Do Money Rules Outperform the Taylor rule?

Aryaman Bhatnagar[1]

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This paper answers two questions: 1) Do money rules increase welfare as opposed to using the conventional Taylor rule? and 2) If so, *when* do these rules increase welfare? In an economy calibrated to match US data, we find that money rules do outperform the Taylor rule in terms of welfare. Among money rules, we see that a flexible money growth rule generates the highest welfare. This is followed by the Taylor rule with money and then the constant money growth rule. These results are robust to changes in model parameters. Next, we look at the impact of key monetary parameters on the welfare gains. We find that a low currency to deposit ratio, elasticity of substitution, reserves to money supply ratio, ratio of banking activities, and money supply to nominal consumption ratio are associated with higher welfare gains. Furthermore, the gains of using money rules are higher under monetary shocks as opposed to real shocks.

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[1] Department of Economics, University of Kansas, USA. Email: aryamanb@ku.edu.

1. Introduction

Targeting interest rates has long been accepted as the central mechanism of monetary policy. In the US for example, the Federal Reserve has been conducting monetary policy by targeting the nominal interest since as early as the 1980s (Thornton, 2006). Today, most central banks in the world use some form of the Taylor rule (Taylor, 1993) either implicitly or explicitly. This monetary policy rule guides the central bank in adjusting interest rates in response to movements in output gap and inflation. New-Keynesian models, which are the workhorse of modern macroeconomics, also include some form of this Taylor rule while describing monetary policy.

In contrast, the role of money and monetary aggregates in monetary policy has diminished over the years. A key contributor to this decline was Poole (1970) which showed that targeting monetary aggregates would produce macroeconomic volatility when the economy is faced with money demand shocks. Targeting interest rates on the other hand would shield the economy from those fluctuations. Modern New-Keynesian models also conclude that once interest rates are included in the model, monetary aggregates are not required since they do not provide any additional information content that is not already embedded in interest rates. This has resulted in the widespread use of cashless models in which optimal monetary policy is one that is characterized by movements in interest rates, which react to output gap and inflation (Woodford, 2003).

Recent studies have however brought money rules back into the spotlight[2]. For instance, Keating & Smith (2013) analyze optimal monetary policy in a standard New-Keynesian model augmented with a financial sector. They show that the optimal Taylor rule places a positive weight on the growth rate of Divisia monetary aggregates (Barnett, 1980). This is due to the fact that the monetary aggregates signal movement in the natural rate that occurs as a result of financial market supply shocks. The paper also shows that such a Taylor rule augmented with money has well behaved determinacy properties.

Similarly, Keating & Smith (2019) compare a standard k-percent money growth rule with the Taylor rule. They use three different monetary aggregates for the k-percent rule: the monetary

[2] Here, we define money rules as monetary policy rules which would include either 1) Taylor type interest rules reacting to a monetary aggregate, or 2) monetary policy rules that target a monetary aggregate

base, the simple sum measure of money, and the Divisia monetary aggregate.The study concludes that the while the interest rate rule dominates the first two aggregate k-percent rules, the Divisia k-percent rule outperforms the interest rate rule.

Belongia & Ireland (2022) advocate the use of a money growth rule, which targets the growth rate of Divisia monetary aggregates. In their model, they use a flexible money growth rule, wherein the growth rate of Divisia aggregate would react to changes in output gap and inflation. They estimate a New-Keynesian model using Bayesian techniques and compare the Federal Reserve's historical policy of interest rate rule management with this money growth rule instead. The study finds that the money growth rule delivers performance comparable to the interest rate rule in stabilizing inflation and output. More importantly, they show that by using the money growth rule, the US could have recovered faster from the 2007-2009 recession by avoiding the limitations of an interest rate rule in a zero lower bound environment.

Barnett et al. (2022) shows that in a New Keynesian (NK) model, an active interest rate feedback monetary policy, when combined with a Ricardian passive fiscal policy, can lead to indeterminacy from the emergence of a Shilnikov chaotic attractor in the region of the feasible parameter space. This in turn can become the source of a liquidity trap phenomenon. Barnett et al. (2021) proposes ways to escape this trap. The study finds that one such approach would be to replace the conventional Taylor rule with interest rate feedback with a Divisia targeting rule. Removing interest rate feedbacks could prevent chaotic dynamics from occurring.

