by (4)) with and without the ZLB constraint, as well as the ZLB frequency. Without the ZLB, monetary policy is able to fully stabilize the economy after shocks to both aggregate demand and money demand under IT and PLT. In the MGT regime, however, monetary policy stabilizes money growth, leading to volatility in output and inflation and thus a welfare loss.

With the ZLB, as Table 2 shows, PLT is the dominant regime, but the benefits of MGT over IT facing aggregate demand shocks mean that the overall welfare loss is substantially lower under MGT than under conventional IT.[15] While PLT does better than MGT in the face of aggregate demand shocks, the ZLB occurs much more frequently under PLT than under MGT (and IT). Hence, the better welfare performance of PLT is very dependent on its credibility—that is, expectations have

[14] In our baseline calibration, under MGT the time spent at the ZLB is rather short. With a smaller value of η, the interest semi-elasticity of money demand, under MGT the periods at the ZLB are longer and thus the consequences for the economy are larger (Section 2.2).

[15] With the ZLB, even if the standard deviation of the money demand shock σ_v is increased by as much as 100% above its baseline (not shown), the overall welfare loss and ZLB frequency remain lower under MGT than under IT.

to move appropriately during the much more frequent episodes at the ZLB, when monetary policy is inactive. In contrast, MGT relies to a lesser extent on its credibility, as monetary policy is less often constrained by the ZLB and is active also during large negative shocks to aggregate demand.[16]

2.2 Sensitivity to Money Demand Elasticity

The analysis so far relies on a money demand equation estimated on U.S. data. Many doubts about MGT as a feasible strategy for monetary policy, illustrated by the quotations on monetary targeting from Mishkin (2001) and Clarida (2019b) as we noted above, relate to the perceived instability of money demand. Our estimated money demand equation uses MZM as a measure of the money stock, for which Teles and Zhou (2005) argue there is a stable money demand relationship. Nevertheless, the concerns about money demand stability motivate us to study more carefully the properties of MGT for alternative parameterizations of the money demand elasticity in the model.

With the ZLB, Figures 5 and 6 show the dynamic responses of the economy under MGT after negative shocks to aggregate demand and money demand for a very wide range of values for η, the interest semi-elasticity of money demand, around its baseline value.[17] A smaller value of η means that a larger cut in the nominal interest rate is needed to stabilize money growth after a negative shock to either aggregate demand or money demand. And if the shock pushes the nominal interest rate to the ZLB, a smaller value of η leads to a longer spell at the ZLB. With a smaller value of η, the larger interest rate cut has a stabilizing impact on output and inflation after an aggregate demand shock (see Figure 5). A larger interest rate cut has a destabilizing effect after a money demand shock (Figure 6), because inflation and the output gap would be stabilized in the face of such a shock by keeping the nominal rate constant.

To evaluate the policy regimes, Figures 7 and 8 show the welfare loss as a function of η with and without the ZLB, respectively. The baseline value $\eta = 26$ is indicated by a vertical line. Without the ZLB, Figure 7 shows the welfare loss is always zero under both IT and PLT. Under MGT, however, the welfare loss is increasing in η after aggregate demand shocks, but decreasing in η conditional on money demand shocks. When facing both types of shock together, the aggregate welfare loss will depend on the relative volatility of the aggregate demand shocks and the money demand shocks.

[16] Our baseline calibration implies a real (and nominal) interest rate of 2 percent in steady state. With a lower steady-state interest rate, the ZLB is hit more often and thus the benefits of MGT increase further relative to IT.

[17] The estimated standard error of η is 1.75 (Section 1.3). Hence the range of values $\eta \in [14, 38]$ that we consider corresponds to about ± 7 standard errors around the point estimate $\eta = 26$.

Under our calibration, the welfare loss from the combined shocks is decreasing in η.

More importantly, Figure 8 shows that in the presence of the ZLB constraint, the welfare loss is much lower under MGT than under IT for aggregate demand shocks as well as in the aggregate for every value of η shown. Under MGT, a smaller value of η leads to more variability in the nominal interest rate and therefore the frequency of ZLB episodes is higher. However, even with smaller values of η, the ZLB frequency remains lower under MGT than under either IT or PLT. In summary, variations in the interest semi-elasticity of money demand affect the performance of MGT, but it does not change our finding that MGT outperforms IT when the ZLB is occasionally binding.

3 The Fiscal Benefit of Stabilizing Money Growth

We now consider an explicit role for expansionary fiscal policy as an additional stabilization tool at the ZLB. That is, we no longer impose $\hat{g}_t = 0$ in every period t, as has been assumed so far in the analysis. Instead, in the scenarios considered here, we introduce a simple rule for the fiscal authority to raise government purchases during recessions. This simple fiscal rule takes the form

$$\hat{g}_t = \max\{0, -\psi \tilde{y}_t\}, \tag{12}$$

where the parameter $\psi \geq 0$ denotes the responsiveness of (real) government purchases in relation to the output gap in the same period t. The purchases are financed by lump-sum taxes. The "max" operator in the fiscal rule implies that, in any given period t, the fiscal authority raises government purchases above steady state, $\hat{g}_t > 0$, only when the output gap is negative, $\tilde{y}_t < 0$. By contrast, as long as output does not fall below its potential level, $\tilde{y}_t \geq 0$, then government purchases remain at steady state, $\hat{g}_t = 0$. We interpret this simple fiscal rule as a stylized representation of fiscal policy used as an asymmetric and automatic stabilizer to fight recessions; see, for example, Eichenbaum (2019) or Blanchard and Summers (2020).

Equipped with the fiscal rule (12), we proceed to study the implications of expansionary fiscal policy for the performance of a money growth target in the presence of a ZLB constraint. To calibrate the parameter ψ, we start by choosing a value that reflects the size of the American Recovery and Reinvestment Act (ARRA) of 2009. According to the Congressional Budget Office (2015), almost 75% of the *total outlays* under the ARRA, i.e. \$496 billion out of a total of \$663 billion, occurred from 2009 to 2011, or on average \$165.3 billion per year. During the same period, nominal potential GDP was on average \$15.68 trillion per year. Rather than employ the average output gap during 2009-2011, the severity of the recession is better captured by the trough output gap of -5.6% that occurred in 2009Q2.[18] Thus, in the fiscal rule (12), the ARRA would correspond to $\psi = (165.3/15,680)/0.056 \approx 0.19$ if the \$165.3 billion consisted entirely of government purchases of goods and services. However, outlays include transfers as well as purchases, and a large share of expenditures under ARRA were transfer payments.[19] We thus view $\psi = 0.19$ as an upper bound for the magnitude of ARRA through the lens of the model economy.

Furthermore, based on the Congressional Budget Office (2020, 2021), we carry out similar calculations for the Coronavirus Aid, Relief, and Economic Security (CARES) Act of 2020 and for the American Rescue Plan (ARP) of 2021. For both Acts, we use the trough output gap of -10.5% that occurred in 2020Q2, associated with the COVID-19 recession. These further calculations yield $\psi = 0.27$ for the CARES Act and $\psi = 0.45$ for the ARP. As was the case with the ARRA, a large share of the CARES and ARP programs constitute transfer payments. We therefore view these values for ψ as upper bounds for the programs passed in response to the COVID-19 recession. Their rising values does indicate that over the past dozen years, with the Fed's inflation targeting strategy and an era of low interest rates, fiscal policy has become increasingly active in fighting recessions alongside monetary policy.

With the ZLB, Figure 9 shows the effects of expansionary fiscal policy on the dynamic responses of the economy after a negative aggregate demand shock. The left panels have $\psi = 0$, as in Figure 3, while the right panels have $\psi = 0.19$, corresponding to the fiscal responsiveness based on ARRA. The dashed vertical line indicates the liftoff from the ZLB under IT. Under all three monetary policy regimes, if the output gap is negative, the increase in government purchases lifts the natural interest rate, which raises the output gap and inflation. Because there is more scope for fiscal stimulus under IT, the boost from the fiscal stimulus is largest under IT. With the fiscal stimulus, the recession is less deep under IT than under MGT for our benchmark negative aggregate demand shock.

The effect of fiscal policy on the nominal interest rate is barely visible under any regime. Under IT, the liftoff from the ZLB occurs and the fiscal stimulus is removed only when inflation is back

[18] We use data from the FRED database, series GDPC1, GDPPOT, and NGDPPOT. We compute the real GDP gap as GDPC1/GDPPOT−1.

[19] In fact, using BEA data on ARRA from the FRED database, transfers (series CUTRPAQ027SBEA) as a share of total expenditures (series TOTEXPQ027SBEA) represented just slightly over 75% of total expenditures under the ARRA. However, G in the model corresponds to purchases by the government sector and would therefore include spending by state and local governments. Thus, some ARRA transfers payments to state and local governments would count in our calibration of ψ.

at target. Under PLT, there is slightly less need of "low for longer" due to the fiscal stimulus and the slightly larger boost to inflation. And in the MGT regime, there is in principle scope for fiscal stimulus even if the ZLB is not binding, which would motivate less monetary stimulus. However, under our baseline calibration, with the coefficient of relative risk aversion set to $\sigma = 1$, government purchases crowd out consumption but raise the price level. The fall in consumption is exactly offset by the price increase, leaving the nominal income level unchanged; given equation (11), the nominal rate is not affected by the fiscal stimulus. With a larger value for σ (not shown), the fiscal stimulus would result in a fall in consumption that is smaller than the price increase, and nominal income rises. The fiscal stimulus would then raise the nominal rate under MGT.

