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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 merit of a money growth target (MGT) relative to a conventional inflation targeting (IT) regime, and to the notion of price level targeting (PLT). Through the lens of a New Keynesian model, and accounting for a zero lower bound (ZLB) constraint on the nominal interest rate, we show, not surprisingly, that PLT performs best in terms of social welfare. However, the ranking between IT and MGT is not a foregone conclusion. In particular, although MGT makes monetary policy vulnerable to money demand shocks, it contributes to achieving price level stability and reduces the incidence and severity of the ZLB relative to both IT and PLT. We also show that MGT lessens the need for the fiscal authority to engage alongside the central bank in fighting recessions. 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.

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

JEL: E31, E42, E52.

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1 Introduction

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 that the ECB too would conduct a similar review. One important motivation for such reviews arises from concerns that current strategies will prove inadequate in an environment of a lower natural rate of interest and more frequent episodes with policy rates constrained by the effective lower bound on nominal interest rates. When this constraint is binding, policy rate cuts are no longer an efficient measure to stabilize the economy after a contractionary shock, 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 resulted in households and firms expecting that inflation will be higher in the future, because the rise in expected inflation would reduce real interest rates and help stimulate economic activity. Such a stabilizing move in inflation expectations might occur if the public believed the central bank was committed to compensating for periods of below-target inflation by allowing inflation to temporarily rise above the target. If the central bank can credibly commit to reverse past target misses, then inflation expectations would move in a manner that helps stabilize the economy when the policy rate is constrained at its lower bound. In this case, the adjustment of inflation expectations would serve as a form of automatic stabilizer, offsetting the central bank's inability to stimulate the economy with policy rate cuts.

A key question to be addressed by the Fed's review is "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?" (See Clarida (2019a).) The research that has addressed this question has focused on replacing the Fed's current strategy of flexible inflation targeting with a 2 percent target inflation rate 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.[1]

Absent from the strategic policy review of the Federal Reserve has been 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 the "long and variable lags" in the effects

[1] See, for example, the discussion of these alternatives in Svensson (2020). See also Walsh (2019) for references and a review of the literature on these alternative targeting regimes.

of monetary policy meant that attempts to employ cyclical variation in the money supply to stabilize the economy would actually be more likely to increase instability. He advocated, therefore, for the Federal Reserve to ensure the money supply grew at a constant rate (the k-percent growth rule). Nevertheless, Clarida (2019b) (p. 12) dismisses monetary growth targeting (MGT) explicitly, by stating "...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 dismissal is surprising, given two recent challenges for the current monetary policy framework: (1) the effective lower bound on policy rates has become a more pressing constraint for monetary policy; and (2) fiscal space has potentially shrunk, limiting the potential uses of fiscal policy to compensate for any limits on monetary policy arising from the effective lower bound. A key ingredient of "make up" policies such as price level targeting is that they induce (trend) stationarity in the price level. It is this belief that the price level will return to a long-run path that ensures inflation expectations adjust in a stabilizing fashion. Credible money growth targeting also induces trend stationarity in the price level and so would also ensure inflation expectations adjust in a stabilizing fashion. Thus, a full review of the Fed's monetary strategy 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 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.

In contrast to 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 in a basic New Keynesian model that is subject to stochastic fluctuations in the natural rate of interest and to money demand shocks.[2] And in addition to accounting for the ZLB, we employ a model-consistent measure of welfare to rank outcomes under different policies. We show that, as expected, 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 stability and reduces the incidence and severity of the ZLB relative to both PLT and IT. As a consequence, MGT outperforms IT in the face of aggregate demand shocks.

[2] See Svensson (2020) for a recent discussion of the advantages of targeting rules over instrument rules.

When monetary policy is constrained by the effective, or zero, lower bound, fiscal policy can play an important role.[3] However, evaluations of monetary policy strategies usually ignore the role of countercyclical fiscal policy. We show that MGT lessens the need for the fiscal authority to engage alongside the central bank in fighting recessions. 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. If debt concerns faced in many countries have reduced the space for fiscal policy to respond when monetary policy is constrained, then monetary policy strategies that ensure inflation expectations act as an automatic stabilizer at the ZLB and reduce the likelihood of episodes at the ZLB that might require fiscal support, both of which MGT does, are particularly desirable.

The rest of the paper is organized as follows. Section 2 provides a literature review, with the focus primarily on recent work investigating money growth policies in New Keynesian frameworks. In section 3, we set up a simple New Keynesian model, and describe our characterization of flexible inflation targeting, price level targeting, and money growth targeting, as well as the calibration of the model. Our main results are reported in section 4. A rule for fiscal policy is introduced in section 5. Conclusions are summarized in the final section.

2 Related Literature

While the Fed never adopted Friedman's k-percent rule for monetary growth, the Federal Open Market Committee (FOMC) began to announce target growth rate ranges for various monetary aggregates after the passage of U.S. House Concurrent Resolution 133 in 1975. The FOMC's policy was criticized by Broaddus and Goodfriend (1984) for resetting the target level each period, a practice known as base drift. This practice allowed temporary errors in the control of money growth to result in permanent changes in the price level. Empirical evidence that the Fed's strategy had resulted in a nonstationary price level was reported in Walsh (1984), although Walsh (1986) established conditions under which full or partial base drift could be consistent with optimal policy. However, it was debatable how important these monetary targets were in the actual conduct of Fed policy; Cook

[3] 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 will follow the literature and treat its value as equal to zero. But our analysis is equally valid with a negative effective lower bound.

(1989), for example, argued that the operating procedures designed to control aggregate reserves were actually used to exercise interest rate control rather than to control money growth.

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 (NK) model during the 1990s, which led to "macroeconomics without the LM Curve," as discussed in Romer (2000). Monetary aggregates disappeared from mainstream monetary policy models, and any pretense of monetary targeting eventually gave way to policy frameworks employing a short-term interest rate in support of objectives such as inflation targeting.

When the ECB was established, it framed monetary policy in terms of inflation and money growth—the so-called dual pillars. The inclusion of money growth as one of the pillars 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, but 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 ECB has almost entirely focused on the price stability target rather than the money growth target.

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. When money-focused policy was considered, it was usually in the context of a fixed target for money growth that was then compared to an optimal interest rate policy or an interest rate instrument rule that responded to inflation and economic activity. For example, Woodford (2003) (p. 298) compared an optimal interest rate policy to a policy that fixes 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. Neither Ireland (2000) nor Collard and Dellas (2005) considered the relative performance of MGT and alternatives in the face of the ZLB. Interestingly, Collard and Dellas found that while their interest rate rule led to more stable output and consumption in the face of money demand shocks, MGT did best in the face of money demand shocks when household welfare, rather than output volatility, was used to rank alternative policies.[4] 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; Galí found the welfare loss in the face of demand and technology shocks was much larger under a money growth peg than under a Taylor rule, though this difference arose primarily from the poor performance of the money growth policy in the face of technology shocks.[5]

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). Thus, deviations from constant money growth can be traded off against deviations from the inflation and output gap targets—i.e., he analyzed a "flexible money growth targeting" regime. He found that extending inflation targeting to incorporate a 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. While policies such as flexible inflation targeting, price level targeting and nominal income targeting have been analyzed accounting for the ZLB,[6] Belongia and Ireland (2018, 2019) are, to our knowledge, the only studies of monetary growth targeting in the face of the ZLB.[7] 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 conclude 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,

[4] The reason for this result is the negative covariance between consumption and leisure generated by MGT. Collard and Dellas (2005) assume non-separability in utility with respect to money balances and both leisure and consumption, and in their baseline calibration, money and consumption are substitutes, while money and leisure are complements. Thus, under MGT in response to a positive money demand shock, the interest rate rises and consumption falls, but leisure rises, muting the effects on household welfare.

[5] Galí (2015) also compares a Taylor rule to a fixed money growth rate showing that, absent money demand shocks, MGT achieves the same welfare loss as an interest rate rule that only includes inflation (see Tables 4.1 and 4.2 on pp. 113 and 119, respectively).

[6] See, for example, Adam and Billi (2006, 2007), and Billi (2011, 2017).

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

thus including the 2008 to 2016 period during which the funds rate was at its 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 also found that a constant money growth rate rule generally did more poorly. Even so, Belongia and Ireland's counterfactual simulations suggest interest rates would have fallen below zero for only four quarters during the financial crisis and Great Recession and that the U.S. economy would have experienced a faster recovery under a constant money growth rate rule. However, they did not provide a welfare ranking of the alternative rules they considered. In addition, they impose the ZLB only when analyzing 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 considered 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. have had "little effect on the volatility of aggregate output fluctuations or on their welfare costs despite stabilizing aggregate consumption" 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.

English et al. (2017) and Galí (2019) analyzed the effectiveness of money-financed fiscal stimulus when the economy is at the ZLB. Both considered monetary policies in which money growth is used to finance an increase in government spending.[8] English et al. (2017) found that a money-financed increase in government purchases leads to a significant rise in inflation and an expansion in real GDP. In addition, they found that such a money-financed fiscal expansion quickly boosts interest rates above the ZLB. They also showed how such a money-financed fiscal policy can be interpreted as equivalent to an interest rate rule that responds to a price level target, where the target price level depends on the fiscal expansion. If such a policy is fully credible, the large upward shift in the target for the price level is largely responsible for the strength of the money-financed fiscal expansion. Both English et al. (2017) and Galí (2019) pointed out the challenges such money-financed fiscal policy

[8] Galí (2019) also considers the case of a money-financed tax cut.

raise in terms of the policy coordination required and the threats posed to central bank independence.

In contrast to money-financed fiscal policy, the fiscal policy we analyze involves a traditional fiscal rule that does not involve monetary financing. We thus do not consider 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 supporting fiscal policies at the ZLB. And 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.

3 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. In all regimes, monetary policy is implemented using the nominal interest rate as the policy instrument. Next we introduce the equations describing the model's equilibrium. Then we estimate a stable money demand relationship in U.S. data, and rely on a standard calibration of the model as a baseline for our analysis.