This paper answers two questions: 1) Do money rules increase welfare as opposed to using the conventional Taylor rule and 2) If so, *when* do these rules increase welfare? In contrast to the previous studies, our paper compares the welfare properties of four different monetary policy rules including the conventional Taylor rule which does not react to money, a Taylor rule with money, a constant money growth rule (k-percent rule) and a flexible money growth rule which reacts to output growth and inflation. To the best of our knowledge, this is the first study to evaluate the welfare properties of a flexible money growth rule. Our paper also studies the impact of certain key parameters and shocks on the welfare gap between the Taylor rule and money rules. This has important policy implications. Furthermore, we provide a new determinacy condition for flexible money growth rules.

The rest of the paper is organized as follows: Section 2 describes the New-Keynesian model. This model incorporates monetary aggregates as well as a financial sector. In Section 3, we talk about the calibration strategy. Section 4 discusses the results of the paper and section 5 provides the conclusions along with policy implications.

2. Model

The New-Keynesian model used in this study was developed by Belongia & Ireland (2014). As usual, the model has monopolistic competition and nominal price rigidity in the goods market. A key component of the model is the shopping time specification, which introduces a role for money. The model also features a financial sector. Banks produce interest bearing deposits and loans. There are five agents: households, finished goods-producing firms, intermediate goods-producing firms indexed by $i \in [0,1]$, banks, and a monetary authority.

2.1 Households

Households derive utility from consumption C_t and leisure ι_t. They have the following utility function:

$$U_t = \sum_{t=0}^{\infty} \beta^t a_t [\ln(C_t) + \eta \ln(\iota_t\ )] \tag{1}$$

This utility function is different from the one in Belongia & Ireland (2014) who assumed a linear form for leisure. Leisure is defined as:

$$\iota_t = 1 - h_t - h_t^s$$

Here, h_t is the unit of labor supplied by households to the intermediate firm and h_t^s is the total shopping time. The households face a preference shock a_t, which follows an autoregressive process:

$$\ln(a_t) = \rho_a \ln(a_{t-1}) + \epsilon_{at} \tag{2}$$

Each household enters the economy each period with M_{t-1} units of currency, B_{t-1} units of bonds and $S_{t-1}(i)$ units of shares in each intermediate firm $i \in [0,1]$.

Beginning of the time period

At the beginning of each time period, households trade securities. They use some of the currency from the last time period to buy new bonds and shares in intermediate firms. The price of each bond is $\frac{1}{r_t}$, where r_t refers to the gross nominal interest rate. The price of each share is $Q_t(i)$. Households also receive lump-sum transfers from the monetary authority, which is denoted by T_t. They set aside N_t units of currency to purchase goods and services. The rest of the money is deposited in the bank (D_t). The households can also take out loans from banks, denoted by L_t. The total nominal value of the deposits is given by:

$$D_t = M_{t-1} + T_t + B_{t-1} + \int_0^1 Q_t(i)S_{t-1}(i)di - \frac{B_t}{r_t} - \int_0^1 Q_t(i)S_{t-1}(i)di - N_t + L_t \tag{3}$$

End of the time period

At the end of the time period t, households receive $r_t^D D_t$ amount from the bank and have to pay back $r_t^L L_t$ to the bank. They also receive nominal dividends from their share holdings denoted by $F_t(i)$. After these transactions, the households carry forward M_t units of currency into the next period.

$$M_t = N_t + W_t h_t + r_t^D D_t - r_t^L L_t + \int_0^1 F_t(i)S_t(i)di - P_t C_t \tag{4}$$

The role of money

Agents in the model need to hold money due to the shopping time friction. In order to purchase goods and services, households must spend h_t^s units of shopping time which is determined by:

$$h_t^s = \left(\frac{1}{\chi}\right)\left(\frac{\upsilon_t P_t C_t}{M_t^A}\right)^{\chi} \tag{5}$$

Here, $\chi > 1$ determines the rate at which effort required to purchase goods increases as the household economizes on its holdings of monetary assets. υ_t is the money demand shock which follows an autoregressive process:

$$\ln(\upsilon_t) = (1 - \rho_\upsilon)\ln(\upsilon) + \rho_\upsilon \ln(\upsilon_{t-1}) + \epsilon_{\upsilon t} \tag{6}$$

$\upsilon > 0$ determines the steady state level of real monetary services demanded relative to consumption.

M_t^A is the true monetary aggregate, which has a CES form:

$$\mathrm{M}_t^{\mathrm{A}} = \left[\nu^{\frac{1}{\omega}} N_t^{\frac{\omega-1}{\omega}} + (1-\nu)^{\frac{1}{\omega}} D_t^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}} \tag{7}$$

Here, $\omega > 0$ determines the elasticity of substitution between currency and deposits. $0 < \nu < 1$ determines the steady state expenditure shares on currency versus deposits.