To evaluate the policy regimes, Table 3 reports the effects of ARRA-equivalent fiscal policy on the welfare loss and ZLB frequency. The fiscal stimulus is particularly welfare enhancing for IT, but MGT still dominates IT. Because the fiscal stimulus in our model has little effect on the nominal interest rate under PLT (and no effect under IT and MGT), the ZLB incidence is barely affected.

With the ZLB, Figure 10 shows the welfare loss over a wide range of parameter values for the fiscal rule, $\psi \in [0, 0.7]$. The ARRA value $\psi = 0.19$ is indicated by a dashed vertical line, the CARES value $\psi = 0.27$ is indicated by a dash-dotted vertical line, and the ARP value $\psi = 0.45$ is indicated by a dotted vertical line. The $\psi = 0$ case corresponds to the baseline in Figure 8. Conditional on only aggregate demand shocks, the welfare loss is decreasing in ψ under all three regimes, but the effect is notably larger under IT than under MGT and PLT. The same is true when facing both types of shock together. MGT still dominates IT for values of ψ below the ARRA and CARES values. Only for the much larger fiscal response represented by the 2021 ARP does IT perform marginally better than MGT. Thus, if the fiscal authority fails to make up for a substantial share of the shortfalls in GDP, then IT performs worse than MGT from the perspective of society. In other words, relative to conventional IT, MGT is more desirable when fiscal space is limited.

4 Concluding Remarks

The current low-interest-rate environment, with the presence of an effective lower bound on nominal interest rates, has drawn increasing scrutiny to alternative monetary policy frameworks. A particularly debated framework is price-level targeting, which (conceptually) succeeds in making inflation expectations adjust automatically in a stabilizing fashion by ensuring the price level is trend stationary. Sixty years ago, Milton Friedman (1960) proposed a simple targeting rule for the money supply that also can ensure price-level trend stationarity. Yet recent debates on whether inflation targeting should be replaced by an alternative policy framework have failed to examine the role money growth targeting might play in alleviating problems arising from the lower bound on nominal rates.

In this paper, we investigate the performance of strict money growth targeting in the presence of a zero lower bound (ZLB) on nominal interest rates. We carry out the analysis in a simple New Keynesian model in which the ZLB binds occasionally, using a welfare measure to compare the performance of strict money growth targeting (MGT) with strict price level targeting (PLT) and standard flexible inflation targeting (IT). In each case, we characterize policy in terms of a targeting criterion that the central bank maintains unless constrained by the ZLB, rather than interpret alternative policy strategies in terms of the variables in a simple instrument rule. In the face of aggregate demand shocks and the ZLB, MGT clearly dominates IT, reducing the welfare loss by 77%, while reducing the frequency of hitting the ZLB from 20% to 0.2% (a 99% reduction).

A primary criticism of MGT has long been that it allows money demand shocks to affect output and inflation, whereas the economy is insulated from such shocks under IT and PLT. We calibrate the volatility of money demand shocks based on an estimate of the demand for MZM (money zero maturity) in the U.S. economy. When both aggregate demand shocks and money demand shocks are present, MGT leads to a welfare loss that is 63% lower than under IT, while the frequency of hitting the ZLB is reduced by 72%. Although PLT still delivers the best overall performance according to our welfare measure, MGT leads to significantly fewer periods during which the ZLB binds (25% under PLT versus below 6% under MGT).

The finding that MGT makes ZLB episodes less frequent is important. In fact, the advantages of PLT are based on the way in which, if credible, it can steer inflation expectations in a way that helps stabilize the economy at the ZLB. Because MGT, like PLT, delivers a stationary price level, MGT also generates stabilizing movements in inflation expectations. Yet, because the ZLB is much less frequent under MGT, monetary policy is constrained less often and therefore relies to a lesser extent on its credibility. For the same reason, it is also potentially less dependent on balance-sheet policies, or fiscal policy support, during recessions.

We also examine how an automatic fiscal response that occurs only when the output gap is negative affects performance under each targeting rule. When the fiscal response is calibrated based on the U.S. American Recovery and Reinvestment Act (ARRA) of 2009 or the Coronavirus Aid, Relief, and Economic Security (CARES) Act of 2020, we find that welfare under IT is significantly increased when such fiscal support occurs. However, despite the fiscal support, MGT still performs better than IT. Only with the much stronger fiscal response of the American Rescue Plan (ARP) of 2021 obtained by counting all outlays as purchases does IT improve over MGT. Therefore, IT may be much more dependent on large and supportive fiscal policies at the ZLB than either PLT or MGT.

The results of this paper suggest that the standard dismissal of a role for money in monetary policy may be unwarranted in a low-interest-rate environment in which episodes at the ZLB are increasingly common. While the framework we employ is a stylized, but common, New Keynesian model, our findings suggest a productive avenue for future research will be to explore the re-introduction of money into monetary policy in a wider class of model environments.

A Appendix

This appendix is organized in three parts providing some extensions and robustness checks to our baseline model. Appendix A.1 introduces a positive trend in the rate of inflation and money growth, thereby reducing the frequency of the ZLB and the benefits of MGT relative to IT. Appendix A.2 considers aggregate supply (markup) shocks, with negligible effects on the analysis. Appendix A.3 introduces nonnegligible welfare costs of money holdings, which are shown to increase the benefits of MGT relative to IT.

A.1 Positive Trend Inflation

The benchmark model assumes that inflation and money growth are equal to zero in steady state. Ascari and Sbordone (2014) discuss how, with positive trend inflation, the simple linearized Phillips curve with Calvo price rigidity is replaced by an inflation equation in which the coefficients depend on the underlying rate of trend inflation. In broader models designed to be taken to the data, the Calvo model is typically modified to assume that, in periods in which a firm is not optimally resetting its price, the firm follows a simple pricing rule. For instance, when it cannot optimize, the firm indexes its price to trend inflation, as in Coibion, Gorodnichenko and Wieland (2012), or to a combination of lagged inflation and the central bank's target inflation rate, as in Justiniano, Primiceri and Tambalotti (2013).[20]

We here allow for a positive trend in both inflation and money growth, by assuming that in any given period firms fully index prices to the trend rate of inflation $\pi \geq 0$ if they cannot reset prices optimally. In this case, the Phillips curve (1) and IS equation (2) remain the same as shown in the main text, but π_t now represents the deviation of inflation from trend and $\hat{\imath}_t \equiv i_t - \rho - \pi$. The money demand equation (3) also remains the same, but p_t and m_t now represent the deviations of the price level and nominal money holdings from trend paths. The inflation trend is pinned down by the growth rate of the money supply $\pi = \mu \geq 0$, under the maintained assumption of zero growth in real output. Thus, allowing for a positive trend in money growth raises the steady-state value of the nominal interest rate and therefore the ZLB constraint becomes $\hat{\imath}_t + \rho + \mu \geq 0$, which is less binding for $\mu > 0$.

Recall that under our baseline calibration, Table 2 showed that in the face of both aggregate

[20] Justiniano, Primiceri and Tambalotti (2013) assume indexation to $\pi_{t-1}^{\iota_p}\pi^{1-\iota_p}$ where π is trend inflation. Their posterior mean estimate is $\iota_p = 0.16$ so indexation is based primarily on the trend rate of inflation.

demand and money demand shocks, the frequency of the ZLB was 20.1% under IT but only 5.6% under MGT. This ZLB frequency under IT reflects the U.S. experience since 1983, during which core PCE inflation averaged 2.3% per year. The lower frequency of the ZLB was a major factor in the finding that MGT dominated IT from a welfare perspective. One might ask how much trend inflation would need to increase for the frequency of the ZLB under IT to be reduced to 5.6% to match MGT. To answer this question, we vary the growth rate of money and find that trend inflation would need to increase by just under 1.8 percentage points annualized for the ZLB frequency under IT to match that achieved under the baseline MGT simulations. We interpret this finding to mean trend inflation would need to rise from 2.3%, the historical average inflation rate used to calibrate the ZLB frequency, to 4.1% to achieve the same ZLB frequency as under MGT.

With the ZLB, Figure A1 shows the dynamic responses of the economy to the same negative aggregate demand shock as in Figures 2 and 3, but with μ and π set to 1.8% at an annual rate. In contrast with Figure 3, now the ZLB binds less often and the period at the ZLB under IT and PLT is much shorter. With IT and PLT, inflation and output fall just slightly due to the contractionary shock. As a consequence, MGT becomes less attractive relative to IT. In the limit, if μ is raised high enough, the ZLB ceases to bind and we are back in the case of Figure 2, where IT and PLT manage to fully stabilize the economy after aggregate demand shocks. That is, if the central bank sets the trend rate of money growth (and inflation) high enough that the ZLB rarely or never binds, then there is no benefit of adopting MGT (and very little of adopting PLT) relative to IT.