3.1 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, e.g., Galí (2015, chapter 3), Walsh (2017, chapter 8), and Galí (2019).

The supply side of the economy is described by a New Keynesian Phillips curve representing the dynamics of price inflation π_t:[9]

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa \hat{y}_t - \lambda \sigma \hat{g}_t, \tag{1}$$

where $\pi_t \equiv \Delta \hat{p}_t = \hat{p}_t - \hat{p}_{t-1}$ is the rate of price inflation between periods $t-1$ and t, and where $\hat{p}_t \equiv \log(P_t/P)$ is the (log) price level expressed in deviation from its steady state. Moreover, $\hat{y}_t \equiv \log(Y_t/Y)$ denotes (log) output in deviation from its steady state, and $\hat{g}_t \equiv (G_t - G)/Y$ denotes (real) government purchases expressed as a fraction of steady state output.[10] 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 its steady state. The slope of the Phillips curve is given by $\kappa \equiv \lambda \left(\sigma + \frac{\alpha+\varphi}{1-\alpha}\right)$, where $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)(1-\alpha)}{\theta(1-\alpha+\alpha\epsilon)}$, and where $\theta \in [0,1)$ is the Calvo index of price rigidity (the probability that a firm does not reset its price in a given period), and $\epsilon > 1$ denotes the elasticity of substitution among varieties of goods. The parameters σ, φ and β denote the household's coefficient of relative risk aversion, the curvature of labor disutility and the discount factor, respectively, and the parameter α denotes the degree of decreasing returns to labor in production.

The demand side of the economy is described by the following two expressions representing a dynamic IS equation and a money demand equation, respectively:[11]

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

$$\hat{m}_t - \hat{p}_t = \hat{c}_t - \eta \hat{\imath}_t + v_t, \tag{3}$$

where $\tilde{y}_t \equiv \hat{y}_t - \hat{y}_t^n$ denotes the output gap, and where $\hat{y}_t^n$ represents the (log) natural level of output, i.e. its equilibrium level in the absence of nominal rigidities. The natural (or flexible-price) level of

[9] Equation (1) is derived from the aggregation of the price setting decisions of firms, in an environment in which such re-optimization takes place with probability $1-\theta$ in any given period.

[10] An increase in government purchases raises the natural level of output and thus puts downward pressure on inflation for a given level of output, which explains the presence of the term $-\lambda\sigma\hat{g}_t$ in equation (1).

[11] Equations (2) and (3) are derived from the optimality conditions of the representative household's utility maximization problem under two assumptions. First, real money holdings (or real balances) are assumed to provide a "transactions service" that households value in terms of utility. It is the real value of monetary holdings that enters the household's utility function because the service that any nominal amount of money can yield depends on its purchasing power. The introduction of money in the utility function (MIU) allows the money demand equation to be derived from the household's optimal behavior. 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 aggregate supply and IS equations in the model. Walsh (2017), chapter 2, shows that, even under a utility that is non-separable in real monetary balances, the real-balance effects tend to be quantitatively negligible when prices are flexible.

output is given by $\hat{y}_t^n \equiv \Gamma \hat{g}_t$, where $\Gamma \equiv \frac{\sigma(1-\alpha)}{\alpha+\varphi+\sigma(1-\alpha)}$. In addition, $\hat{\imath}_t \equiv i_t - \rho$ denotes the short-term nominal interest rate expressed in deviation from its steady state, and the latter corresponds to the discount rate $\rho \equiv -\log \beta$. The short-term real interest rate is given by $\hat{\imath}_t - E_t\{\pi_{t+1}\}$, while 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 (or aggregate demand shock) which is assumed to follow an exogenous $AR(1)$ process with autoregressive coefficient ρ_z and standard deviation σ_z.[12]

Moreover, in the above money demand relationship, $\hat{m}_t \equiv \log(M_t/M)$ denotes the household's (log) nominal money holdings in deviation from its steady state. We note that the *inverse* velocity of circulation of the money stock is then given by $\hat{m}_t - \hat{p}_t - \hat{c}_t$, expressed as a deviation from its steady state. The parameter $\eta \geq 0$ denotes the interest semi-elasticity of money demand. Finally, 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.[13] The main focus of our analysis below is to study the potential relevance of money holdings for the conduct of monetary policy in the presence of a ZLB constraint.

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 loss experienced by the representative household as a result 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[14]

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

[12]This shock's innovation is assumed 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.

[13]This shock's innovation is assumed an i.i.d. normally distributed process with zero mean and standard deviation given by $\sigma_{ev} = \sigma_v\sqrt{1-\rho_v^2}$.

[14]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. As a consequence, changes in the nominal interest rate, which acts as a "tax" on money holdings, are only a minor source of the welfare loss due to fluctuations in the economy. Such a welfare metric, thus, corresponds to the case of a "cashless limit" economy in an MIU model, in which the equilibrium real balances are small and the velocity of money is large in the economy. See, for example, Galí (2015, chapter 2) for a discussion of such a modeling approach as favored in much of the recent monetary policy literature. Nevertheless, in the Appendix, we relax the aforementioned assumption, and consider instead a welfare metric that incorporates nonnegligible consequences from money holdings, to investigate whether the model's predictions remain intact.

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 that $\hat{c}_t = \hat{y}_t = \tilde{y}_t$ 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. Later in the analysis, however, we 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. Next we close the model with a description of monetary policy.

3.2 Monetary Policy

In our analysis, we consider three alternative monetary policy regimes that take the form of targeting rules—i.e., flexible inflation targeting (IT), strict price level targeting (PLT), and strict money growth targeting (MGT). In all of them, and thus even in the case of a money growth target as we introduce below, the central bank employs as its policy instrument the short-term nominal interest rate, which is subject to a ZLB constraint, $i_t \geq 0$. Output, inflation, and the stock of money in circulation are then determined by the equilibrium conditions together with the central bank's targeting rule. Although the monetary policy instrument is exactly the same one in all three regimes considered, the regimes differ crucially in the central bank's choice of targets to 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[15]

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

for all $t = 0, 1, 2 \ldots$. The central bank then conducts policy to achieve $\pi_t + (1/\epsilon)\tilde{y}_t = 0$ to the extent feasible, i.e. as long as the ZLB constraint is not binding, $i_t > 0$. However, the ZLB prevents the central bank from attaining its dual mandate. As a consequence, the condition relating inflation to the output gap may not be satisfied, and $\pi_t + (1/\epsilon)\tilde{y}_t < 0$ if the ZLB binds, $i_t = 0$. We interpret this regime as a stylized representation of the one prevailing in many advanced economies with formal inflation targets.

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 variable, rather than pursue a dual mandate. Specifically, the single goal of monetary policy is to stabilize the price level along a target path (or trend). It, thus, corresponds to the complementary slackness condition[16]

$$\underbrace{\left(\hat{p}_t\right)}_{\leq 0}\underbrace{\left(\hat{\imath}_t + \rho\right)}_{\geq 0} = 0, \tag{6}$$

for all $t = 0, 1, 2 \ldots$, where $\hat{p}_t$ denotes the (log) price level, expressed in deviation from its steady state. In this regime, the central bank conducts policy to achieve $\hat{p}_t = 0$ for as long as the ZLB does not bind, $i_t > 0$. But if the ZLB binds, $i_t = 0$, then the price level may fall below trend, $\hat{p}_t < 0$. This regime implies that, in contrast to the previous one, the price level is (trend) stationary.

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 required to stabilize prices and output in the economy, with real money balances determined by money demand, that is, by (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 particular role for the conduct of monetary policy. Next we introduce a regime with a *direct* role for money in the conduct of monetary policy.

[15] This regime corresponds to the optimal discretionary (or time-consistent) monetary policy, subject to a ZLB constraint. Technically, each period the central bank sets $i_t \geq 0$ to minimize a loss function $\pi_t^2 + (\kappa/\epsilon)\,\tilde{y}_t^2$ subject to the equilibrium conditions (1)–(3), while taking expectations of future economic conditions as given. This problem's optimality conditions together with the ZLB constraint gives the slackness condition (5). See, for example, Galí (2015, chapter 5) for a derivation.

[16] 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 $\hat{p}_t^2$, rather than a dual mandate.

The third regime we consider (MGT) is a description of *strict money growth targeting*, a proposal generally associated with Friedman (1960). Without loss of generality in our analysis, we assume a zero money growth target, which is consistent with zero inflation in the steady state of the model economy. This regimes takes the form[17]

$$\Delta \hat{m}_t = 0, \tag{7}$$

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, which is subject to a ZLB constraint. But in contrast to the previous regimes, the money demand equation (3) is no longer redundant, so the ZLB is incorporated in the set of equilibrium conditions by replacing (3) with the complementary slackness condition

$$\Big(\underbrace{\hat{m}_t - \hat{p}_t - \hat{c}_t + \eta \hat{\imath}_t - v_t}_{\geq 0}\Big)\Big(\underbrace{\hat{\imath}_t + \rho}_{\geq 0}\Big) = 0, \tag{8}$$

thereby real money balances may overshoot the satiation level, $\hat{m}_t - \hat{p}_t > \hat{c}_t + v_t$, if the ZLB binds, $i_t = 0$.[18] For this reason, the ZLB does not prevent the central bank from attaining its money growth target, even though the ZLB can affect the adjustment of prices and output. We view this regime as a "modern" representation of Friedman's k-percent policy rule, which takes explicitly into account the presence 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? Next we describe the calibration of the model.

[17] This condition is not derived from an optimization problem of monetary policy aiming to minimize a loss function, in contrast to the other regimes introduced above. Rather, in this regime, the central bank is assumed to pursue strict stabilization of its "single" target, i.e. a zero money growth target, subject to a ZLB constraint.

[18] In addition, under standard assumptions regarding the household's preferences, the demand for real monetary balances remains bounded below a finite satiation point, see Galí (2019) for details.