A.2 Supply Shocks

In our main analysis, we do not consider the effects of aggregate supply shocks, focusing on the effects of negative demand shocks that can push the economy to the ZLB. Aggregate supply shocks could arise from stochastic fluctuations in aggregate productivity or from markup shocks to the Phillips curve (1). A large, positive but temporary productivity shock would increase output, but the real interest rate would need to fall to ensure consumption also rose to maintain a zero output gap. Under IT, this could push the economy to the ZLB. However, in this case, the ZLB would be associated with a strong expansion of output, a scenario that does not align well with historical periods at the ZLB. A negative markup shock calls for an expansionary policy to stabilize inflation, but such shocks are unlikely to push the nominal interest rate to the ZLB. Nevertheless, we here introduce a markup shock u_t which gives rise to a trade-off between stabilizing inflation and output. In this case, the

Phillips curve (1) becomes

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa \tilde{y}_t + u_t. \tag{13}$$

Figure A2 shows the dynamic responses of the economy after a negative markup shock, $u_t < 0$, that warrants an expansionary monetary policy response under IT. To calibrate the shock u_t, we set its persistence $\rho_u = 0.9$, and we set its standard deviation $\sigma_u = 0.1\%$ so that under IT the nominal interest rate falls as much as half the way to the ZLB after a two-standard-deviation shock. Despite the shock, MGT keeps the policy rate unchanged and so is less effective stabilizing inflation but more effective stabilizing output, relative to the other regimes. In fact, under our baseline calibration, with the coefficient of relative risk aversion set to $\sigma = 1$, the shock reduces the price level but raises consumption, which exactly offset each other leaving the nominal income level unchanged. As nominal income is unchanged, and given equation (11), the nominal rate is not affected by the shock. However, with a larger value for σ (not shown), the shock would result in a fall in the price level that is larger than the increase in consumption, then nominal income falls and the nominal rate falls.

Furthermore, under all three policy regimes, the quantitative effects of markup shocks are relatively small. Under MGT, the fall in inflation due to the negative markup shock is only one-tenth of that caused by a negative aggregate demand shock at the ZLB (Figure 3). Because of the small volatility generated by markup shocks, the welfare costs associated with such shocks are also small. When measured by metric (4) and expressed as a fraction of the household's permanent consumption, the welfare loss due to markup shocks amounts to only 0.03% under MGT, 0.02% for IT, and 0.01% for PLT. These welfare losses are much smaller than those caused by shocks to aggregate demand and money demand if facing the ZLB (Table 2). In sum, the welfare consequences of introducing aggregate supply (markup) shocks into the analysis are negligible, relative to the effects of aggregate demand shocks and an occasionally binding ZLB constraint.

A.3 Welfare Costs of Money Holdings

Throughout the main analysis, we have assumed explicitly that the welfare consequences of money holdings are negligible. We now modify this assumption to investigate whether the model's predictions remain intact if accounting for nonnegligible welfare costs of money holdings.

Specifically, we modify the model to allow for changes in the nominal interest rate to act as a "tax" on money holdings. At the same time, to continue focusing entirely on the welfare effects due to fluctuations rather than steady-state distortions, we assume the steady-state return on money holdings equals the steady-state value of the nominal interest rate. Thus, we introduce into the welfare metric (4) an additional component associated with the volatility of the nominal interest rate, $(\eta\kappa/\lambda)\, var\,(\hat{\imath}_t)$. This term is consistent with Woodford (2003) chapter 6, assuming that household utility is additively separable in real monetary balances. Because we continue to assume the central bank does not pursue any goals other than inflation and output gap stability and therefore no other model equations are modified, the responses to shocks remain exactly the same as shown in the main text, even though the welfare loss is affected.

As in Figure 10, Figure A3 shows the welfare loss with the ZLB for different values of the fiscal rule responsiveness ψ, but now with nonnegligible welfare costs of money holdings. The welfare loss from money holdings is shown in the right panel. Conditional on only aggregate demand shocks or facing both types of shock together, the welfare cost of money holdings is notably lower under MGT compared to IT. This is because the nominal interest rate moves much more under IT and PLT (Figure 3). The welfare costs of money holdings are not affected by the responsiveness of fiscal policy under IT and MGT but are slightly decreasing in ψ under PLT (barely visible). Overall, MGT performs better than IT up to an even higher value of ψ than in Figure 10. Thus, including into the analysis the welfare costs of money holdings reinforce the benefits of MGT relative to IT.

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Table 1: Baseline calibration

Parameter	Description	Value
β	Discount factor	0.995
σ	Curvature of consumption utility	1
δ	Curvature of government purchases utility	1
φ	Curvature of labor disutility	5
ϵ	Elasticity of substitution of goods	9
α	Index of decreasing returns to labor	0.25
θ	Calvo index of price rigidities	0.75
η	Interest semi-elasticity of money demand	26
ψ	Fiscal rule coefficient on negative output gap	0
ρ_v	Persistence of money demand shock	0.92
ρ_z	Persistence of aggregate demand shock	0.9
σ_v	Std. deviation of money demand shock	0.11
σ_z	Std. deviation of aggregate demand shock	0.06

Note: Values are shown in quarterly rates.

Table 2: Welfare loss under the baseline calibration

	$\mathbb{L}$(%) no ZLB	$\mathbb{L}$(%) with ZLB	ZLB frequency (%)
Aggregate demand shock			
IT	0	4.55	20.1
PLT	0	0.04	25.1
MGT	1.04	1.04	0.2
Money demand shock			
IT	0	0	0
PLT	0	0	0
MGT	0.62	0.62	3.2
Both types of shock			
IT	0	4.55	20.1
PLT	0	0.04	25.1
MGT	1.67	1.68	5.6

Note: $\mathbb{L}$ is the permanent consumption loss from fluctuations.

Table 3: Effects of fiscal policy on welfare loss under the ZLB

	$\psi = 0$		ARRA $\psi = 0.19$	
	$\mathbb{L}$(%)	ZLB frequency (%)	$\mathbb{L}$(%)	ZLB frequency (%)
	Aggregate demand shock			
IT	4.55	20.1	2.40	20.1
PLT	0.04	25.1	0.03	25.0
MGT	1.04	0.2	0.97	0.2
	Money demand shock			
IT	0	0	0	0
PLT	0	0	0	0
MGT	0.62	3.2	0.58	3.2
	Both types of shock			
IT	4.55	20.1	2.40	20.1
PLT	0.04	25.1	0.03	25.0
MGT	1.68	5.6	1.57	5.6

Note: $\mathbb{L}$ is the permanent consumption loss from fluctuations.

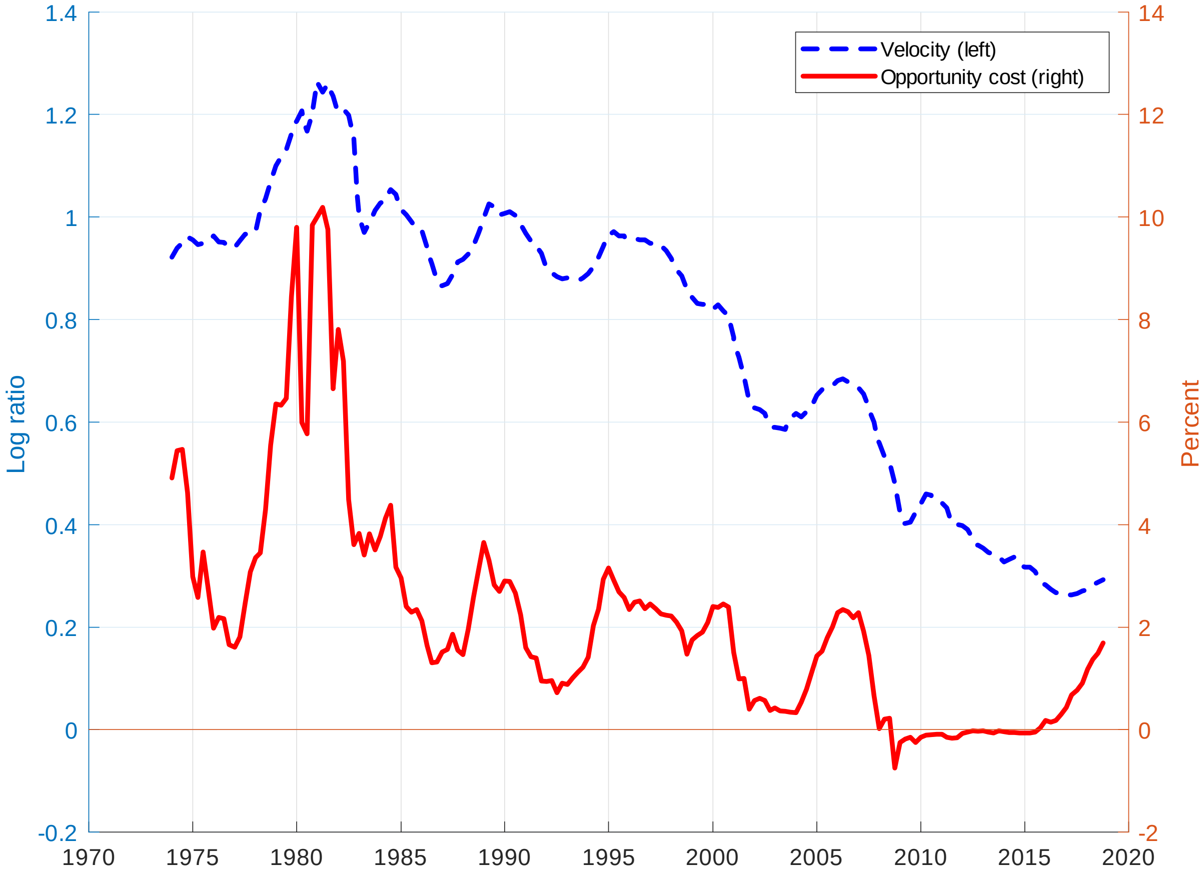

Figure 1: Velocity of MZM money stock and the opportunity cost. Source: FRED database.

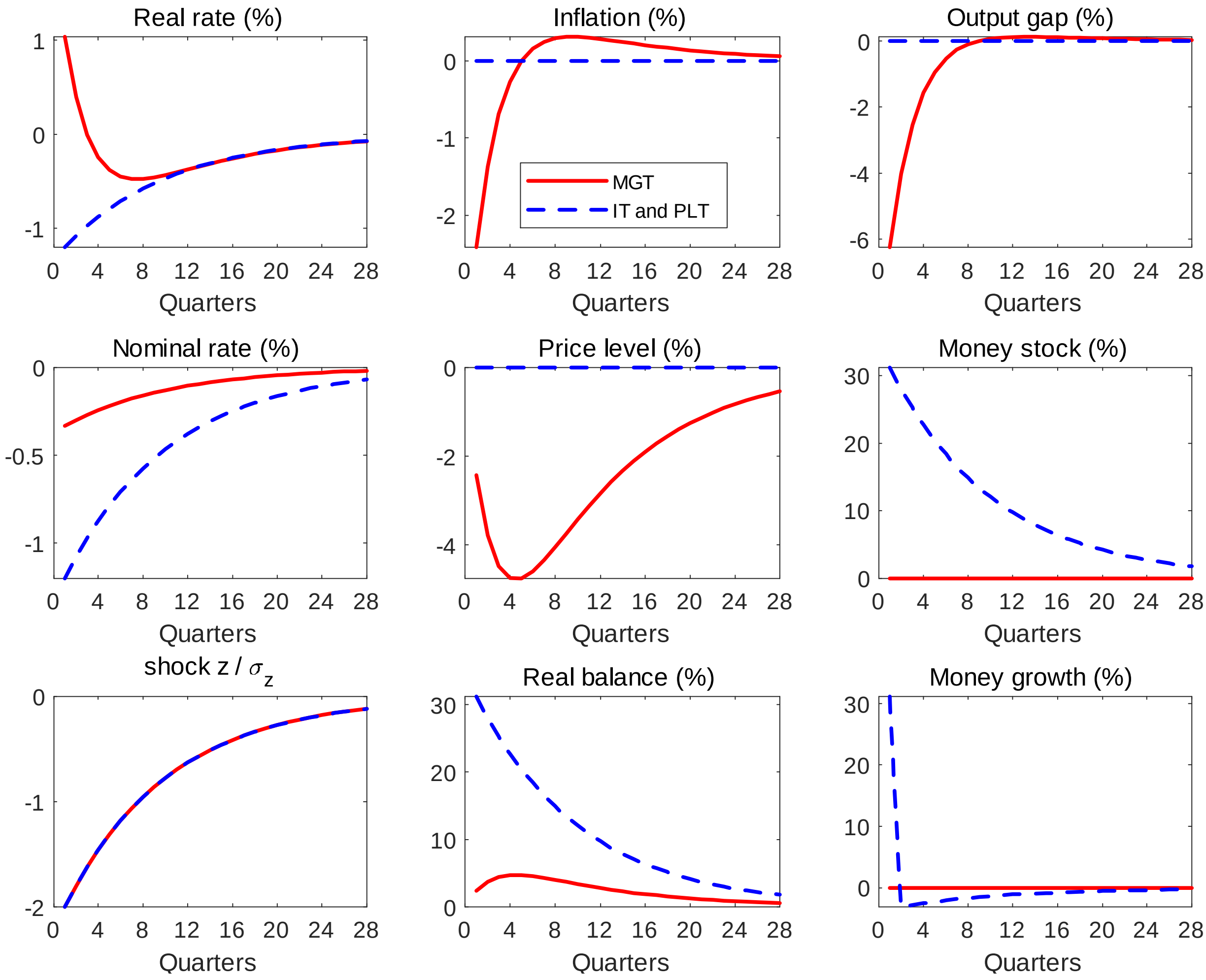

Figure 2: Responses to a negative aggregate demand shock without ZLB. Deviations from steady state.

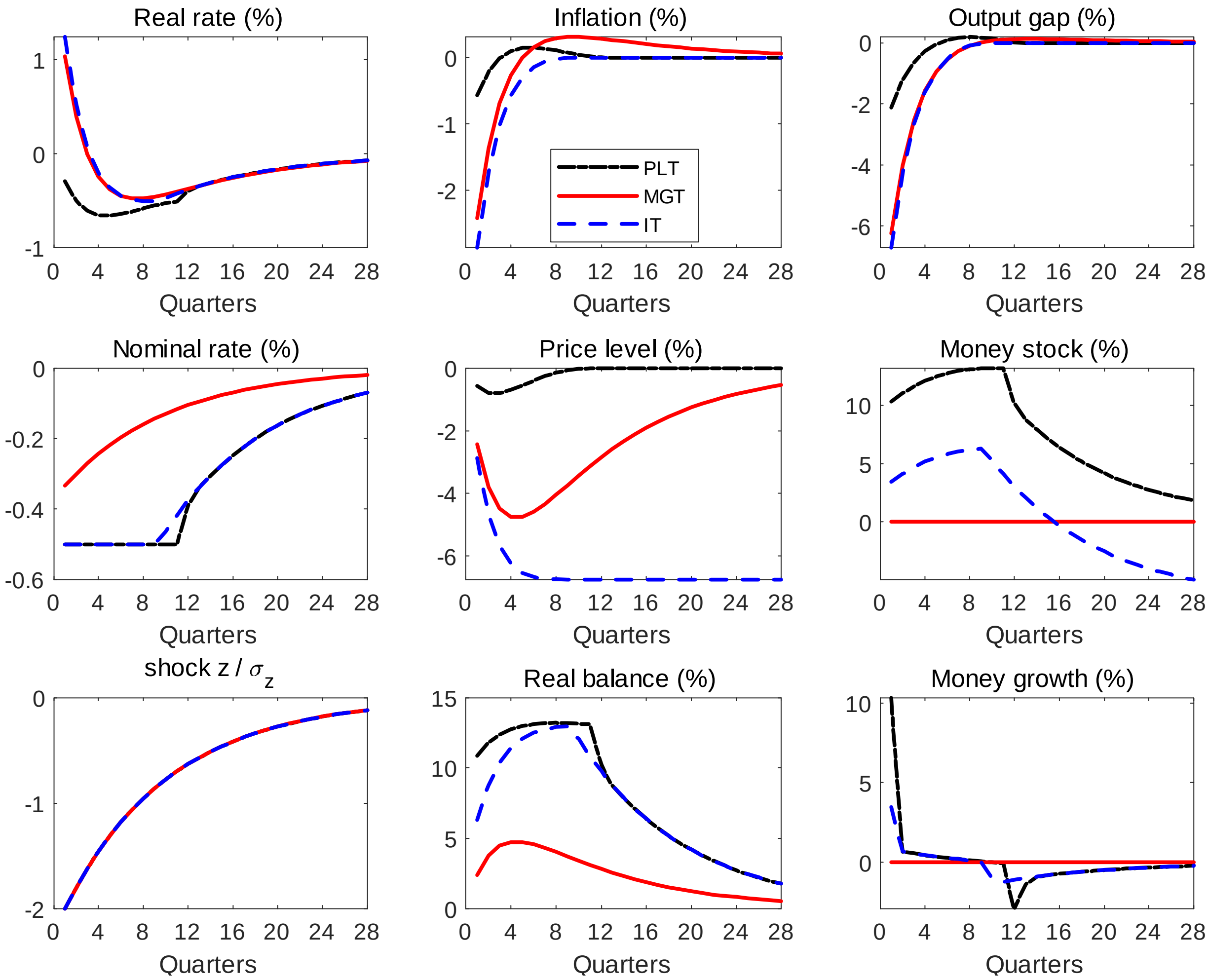

Figure 3: Responses to a negative aggregate demand shock with ZLB. Deviations from steady state.