3.3 Calibration

We take the money demand relationship (3) to U.S. data. To do so, 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. In fact, 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.[19] Furthermore, to account for the fact that money may earn interest, we 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.[20] Figure 1 plots the (log) velocity of the MZM money stock and the opportunity cost since 1974.[21] 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. Next we formally estimate the stable relationship between those two variables, and the residual variation then corresponds to the money demand shock in our model.

We, thus, proceed to estimate equation (3) and rely on that estimate for our baseline calibration.[22] 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.[23] The focus is on that period because it precedes the recent ZLB episode, and is characterized by a stable relationship between money velocity and the opportunity cost as implied by the model. Based on that regression, we set the interest semi-elasticity of money demand η to 26. In the analysis, however, we also report

[19] Specifically, 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 (i.e. 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. See Teles and Zhou (2005) for further details.

[20] We employ the MZM's opportunity cost to obtain estimates of the money demand relationship that are reasonable and consistent with those already present in the literature, following Teles and Zhou (2005). Thus, in the estimation, the opportunity cost is determined by two separate short-term nominal interest rates, as taken from the data. However, the model is stylized with a single nominal interest rate employed by the central bank as its only policy instrument.

[21] 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.

[22] Our procedure for the estimation of the model's money demand relationship follows 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.

[23] The estimation gives: $log(1/MZMV_t) = -0.73 - 25.60(TB3MS_t - MZMOWN_t)/400 + v_t$, with standard error of the slope coefficient $SE(\eta) = 1.74$, and $\bar{R}^2 = 0.61$.

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 to construct a time series that we estimate with an $AR(1)$ model. On the basis of the latter estimate 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 that the marginal utility of government purchases decreases at the same rate as the marginal utility of 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 $\sigma_z = 0.06$ 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.[24] We start by considering scenarios in which government purchases are not employed as an additional stabilization tool. Thus, for now, we impose $\hat{g}_t = 0$ for all t, but we modify this assumption later in the analysis.

4 The Effects of Stabilizing Money Growth Facing the ZLB

We use the New Keynesian model—given by the above equations (1) through (8)—as a framework to analyze a 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 inflation targeting or 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. In Section 5 we will analyze how the different regimes affect the need for fiscal policy support at the ZLB.

Under each policy regime, we study the impact of negative shocks to aggregate demand (z_t)

[24] The model outcomes are obtained with Dynare (https://www.dynare.org) using an extended-path method. Replication files are available from the authors upon request.

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 a negative money demand shock (v_t), which affects the economy only under the MGT regime.[25] Throughout we evaluate the welfare loss experienced by a representative household using the welfare criterion (4).

4.1 The Effect of Shocks in the Baseline Model

The focus of the analysis is on shocks that have the potential to push the economy to the ZLB. Figures 2 and 3 show the dynamic responses of the economy after a negative aggregate demand shock that pushes down the natural rate of interest, and therefore warrants an expansionary monetary policy response.[26] In the absence of a ZLB constraint, Figure 2 shows that the nominal interest rate is reduced under all three regimes. Under inflation targeting (IT) and price-level targeting (PLT), the reduction in the nominal rate implies that the real interest rate exactly shadows the natural real rate, offsetting all effects on aggregate demand and inflation.[27] These policy responses imply a temporary expansion of the money stock, but this has no impact on the rest of the economy. Under MGT, instead, the central bank perfectly stabilizes the money growth rate, implying a more modest reduction in the nominal interest rate, and an initial increase in the real rate. As a consequence, output and inflation fall. However, the MGT regime implies that the price level is stationary, so inflation eventually rises above target, serving to return the price level to its initial value.[28] Without a ZLB constraint, the IT and PLT regimes imply several quarters of a negative nominal interest rate. Importantly, the nominal interest rate never hits the ZLB constraint in the MGT regime.

In the presence of the ZLB constraint, Figure 3 shows that it is no longer possible to make the real rate shadow perfectly the natural rate under IT and PLT and offset the effects of the shock on output and inflation. Therefore, output and inflation fall on impact. Under IT the real rate even increases, similar to MGT. Under PLT, the stationarity of the price level has a dampening effect on inflation expectations, as households and firms foresee that inflation will overshoot the target.

[25] We do not study the effects of aggregate supply (or cost-push) shocks to the Phillips curve (1), as such shocks are unlikely to push the economy to the ZLB.

[26] The dynamic responses are driven by an initial impulse to z_t of size $2\sigma_z$, large enough to imply that under the IT regime the ZLB binds for 9 quarters. Note that growth rates and interest rates are shown in quarterly rates (not annualized). The steady-state level of the real and nominal interest rates is thus 0.5 percent per quarter.

[27] In the model without fiscal policy, i.e. if $\hat{g}_t = 0$ for all t, the natural rate is given by $\hat{r}_t^n \equiv (1 - \rho_z)\, z_t$.

[28] Given that we ignore control errors in all three regimes, MGT implies that $\hat{p}_t$ is (trend) stationary. Also under the PLT regime $\hat{p}_t$ and $\hat{m}_t$ are stationary. By contrast, under IT, $\hat{p}_t$ and $\hat{m}_t$ are non-stationary while $\hat{m}_t - \hat{p}_t$ is still stationary. Thus, during a ZLB episode, only the inflation targeting regime fails to generate the expectations of inflation needed to return the price level to its initial equilibrium level.

Therefore the real rate falls, and the effect on output and inflation are more modest than under IT.

Under MGT the nominal interest rate never reaches the ZLB, so the responses to the negative demand shock are the same as in Figure 2. Compared with IT, the stationarity of the price level under MGT mimics some of the advantages of PLT. The effects on output and, in particular, inflation are therefore smaller under MGT than under IT. Under MGT, as $\hat{m}_t = 0$ for all t, the money demand equation (3) implies the nominal interest rate is given by

$$i_t = \rho + \frac{1}{\eta} \left(\hat{p}_t + \hat{c}_t + v_t \right). \tag{9}$$

Thus, the nominal rate responds to the level of nominal income $(\hat{p}_t + \hat{c}_t)$. Specifically, as long as the price level and/or income are below their steady-state value, the nominal rate is kept low. This contrasts with IT under which inflation, but not the price level, is returned to its initial value. The real interest rate is therefore higher under IT, and inflation and output are lower. Importantly, while the nominal rate never reaches the ZLB under MGT, PLT implies a "low for longer" policy where the interest rate is kept at the ZLB longer than under IT. Relative to the PLT regime, MGT therefore has the additional benefit of reducing the incidence of periods at the ZLB.

A disadvantage with the MGT regime, along the lines of Poole (1970), is that money demand shocks have the potential to destabilize the economy. In our model, money demand shocks have no direct impact on the economy conditional on i_t, as the stock of money is redundant for the determination of output and inflation. But under MGT, the central bank will respond to money demand shocks by adjusting the interest rate in order to stabilize the money growth rate, with consequences for output and inflation.

To illustrate, Figure 4 shows the dynamic responses after a negative shock to money demand, with and without the ZLB constraint.[29] This shock will put downward pressure on the money stock, so under IT and PLT the money stock falls temporarily. But output and inflation remain unchanged, so the central bank does not respond. Under MGT, the central bank instead needs to reduce the nominal interest rate to stabilize money growth, raising output and inflation. Adding the ZLB constraint, the reduction in the nominal and real interest rate is slightly smaller, and the effect on output and inflation are correspondingly more modest.

Overall, compared with the conventional IT regime, MGT thus has the advantage that inflation

[29] This initial impulse is set large enough $(2.5\sigma_v)$ to drive the economy to the ZLB.

is more stable when the economy is hit by negative aggregate demand shocks, due to the stationarity of the price level. Relative to PLT, the ZLB is less likely to bind under MGT. But after money demand shocks, the MGT regime leads to volatility that is avoided under IT and PLT.

To evaluate the three regimes, Table 2 reports the welfare loss of a representative household with and without the ZLB constraint, as well as the frequency of ZLB episodes. In the absence of the ZLB constraint, monetary policy is able to stabilize the economy perfectly 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 a larger welfare loss.

With the ZLB constraint, as Table 2 shows, PLT is the dominant regime, but the benefits of MGT over IT under aggregate demand shocks means that the overall welfare loss is substantially lower under MGT than under conventional IT. Also, 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). The better welfare performance of PLT is therefore very dependent on its credibility—expectations have to move appropriately to mute the much more frequent episodes at the ZLB, when monetary policy is inactive. MGT instead 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.

4.2 Stability of Money Demand

Our 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 quote from Clarida (2019b) 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 that 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 money demand.

Figures 5 and 6 therefore show the dynamic responses of the economy under MGT after negative shocks to aggregate demand and money demand for a wide range of values for the interest semi-elasticity η around its baseline.[30] A smaller value of η means that a larger interest rate reduction is needed to stabilize money growth after a negative shock to either aggregate demand or money demand, and if the shock drives the nominal interest rate to the ZLB, a smaller value of η leads to a

[30] The estimated standard error of η is 1.74. The range of values of $\eta \in [14, 38]$ thus corresponds to about ± 7 standard errors around the point estimate of $\eta = 26$ (Section 3.3).

longer spell at the ZLB. This larger interest rate cut has a stabilizing impact on output and inflation after an aggregate demand shock (see Figure 5), but a destabilizing effect after a money demand shock (Figure 6).

Figures 7 and 8 show the welfare loss as a function of η with or without the ZLB, respectively (the baseline value of $\eta = 26$ is indicated by a vertical line). Without the ZLB in Figure 7, the welfare loss is always zero under IT or PLT. Under MGT, the welfare loss is increasing in η after aggregate demand shocks, but decreasing conditional on money demand shocks. Combining the two shocks, the aggregate welfare loss will depend on the relative volatility of aggregate demand and money demand shocks. Under our calibration, the welfare loss is decreasing in η.