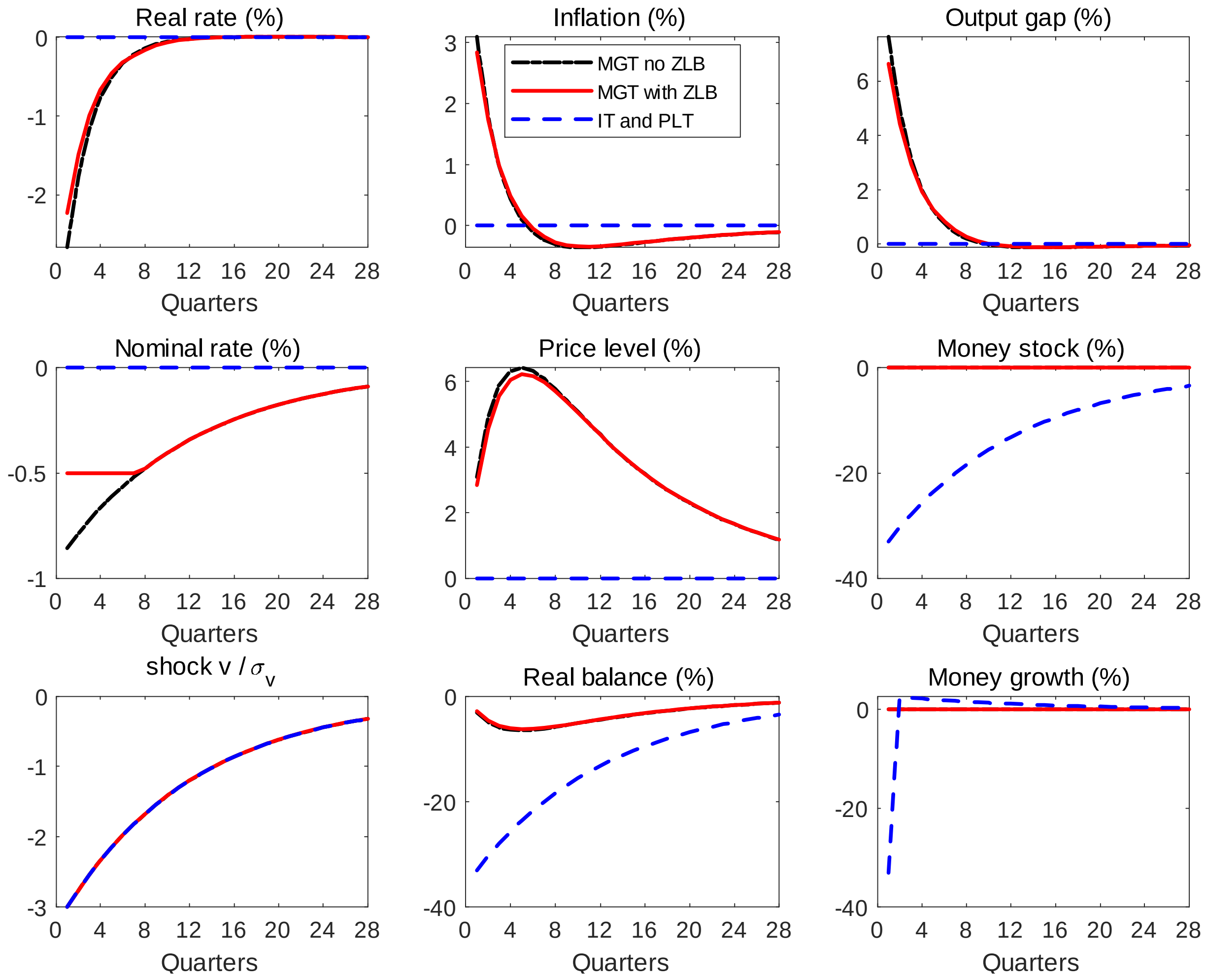

Figure 4: Responses to a negative money demand shock with and without ZLB. Deviations from steady state.

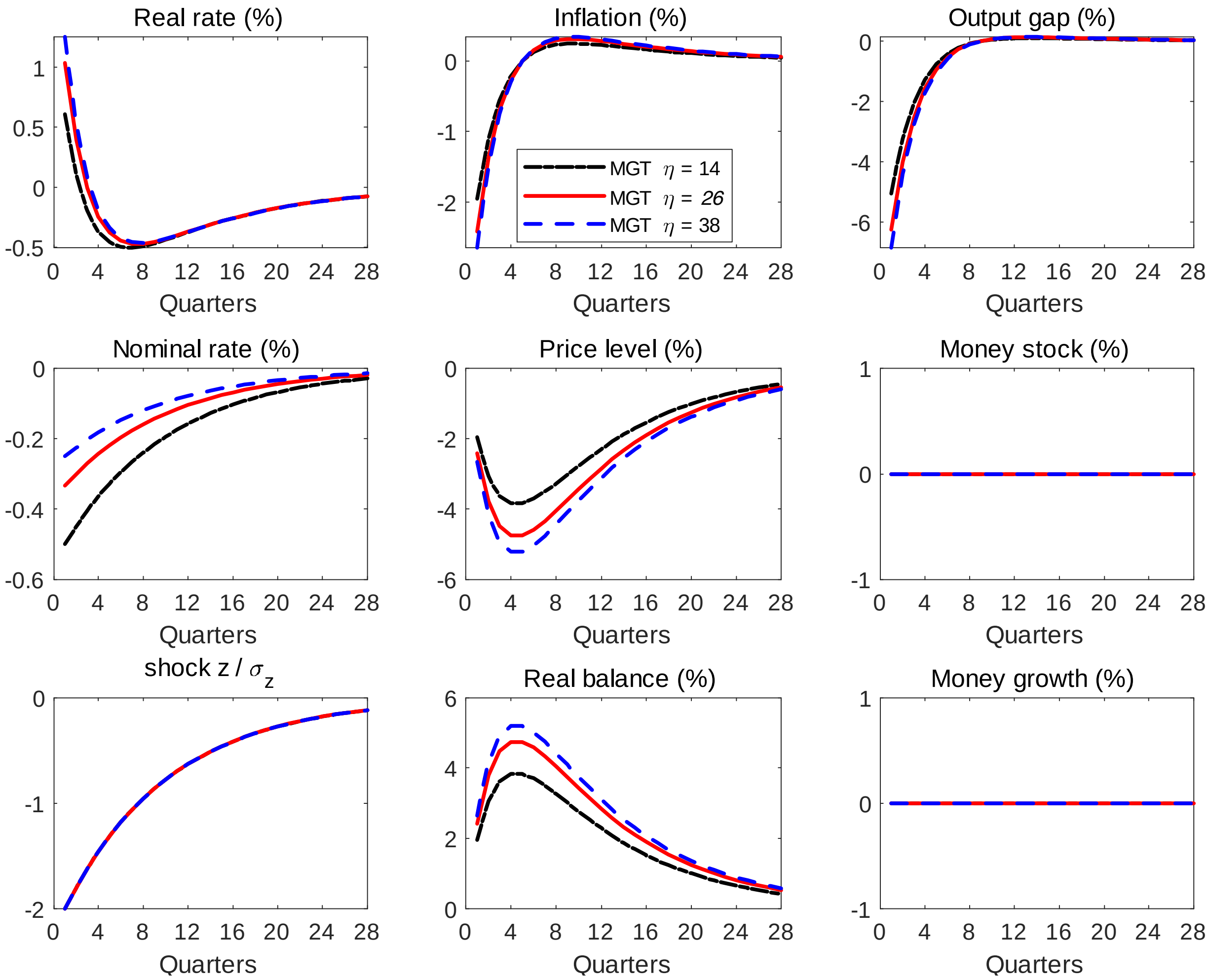

Figure 5: Responses to a negative aggregate demand shock under MGT and the sensitivity to money demand elasticity with ZLB. Deviations from steady state.

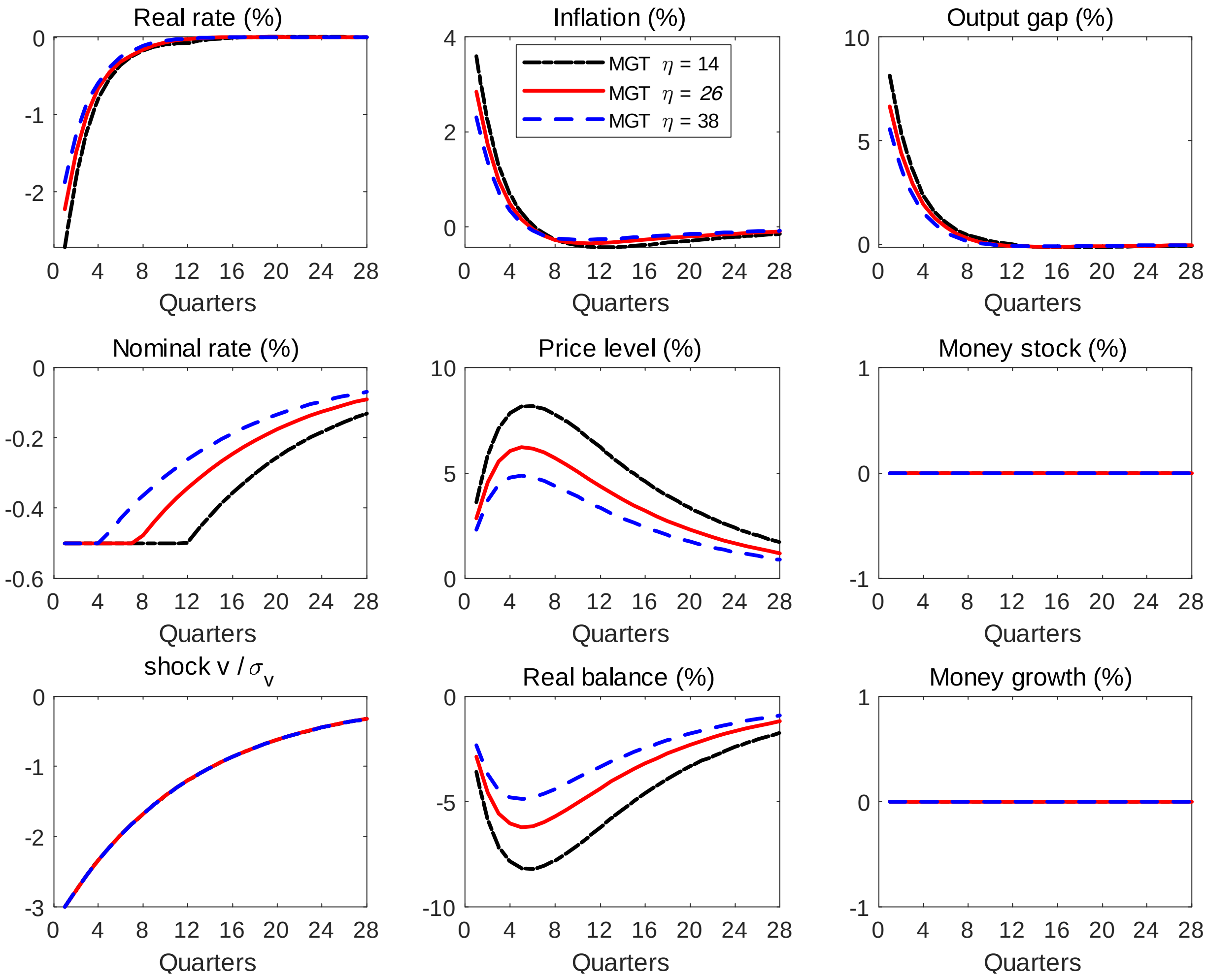

Figure 6: Responses to a negative money demand shock under MGT and the sensitivity to money demand elasticity with ZLB. Deviations from steady state.

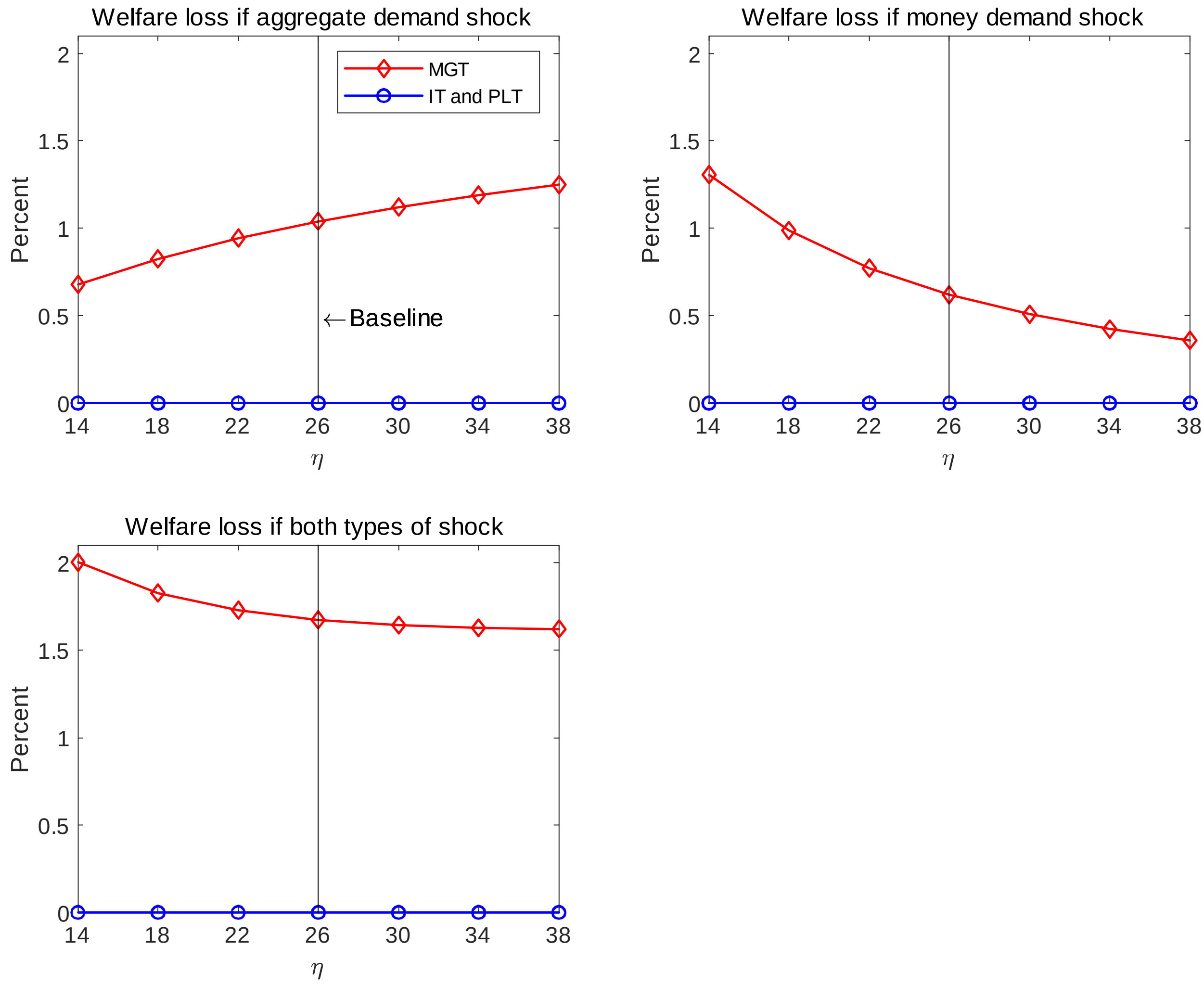

Figure 7: Welfare loss and the elasticity of money demand without ZLB. Percent of permanent consumption.

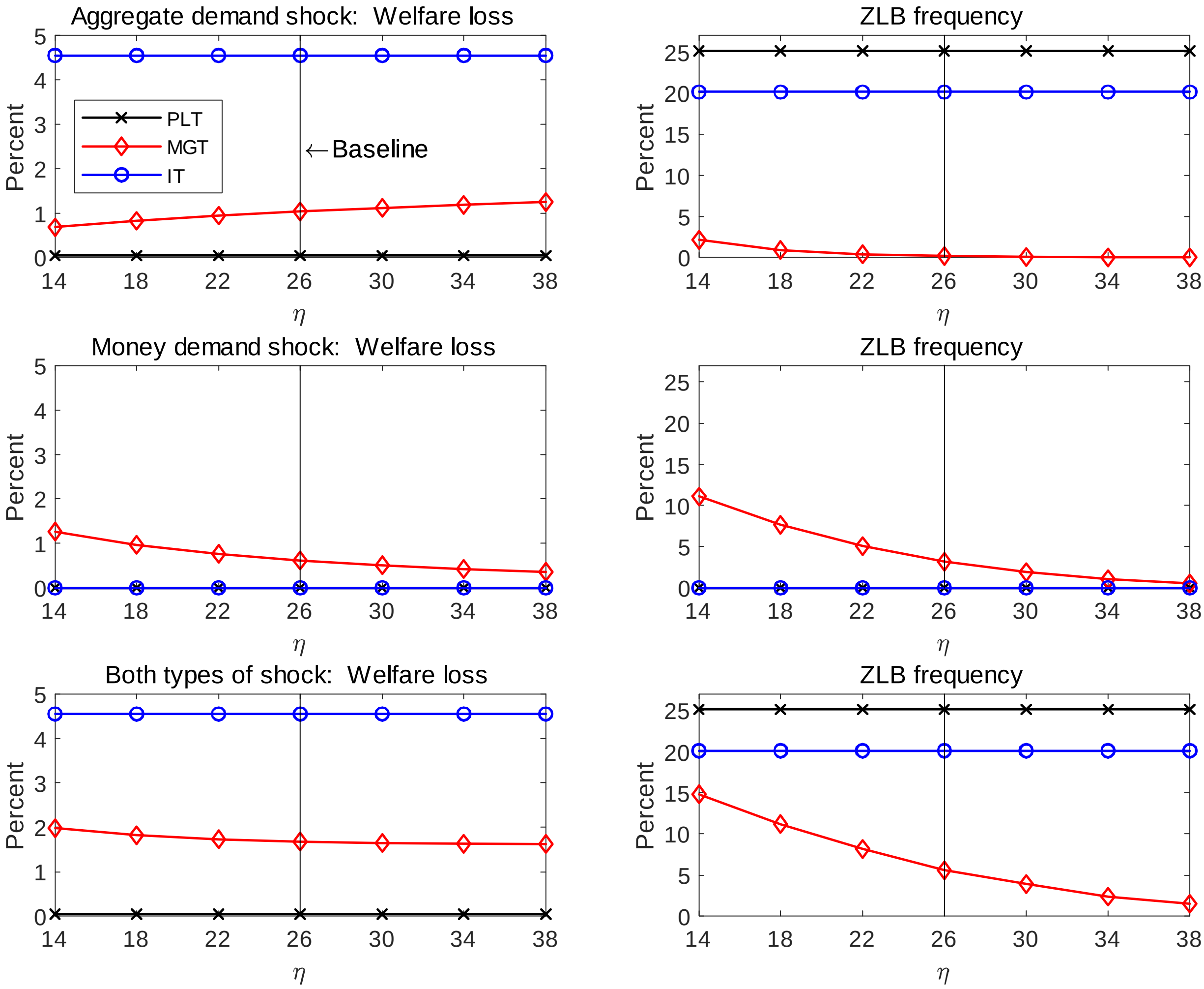

Figure 8: Welfare loss and the elasticity of money demand with ZLB. Percent of permanent consumption.