More importantly, when the ZLB is present, in Figure 8, the welfare loss under MGT is much below that under IT for aggregate demand shocks as well as in the aggregate for every value of η shown. As a smaller value for η leads to more variability in the interest rate under MGT, the frequency of ZLB episodes is higher. But the ZLB frequency is still lower under MGT than under either IT or PLT. Thus, while variations in the elasticity of money demand affect the performance of MGT, with our calibration it is not sufficient to overturn our general conclusion about the benefits of MGT relative to the other two regimes.

5 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. Specifically, we no longer impose $\hat{g}_t = 0$ for all 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

$$\hat{g}_t = \max\{0, -\psi \tilde{y}_t\}, \tag{10}$$

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 "max" operator in the 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, $\tilde{y}_t \geq 0$, the government purchases remain at steady state, $\hat{g}_t = 0$. We interpret this rule as a stylized representation of fiscal policy as an asymmetric and automatic stabilizer to fight recessions (see, e.g., Eichenbaum (2019) or Blanchard and Summers (2020)).

Equipped with this fiscal rule, we proceed to study the implications of government purchases for the performance of a money growth target in the presence of a ZLB constraint. To calibrate the parameter ψ, we choose a value reflecting the magnitude of the American Recovery and Reinvestment Act (ARRA) of 2009. According to the Congressional Budget Office (2015), almost 87% of the budgetary effects of the ARRA, i.e. \$725 billion, occurred from 2009 to 2011, or on average \$241.7 billion per year. During the same period, real potential GDP was on average \$16.3 trillion per year, while the real GDP gap was on average around -4.5%. Thus, in our model the ARRA would correspond to $\psi = (241.7/16,300)/0.045 \approx 0.33$.[31] We therefore view $\psi = 0.33$ as representing a realistic "upper bound" for the responsiveness of government purchases in fighting recessions going forward in the United States.

As MGT implies a smaller impact of aggregate demand shocks on output and (especially) inflation, and a considerably smaller welfare loss than under IT, the MGT regime is less in need of fiscal support than the conventional IT regime. Nevertheless, Figure 9 shows the dynamic responses of the economy after a negative aggregate demand shock with the ZLB, but with different responsiveness of fiscal policy. The left panels have $\psi = 0$, as in Figure 3, while the right panels have $\psi = 0.33$. 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 real 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 larger under IT, and the recession is then less deep under IT than MGT.

Note that the effects of fiscal policy on the nominal rate are barely visible under any regime. Under IT, the economy is back to steady state at the same time as the liftoff from the ZLB, and the fiscal stimulus is therefore removed. Under PLT, there is slightly less need for "low for longer" under the fiscal stimulus, due to a slightly larger boost to inflation, but the effect is quantitatively small. And in the MGT regime, there is in principle scope for fiscal policy even if the ZLB is not binding, which would motivate less monetary stimulus. 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

[31] The data series used here are real GDP from the BEA (i.e. GDPC1) and the CBO's measure of real potential GDP (i.e. GDPPOT), both taken from the Federal Reserve Bank of St. Louis FRED database. We compute the real GDP gap as GDPC1/GDPPOT−1.

unchanged. Therefore, given equation (9), the nominal rate is not affected by the fiscal stimulus. With a larger value for σ (not shown), the fiscal stimulus results in a fall in consumption that is smaller than the price increase, thereby nominal income rises. The fiscal stimulus then raises the nominal rate.

As shown in Table 3, fiscal policy is particularly welfare enhancing in the IT regime, but MGT still dominates IT due to the stationarity of the price level. And as the fiscal stimulus in our model has little effect on the nominal interest rate, the incidence of hitting the ZLB is barely affected. Figure 10 shows the welfare loss from fluctuations in the economy over the wide range of $\psi \in [0, 1]$ in the presence of the ZLB. The ARRA-equivalent value $\psi = 0.33$ is indicated by a dashed vertical line, while $\psi = 0.66$ is indicated by a dash-dotted vertical line. The value $\psi = 0$ corresponds to the baseline in Figure 8. Conditional on 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 the two shocks are combined. MGT still dominates IT for values of ψ below the ARRA value of $\psi = 0.33$. 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.

6 Concluding Remarks

The presence of a lower bound on nominal interest rates that may, in a low-interest-rate environment, pose a serious constraint on monetary policy has drawn increasing scrutiny to policy frameworks such as price-level targeting that (conceptually) succeed 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 have investigated the performance of money growth targeting in the presence of a lower bound on nominal interest rates. We carry out this investigation 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 with inflation targeting and price level targeting. In each case, we characterize policy in terms of a targeting criterion that the central bank maintains unless constrained by the ZLB rather than by interpreting 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 standard inflation targeting, reducing the welfare loss by 77% while reducing the frequency of hitting the ZLB from 25% 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 these shocks under IT and PLT. We calibrate the volatility of money demand shocks based on an estimate of the demand for MZM in the U.S. and find that when both aggregate demand 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%. While PLT still delivers the best overall performance according to our welfare measure, MGT leads to significantly fewer periods during which the ZLB constraint is binding (25% under PLT versus below 6% under MGT).

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 American Recovery and Reemployment Act of 2009, we find that welfare under IT is significantly increased when such fiscal support occurs. However, MGT still performs better. Thus, IT may be more dependent on 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.

Appendix: The Welfare Cost of Money Holdings

Throughout the main analysis, we have assumed explicitly that the welfare consequences of money holdings are negligible. In this Appendix, we 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 that 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 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 11 shows the welfare loss under the ZLB constraint for different parameterizations of the fiscal rule, but 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 (top panel) or facing both types of shock together (bottom panel), the welfare cost of money holdings is notably lower under MGT because the nominal rate moves more under IT and PLT both if the ZLB is not binding (Figure 2) and if the ZLB binds (Figure 3). The welfare cost of money holdings is not affected by the responsiveness of fiscal policy (ψ) under IT and MGT, but is very 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 cost of money holdings reinforces 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
α	Index of decreasing returns to labor	0.25
ϵ	Elasticity of substitution of goods	9
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

	$\psi = 0$		$\psi = 0.33$	
	$\mathbb{L}$(%)	ZLB frequency (%)	$\mathbb{L}$(%)	ZLB frequency (%)
		Aggregate demand shock		
IT	4.55	20.1	1.63	20.1
PLT	0.04	25.1	0.03	24.9
MGT	1.04	0.2	0.93	0.2
		Money demand shock		
IT	0	0	0	0
PLT	0	0	0	0
MGT	0.62	3.2	0.56	3.2
		Both types of shock		
IT	4.55	20.1	1.63	20.1
PLT	0.04	25.1	0.03	24.9
MGT	1.68	5.6	1.51	5.6

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

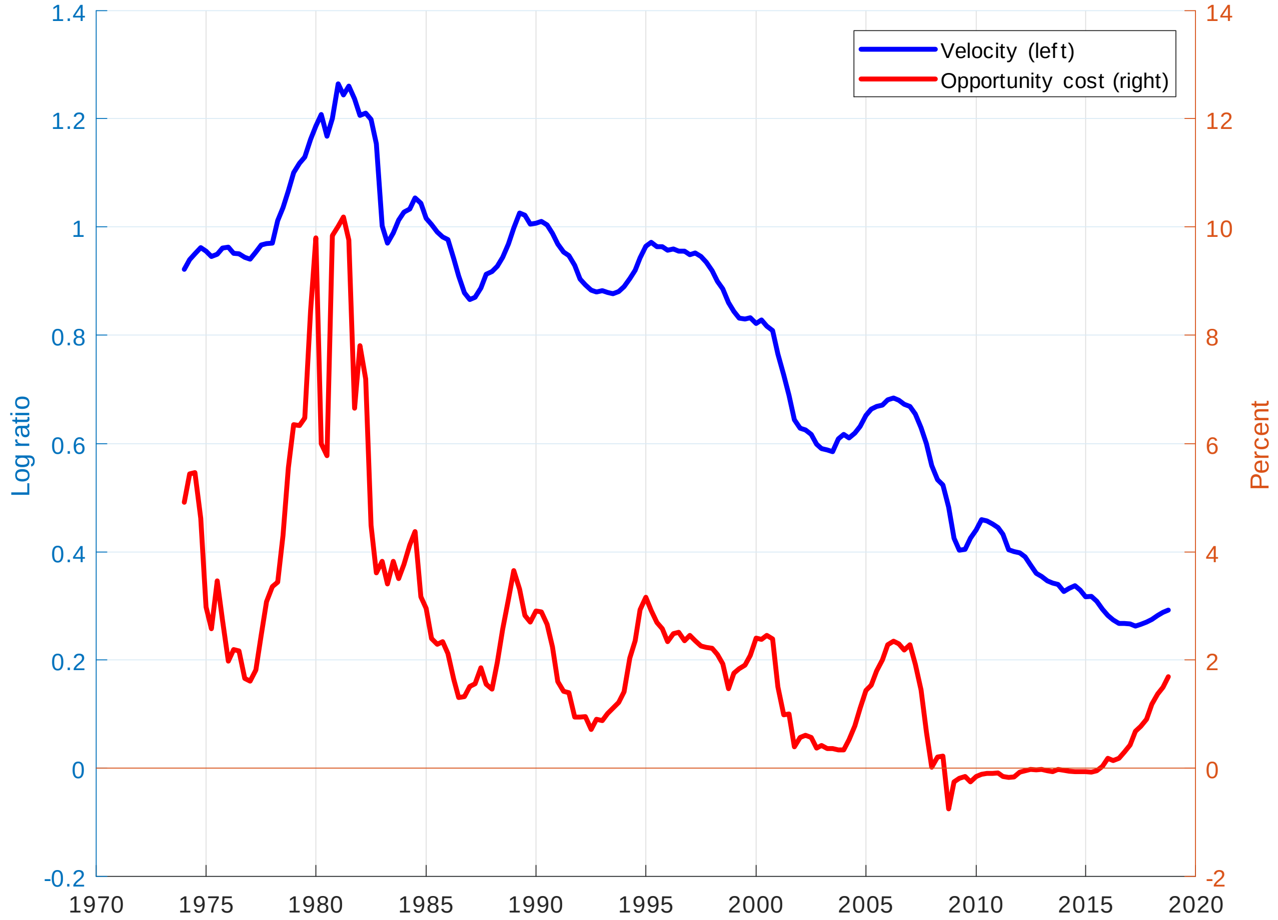

Figure 1: Velocity of MZM money stock and the opportunity cost (source: FRED database)