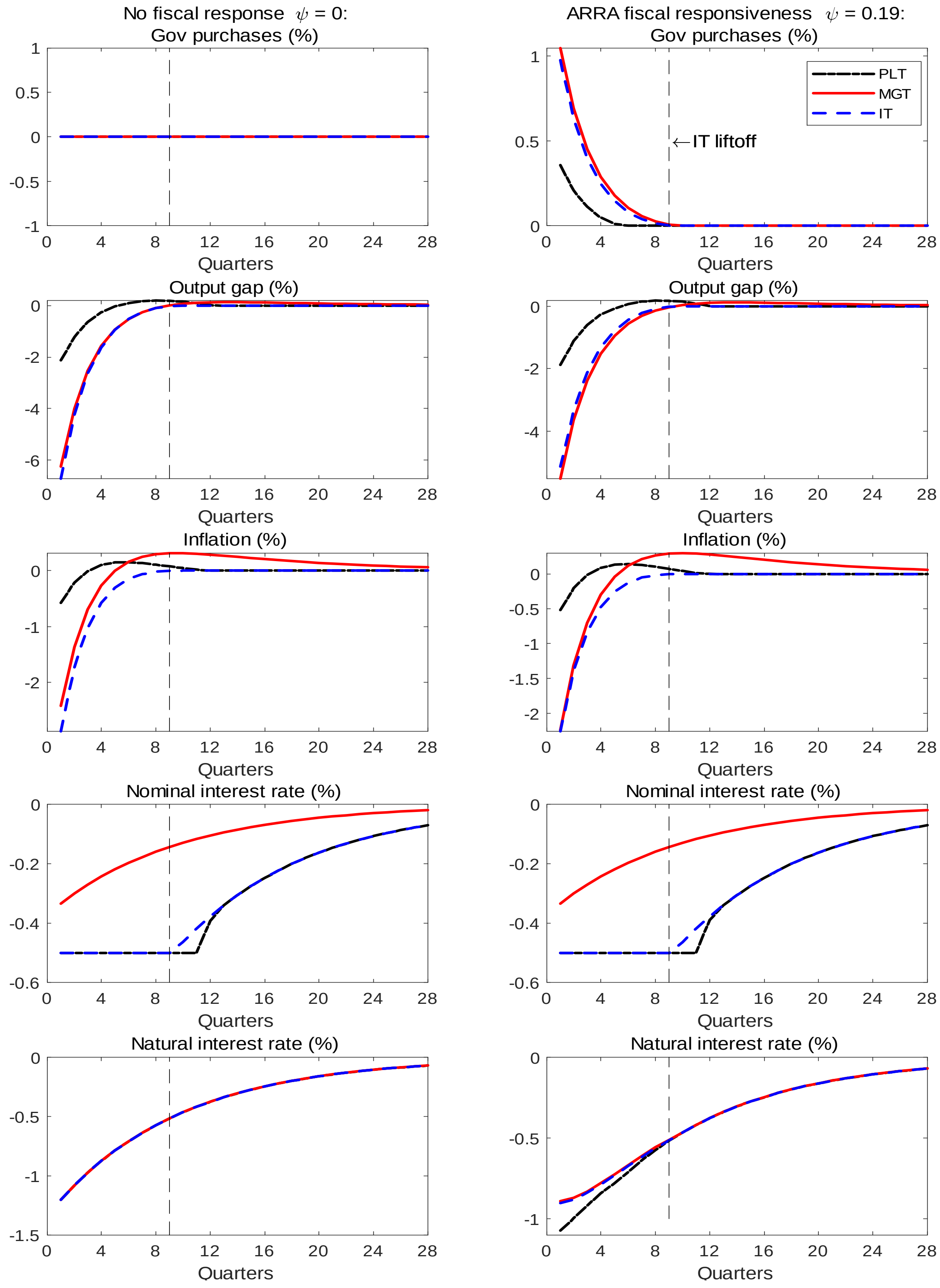

Figure 9: Effects of an increase in government purchases during ZLB episode. Deviations from steady state due to a negative aggregate demand shock of two standard deviations.

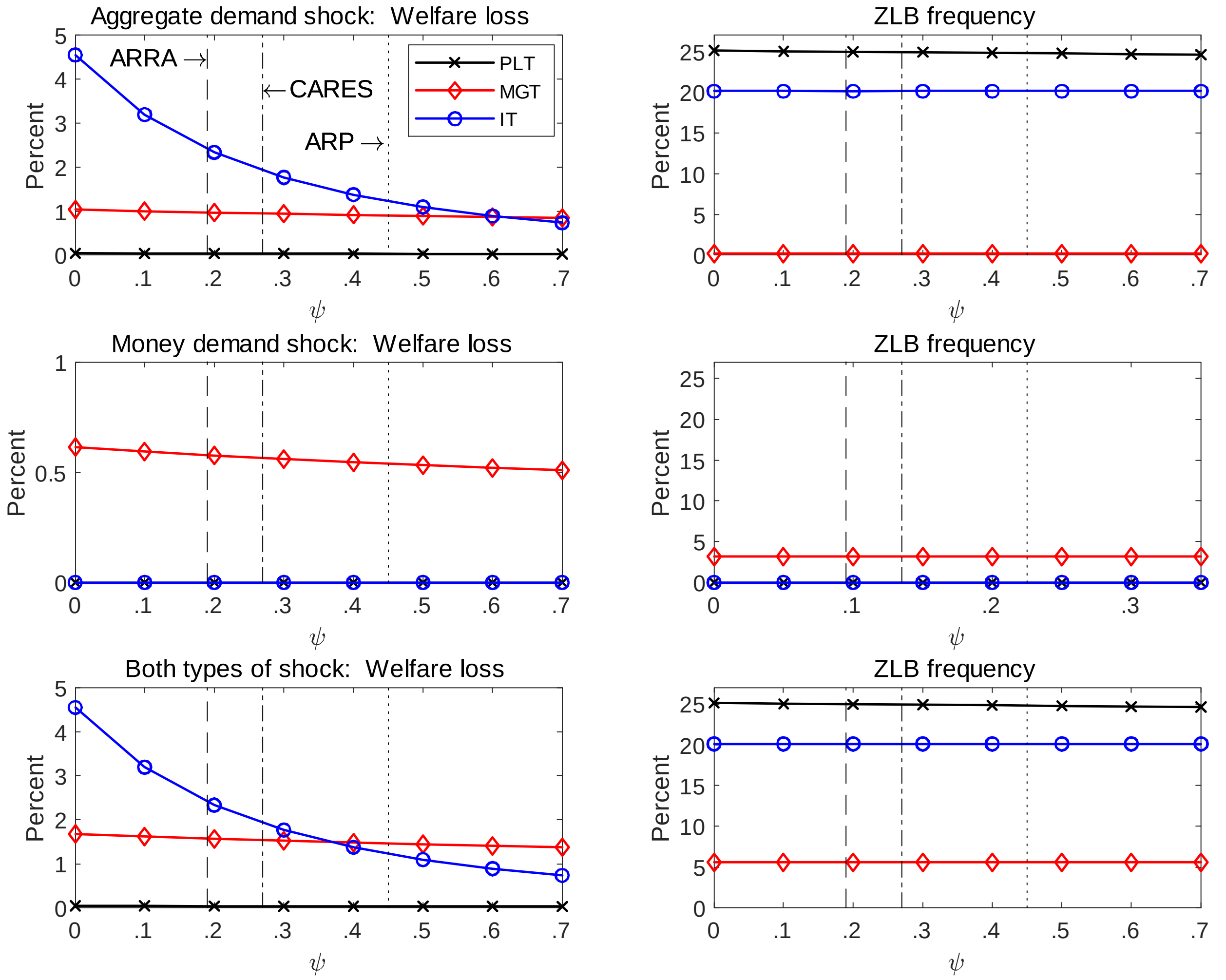

Figure 10: Welfare loss and the responsiveness of government purchases with ZLB. Percent of permanent consumption.

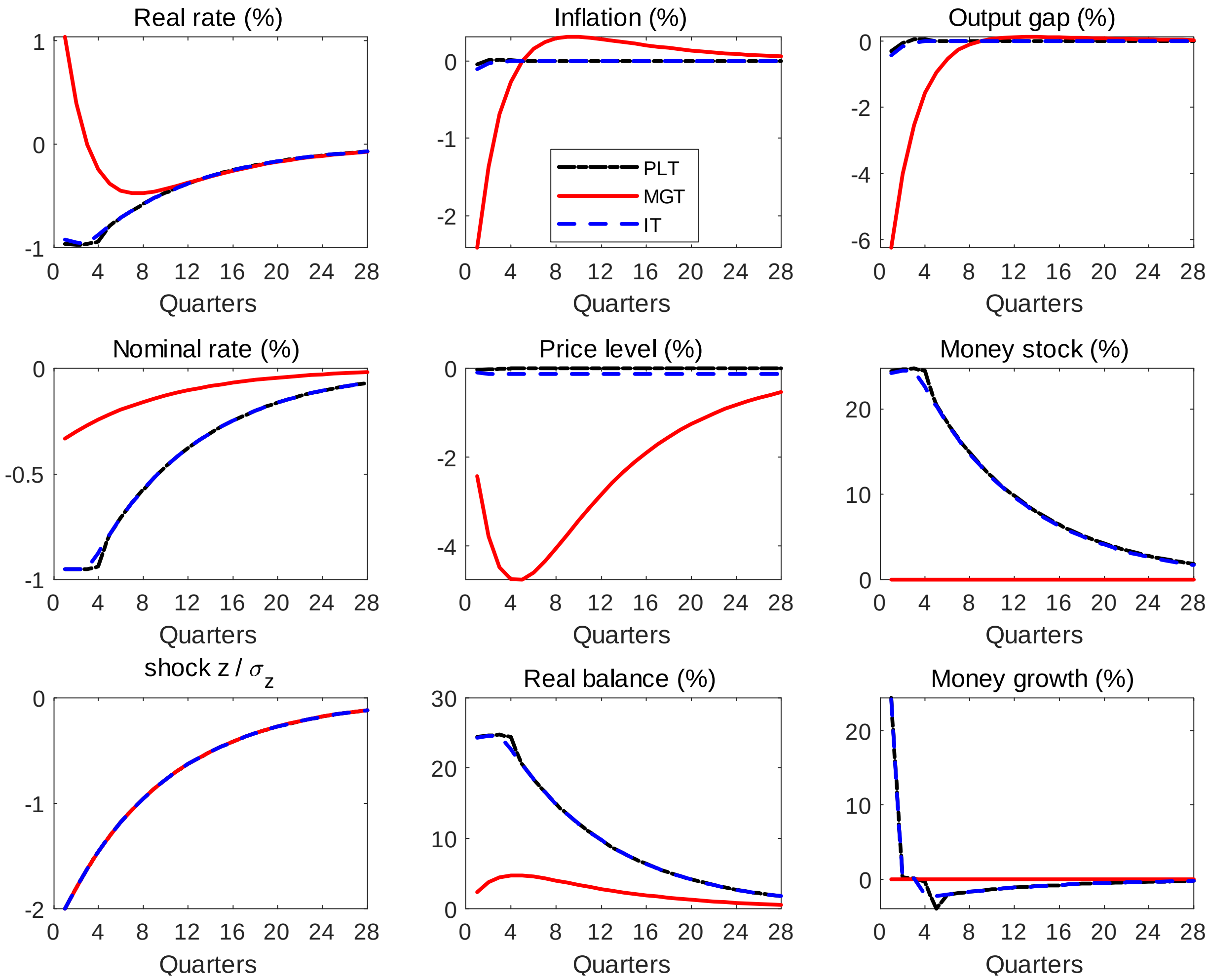

Figure A1: Responses to a negative aggregate demand shock under positive trend inflation with ZLB. The trend in inflation is 1.8 percent annualized. Shown are deviations from *trend rate* (money growth and inflation), *trend path* (money stock and price level), and *steady state* (output and interest rates).

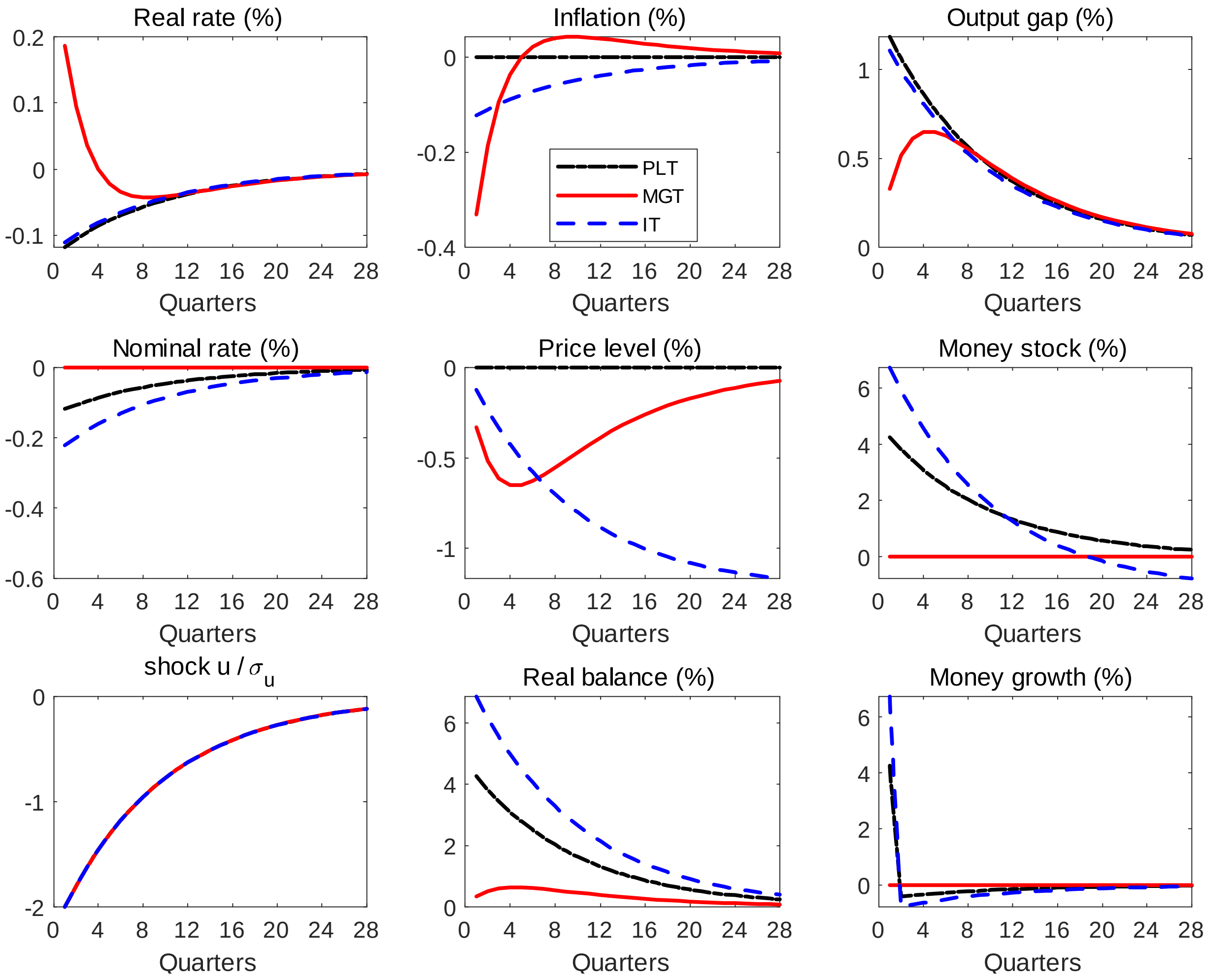

Figure A2: Responses to a negative markup shock, ZLB not reached. Deviations from steady state.

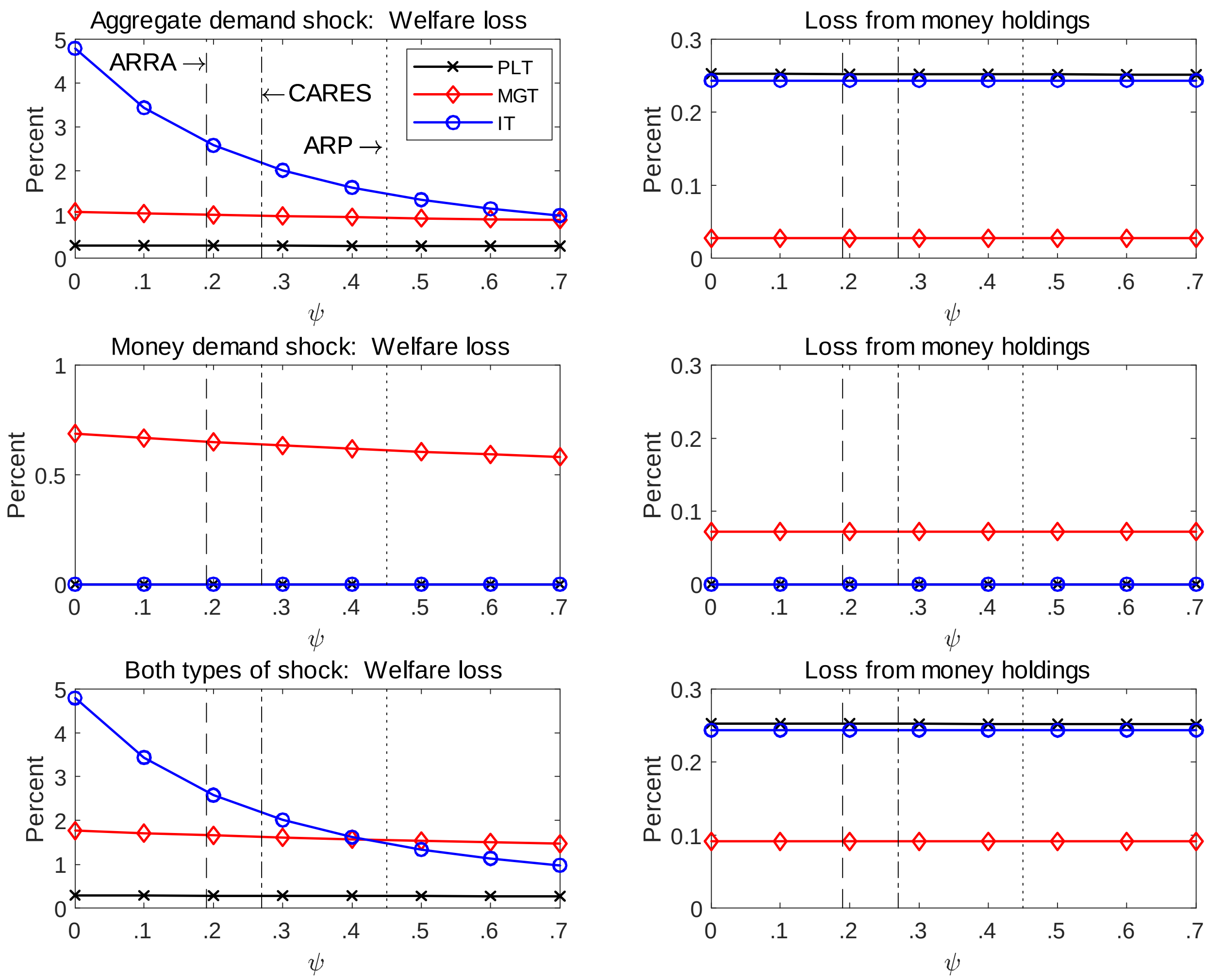

Figure A3: Welfare loss with costs of money holdings and the responsiveness of government purchases with ZLB. Percent of permanent consumption.