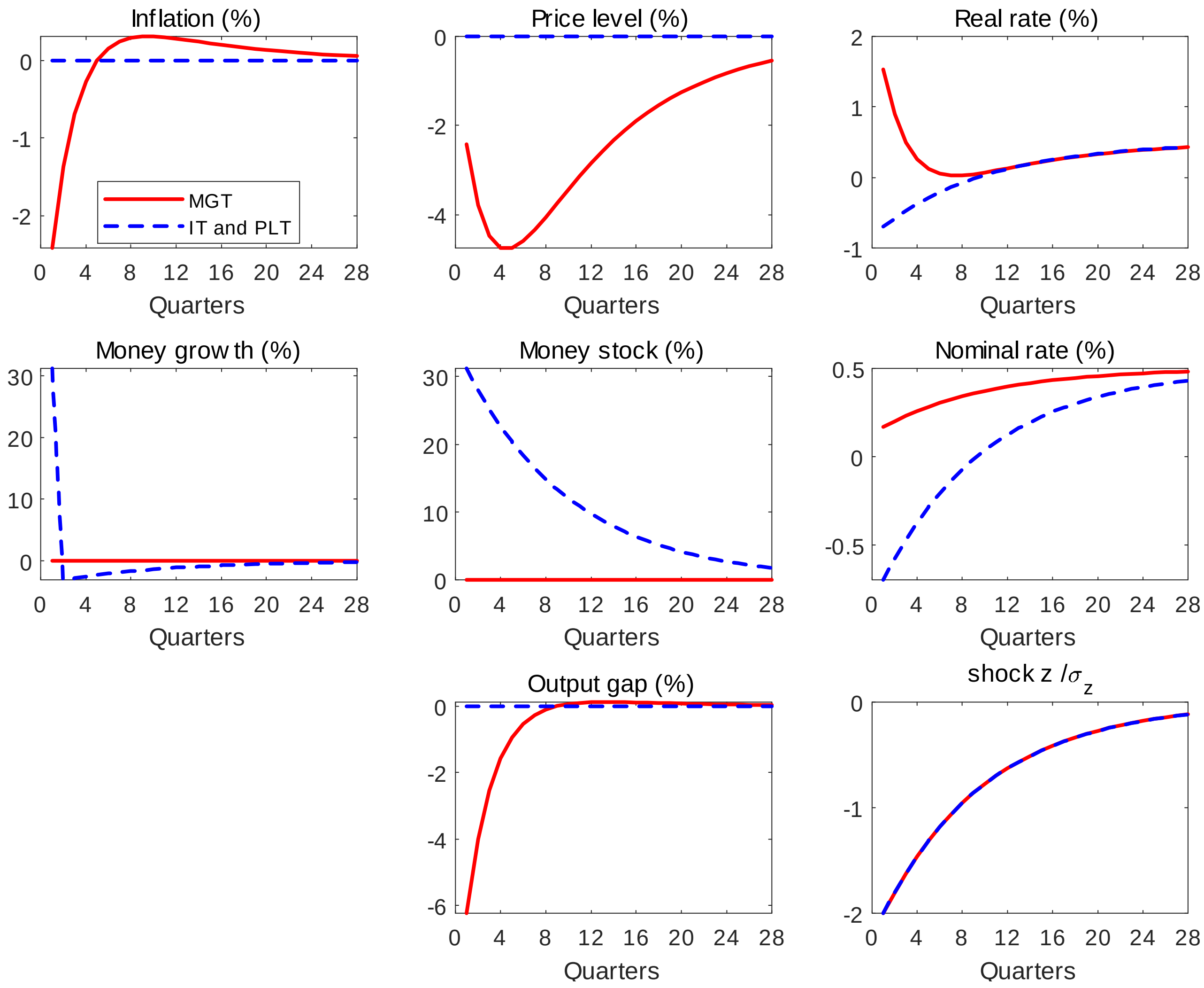

Figure 2: Responses to a negative aggregate demand shock without ZLB constraint

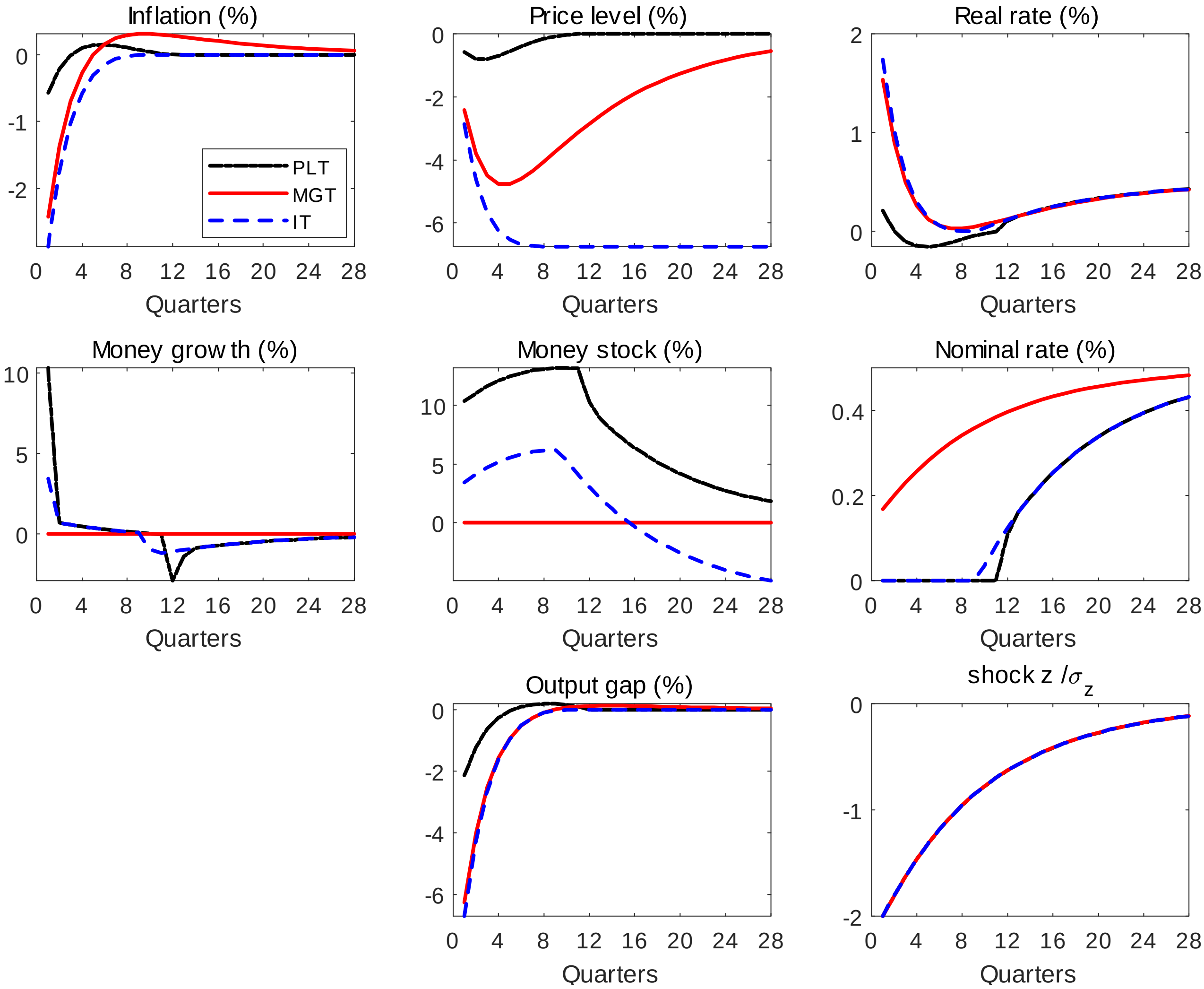

Figure 3: Responses to a negative aggregate demand shock with ZLB constraint

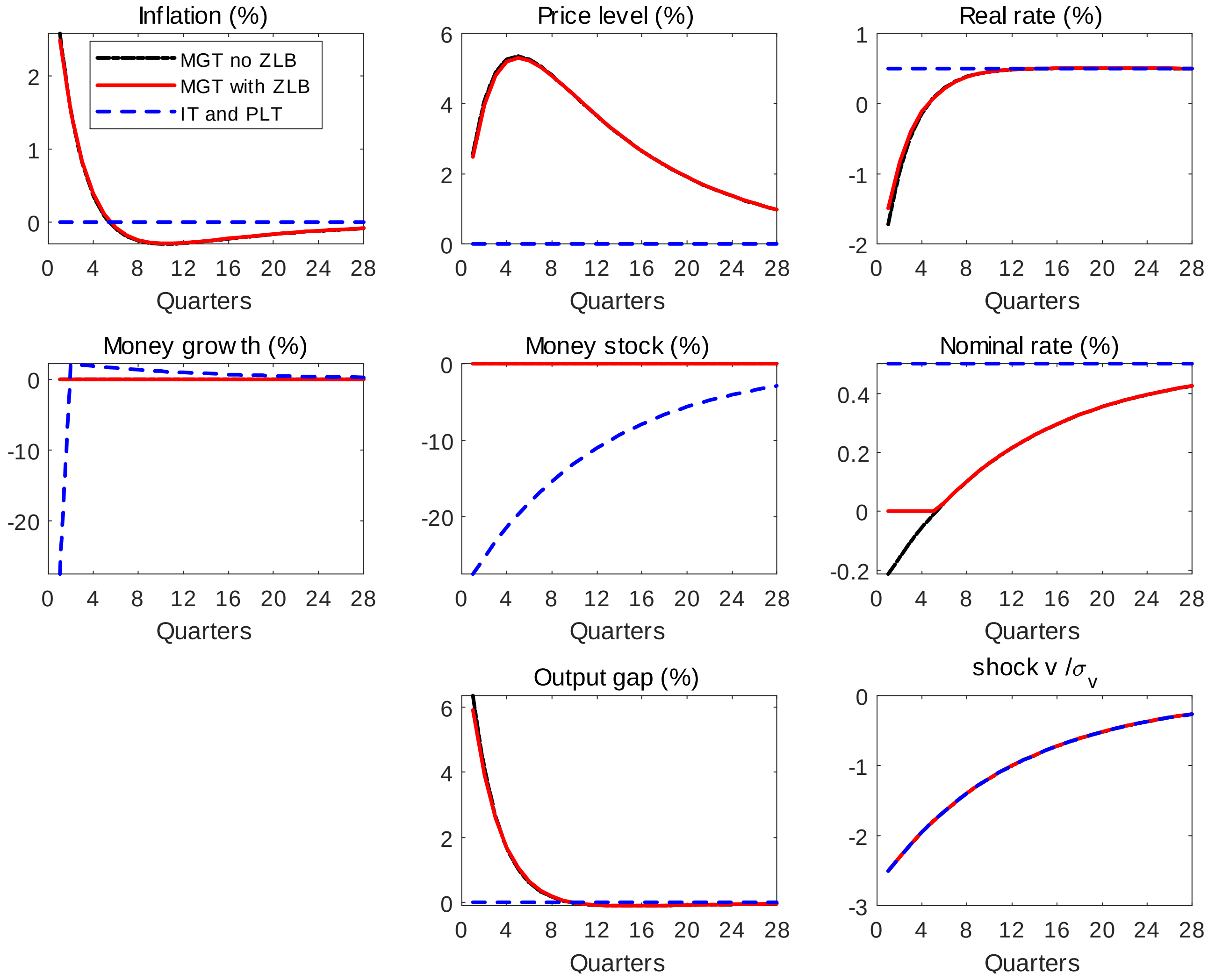

Figure 4: Responses to a negative money demand shock with and without ZLB constraint

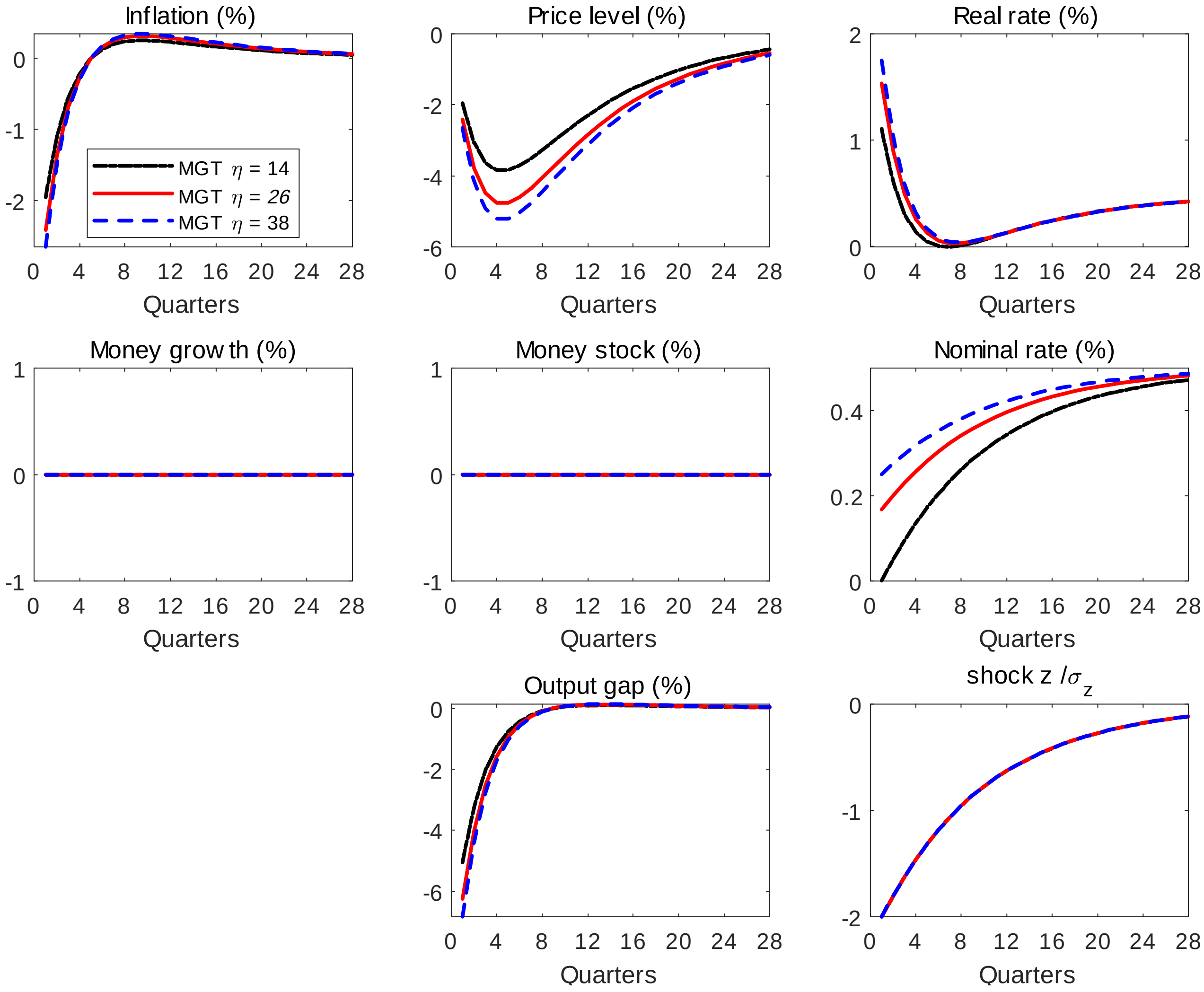

Figure 5: Responses to a negative aggregate demand shock under MGT: sensitivity to money demand elasticity

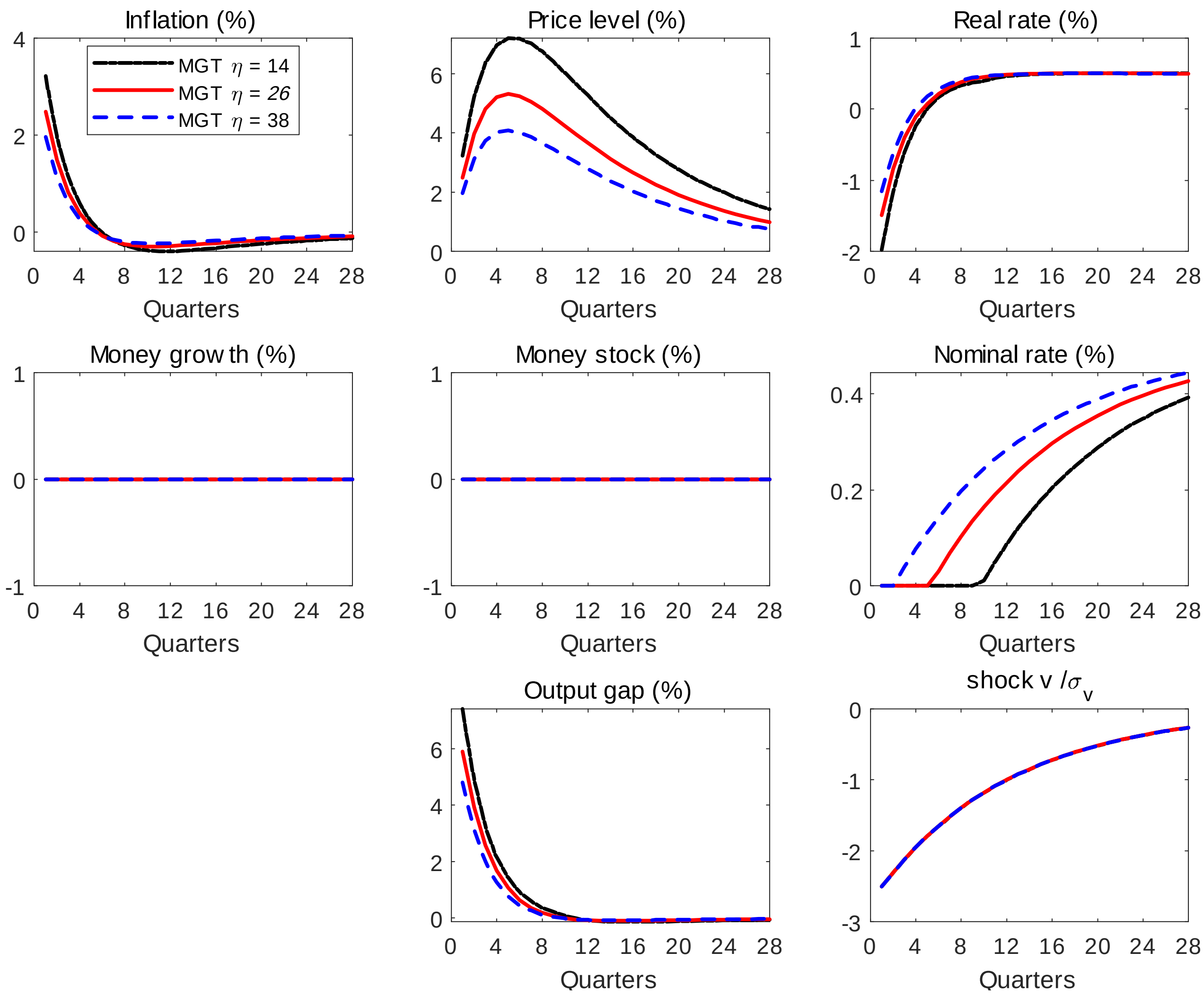

Figure 6: Responses to a negative money demand shock under MGT: sensitivity to money demand elasticity

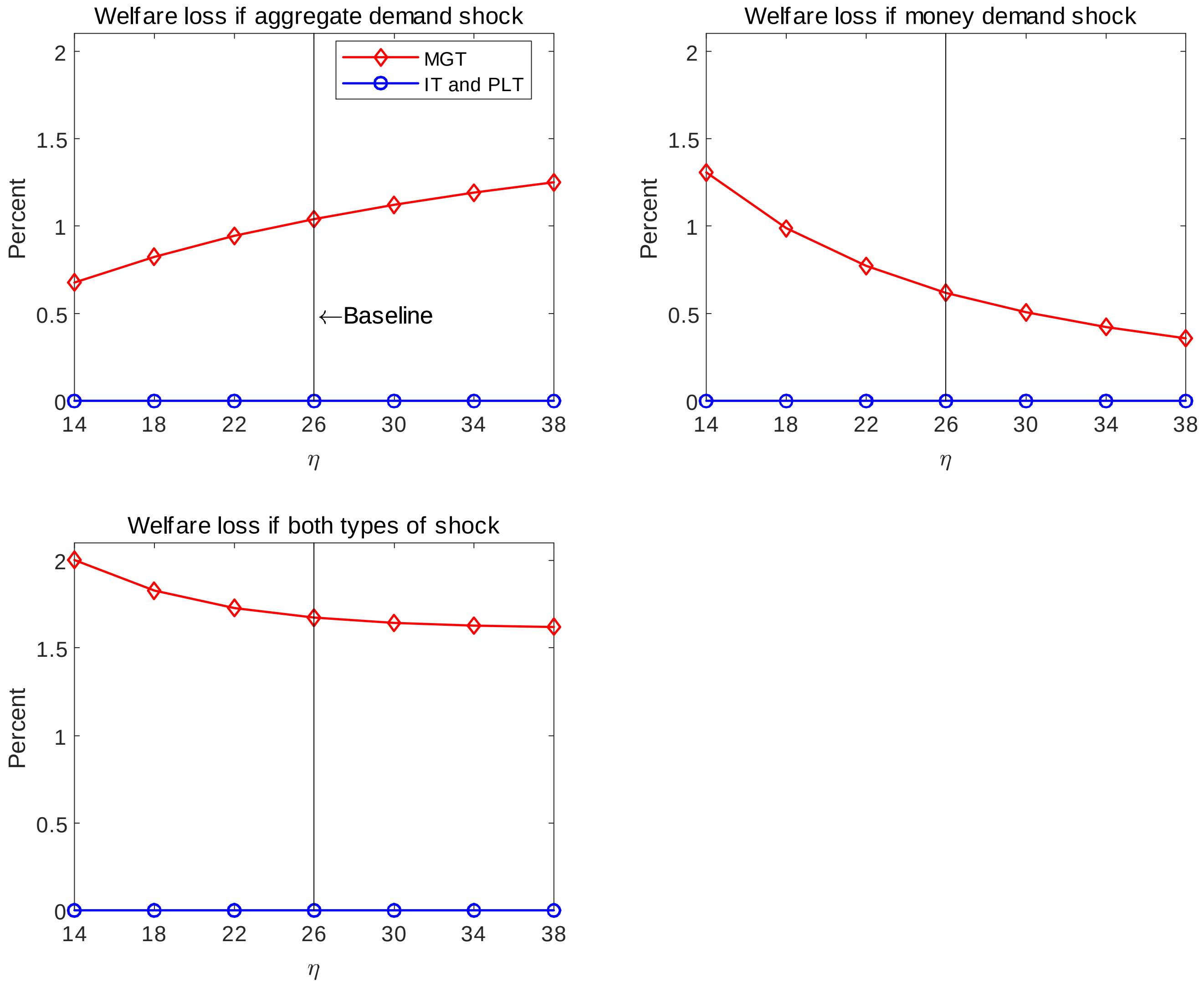

Figure 7: Welfare loss and the elasticity of money demand without ZLB constraint

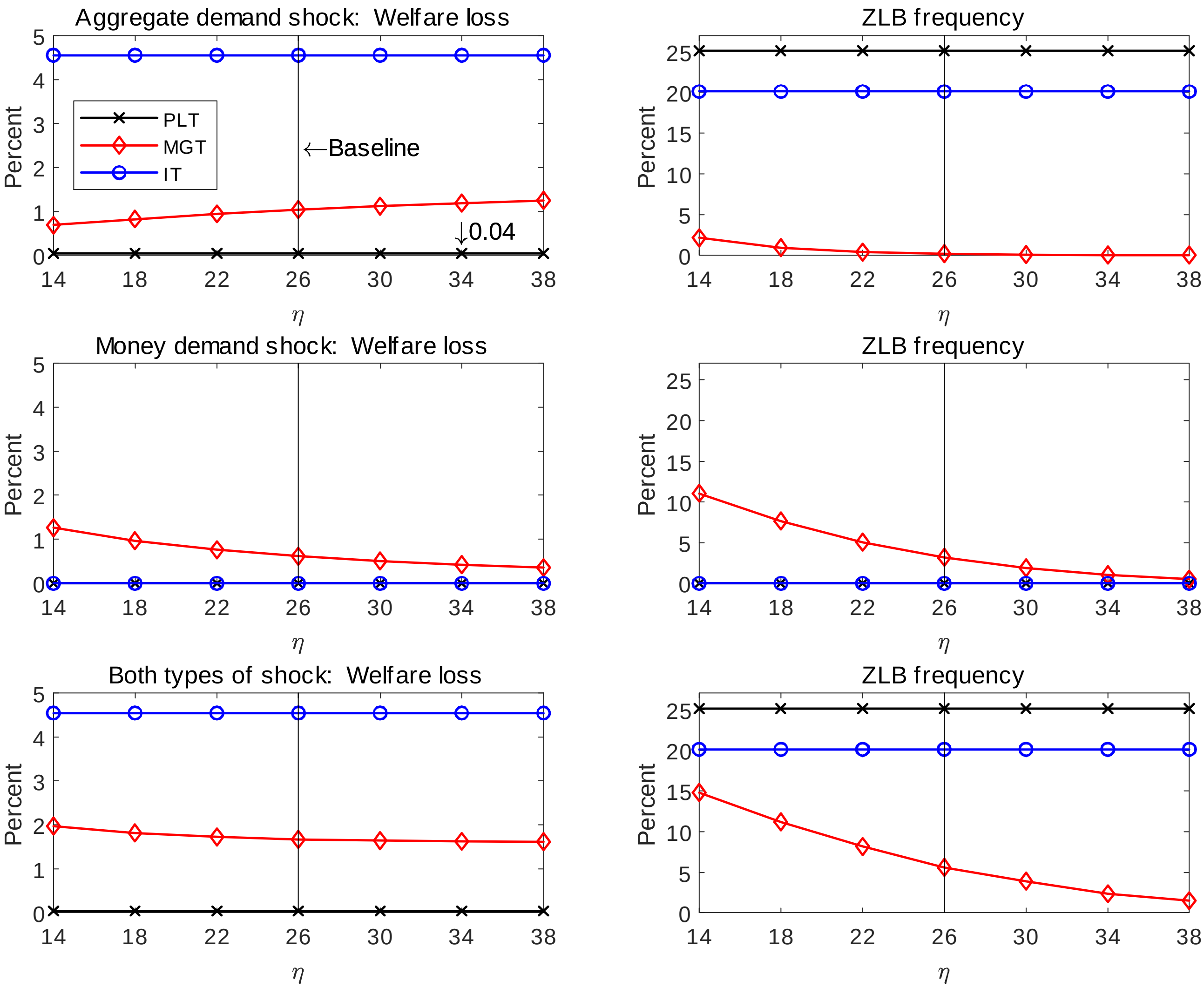

Figure 8: Welfare loss and the elasticity of money demand with ZLB constraint

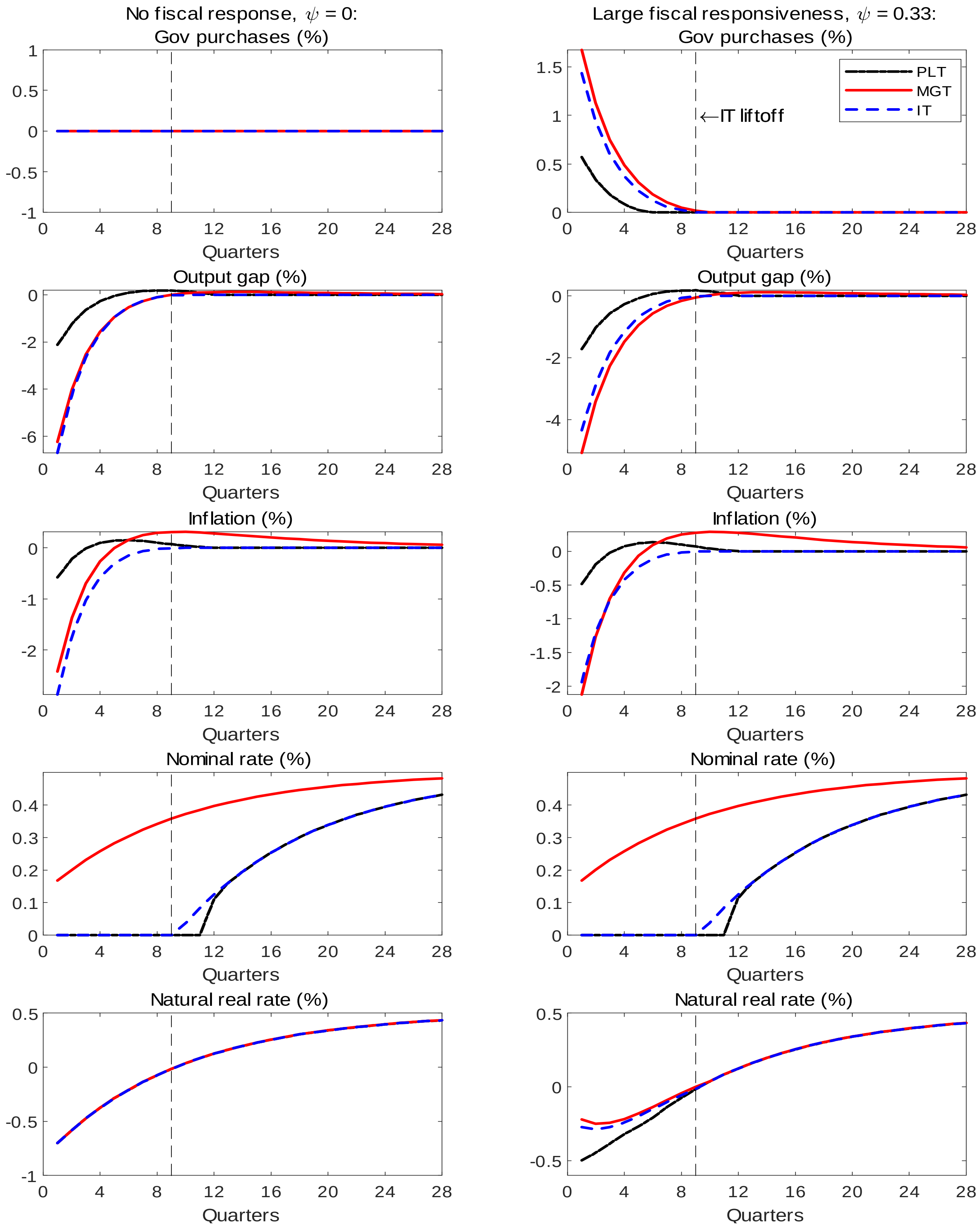

Figure 9: Effects of a large increase in government purchases during ZLB episode

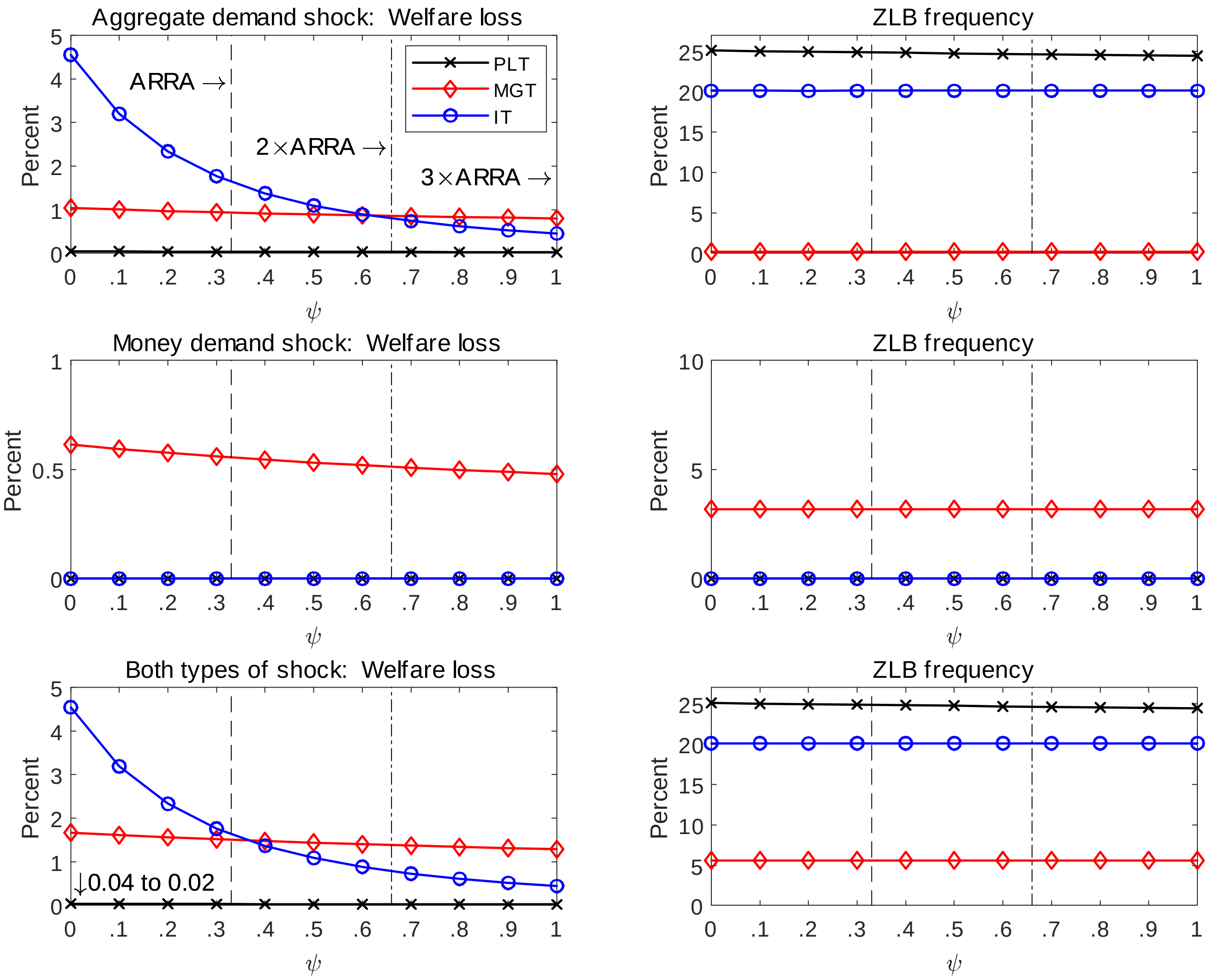

Figure 10: Welfare loss and the responsiveness of government purchases with ZLB constraint

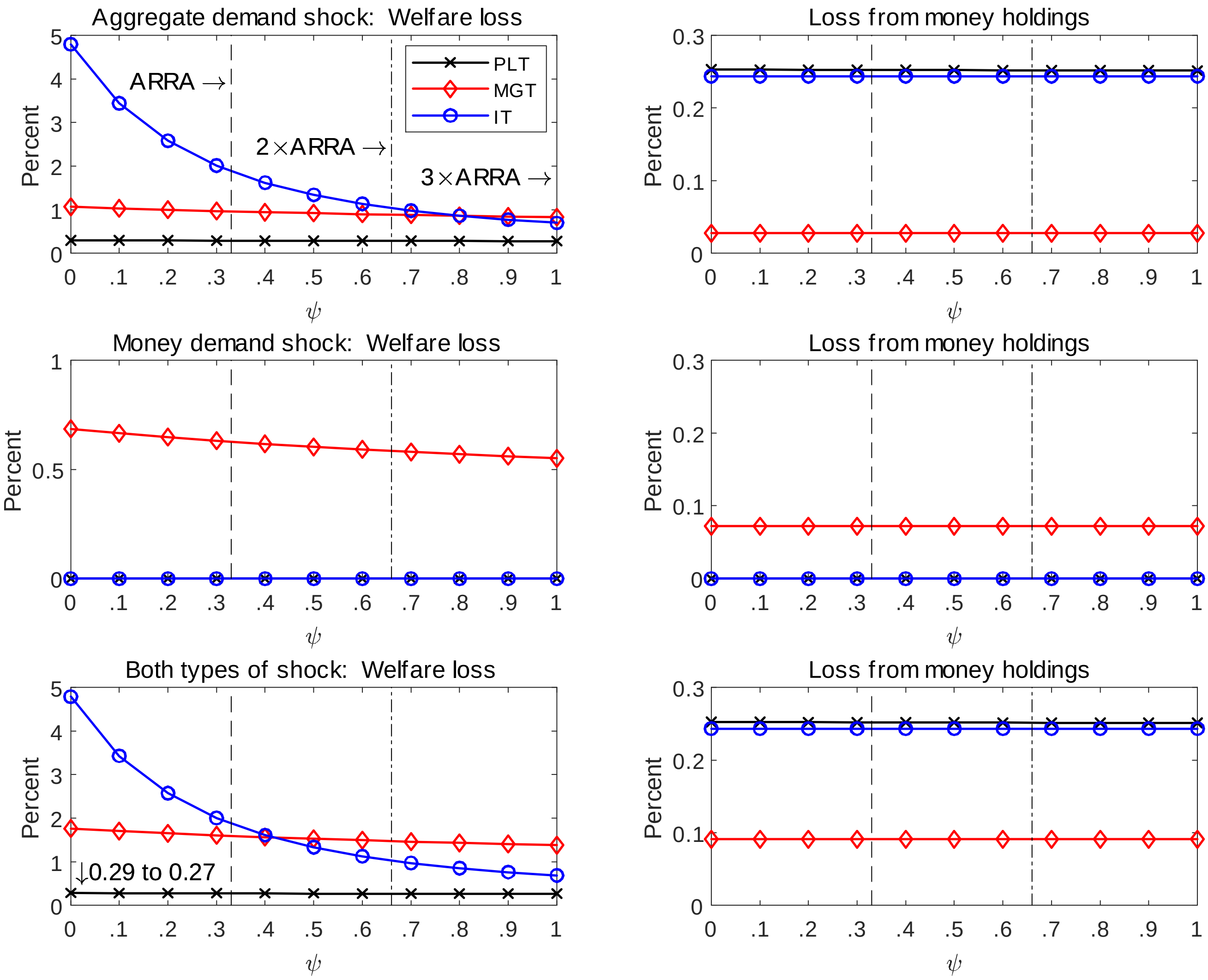

Figure 11: Welfare loss with costs of money holdings and the responsiveness of government purchases with ZLB constraint

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