2.2 Finished goods-producing firms

The representative finished goods-producing firm produces Y_t by combining inputs Y_{t-1} that it purchases from the intermediate goods-producing firm using the following technology:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}} \tag{8}$$

Here, θ governs the elasticity of substitution between the intermediate goods. The final goods market is perfectly competitive. Hence, the finished goods-producer takes output price P_t as given while maximizing profits:

$$P_t \left[\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}} - \int_0^1 P_t(i) Y_t(i) di \tag{9}$$

This gives us the first order condition:

$$Y_t(i) = [P_t(i)/P_t]^{-\theta} Y_t \tag{10}$$

In equilibrium, the zero profit condition implies:

$$P_t = \left[P_t(i)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{11}$$

2.3 Intermediate goods-producing firms

The representative intermediate firm operates in a monopolistically competitive market. Each period, the intermediate firm (i) hires labor $h_t(i)$. Using this labor, the firm produces $Y_t(i)$ units of output.

$$Y_t(i) = Z_t h_t(i) \tag{12}$$

Z_t is an aggregate technology shock that follows a random walk with positive drift:

$$\ln(z_t) = \rho_z \ln(z_{t-1}) + \epsilon_{zt} \tag{13}$$

The intermediate firm is a price setter, given that this is a monopolistically competitive market. The firm faces a quadratic cost of adjusting its nominal price (Rotemberg, 1982). This is given by:

$$\frac{\phi}{2}\left[\frac{P_t(i)}{\pi P_{t-1}(i)} - 1\right]^2 Y_t \tag{14}$$

2.4 Banks

The representative bank operates in a perfectly competitive market. The bank accepts deposits (D_t) and provides loans (L_t). The bank holds reserves which are determined by the reserve ratio, τ_t. This follows an autoregressive process:

$$\ln(\tau_t) = (1 - \rho_\tau)\ln(\tau) + \rho_\tau \ln(\tau_{t-1}) + \epsilon_{\tau t} \tag{15}$$

Loans and deposits are related in the following way:

$$L_t = (1 - \tau_t) D_t \tag{16}$$

The bank creates deposits using a constant-returns-to-scale technology that requires x_t units of finished goods to per deposit. This deposit cost follows an autoregressive process:

$$\ln(x_t) = (1 - \rho_x)\ln(x) + \rho_x \ln(x_{t-1}) + \epsilon_{xt} \tag{17}$$

Given that this is a perfectly competitive industry, profits are driven down to zero. As a result, we get the following condition in equilibrium:

$$r_t^D = 1 + (r_t^L - 1)(1 - \tau_t) - x_t \tag{18}$$

2.5 Monetary aggregation

We can use two approaches to compute the aggregate monetary services. The first approach is the commonly used simple sum monetary aggregate. Here, the monetary aggregate is a sum of currency and deposits:

$$M_t^S = N_t + D_t \tag{19}$$

As Barnett (1980) shows, simple sum monetary aggregates are theoretically flawed. In contrast, using Divisia monetary aggregates is a far better choice as they are derived from rigorous microeconomic foundations and track the true monetary aggregate. Using them also does not require prior knowledge of the model parameters or functional forms.

To derive the Divisia aggregates, we need to start with the own rate or return r^A, given by:

$$r_t^A = \mathrm{r_t} - [\nu(r_t - 1)^{1-\omega} + (1-\nu)(r_t - r_t^D)^{1-\omega}]^{\frac{1}{1-\omega}} \tag{20}$$

The user cost of the monetary aggregate u_t^A, currency u_t^N, and deposits u_t^D are as follows:

$$u_t^A = (r_t - r_t^A)/r_t \tag{21}$$

$$u_t^N = (r_t - 1)/r_t \tag{22}$$

$$u_t^D = (r_t - r_t^D)/r_t \tag{23}$$

Based on this, we can compute the expenditure shares

$$E_t = u_t^N N_t + u_t^D D_t \tag{24}$$

The associated expenditure shares of currency and deposits are:

$$S_t^N = u_t^N N_t / E_t \tag{25}$$

$$S_t^D = u_t^D D_t / E_t \tag{26}$$

Finally, the growth rate of the Divisia quantity index for monetary services can be written as:

$$\mu_t^Q = (\mu_t^N)^{\frac{S_t^N + S_{t-1}^N}{2}} * (\mu_t^D)^{\frac{S_t^D + S_{t-1}^D}{2}} \tag{27}$$

where:

$$\mu_t^N = N_t / N_{t-1} \tag{28}$$

$$\mu_t^D = D_t / D_{t-1} \tag{29}$$

2.6 Monetary authority

The central bank sets the monetary policy. In our model, the central bank can use one of the following monetary policy rules:

1. Taylor rule without money (TR):

$$r_t = \rho_r r_{t-1} + \rho_\pi \pi_t + \rho_{gy} g y_t \tag{30}$$

2. Taylor rule with money (TRM):

$$r_t = \rho_r r_{t-1} + \rho_\pi \pi_t + \rho_{gy} g y_t + \rho_m \mu_t \tag{31}$$

3. Constant money growth rule (CMGR):

$$\mu_t = \mu \tag{32}$$

4. Flexible money growth rule (FMGR):

$$\mu_t = \rho_{mm} \mu_{t-1} + \rho_{mpi} \pi_t + \rho_{mgy} g y_t \tag{33}$$

3. Calibration

The calibration strategy is similar to that of Belongia & Ireland (2014). β as usual is 0.99. The technology growth rate z has been set at 1.005, which implies 2% growth per year. Following the same logic, inflation target π has also been set at 1.005. The utility function constant, η, is chosen to pin down the steady state value of hours worked which should be 0.33 (eight hours out of a total of twenty four hours). Using this calibration strategy, we get a value of 1.6 for η. Goods aggregate parameter θ is 6 to ensure that the steady state markup equals 20%. Price adjustment parameter ϕ is equal to 50, which suggests that prices adjust on average every 3.75 quarters. The weight on monetary aggregate, ν, is calibrated to match the steady state ratio of currency to money supply. For the US economy, this value is roughly equal to 10%. Based on this, we get a value of ν equal to 0.215. The shopping time parameter, χ, and the elasticity of substitution, ω, are set at 2 and 1.5 respectively as in Belongia & Ireland (2014). x denotes the per unit deposit creation cost. We set x equal to 0.01 to match the ratio of banking activities to GDP , which is roughly 2%. The parameter υ has been calibrated to match the ratio of money supply to nominal consumption, which is roughly 3.3% for the US. We set τ equal to 0.055 to arrive at the value of reserves to money supply. The values for standard deviations and persistence parameters for each of the five shocks have been obtained from Belongia & Ireland (2014).

Table 1: Calibrated values

Parameter	Description	Value
β	Discount rate	0.99
z	Technology growth rate	1.005
π	Inflation target	1.005
η	Utility function constant	1.60
θ	Good aggregate CES	6
ϕ	Price adjustment cost	50
ν	Monetary aggregate weight	0.215
χ	Shopping time effort	2
ω	Elasticity of substitution	1.5
x	Deposit creation cost	0.01
τ	Reserves ratio	0.055
υ	Money demand shock	0.425
ρ_a	Preference shock persistence	0.9
ρ_x	Deposit cost shock persistence	0.5
ρ_τ	Reserves demand shock persistence	0.5
ρ_υ	Money demand shock persistence	0.95
σ_τ	Standard deviation of reserve shock	1
σ_x	Standard deviation of deposit cost shock	0.25
σ_υ	Standard deviation of money demand shock	0.01
σ_a	Standard deviation of preference shock	0.01
σ_z	Standard deviation of productivity shock	0.01

4. Results

In this section, we will answer two questions: 1) Do money rules increase welfare as opposed to using the conventional Taylor rule and 2) If so, *when* do these rules increase welfare?

4.1 Do money rules increase welfare?

4.1.1 Analyzing the variances

In order to compare these four rules, we will first compare and contrast the variances of output, inflation and interest rates. **Table *2*** provides the standard deviation of each of these variables under the four monetary policy rules. As we can see, the Taylor rule generates the highest variance for *all* three variables. The optimal Taylor rule with money produces the lowest variance of output. The flexible money growth rule provides the lowest variance of inflation, while the constant money growth rule does the same for interest rates.

Table 2: Standard deviation of key variables under alternate regimes

	Output	**Inflation**	**Interest Rates**
TR	0.0053	0.0103	0.0185
TRM	**0.0036**	0.0043	0.0160
FMGR	0.0038	**0.0030**	0.0168
CMGR	0.0049	0.0054	**0.0152**

4.1.2 Welfare evaluation

Next, we compare the welfare under each rule numerically. To do so, we take a second order approximation of the model. Welfare is defined recursively as: $V_t = U(C_t, h_t, h_t^s) + \beta V_{t+1}$. Based on this model, we obtain the unconditional expectation of welfare under the baseline Taylor rule. Then we do the same to obtain the unconditional expectation of welfare under the other three rules. To arrive at a measure of welfare gain, we use a consumption-equivalent welfare gain approach.

Here, the welfare gain is defined as:

$$\lambda = exp\left((1-\beta)\left(E(V_t^1) - E(V_{baseline})\right)\right) - 1$$

This can be interpreted as the amount of consumption households would be willing to give up to be in the alternate monetary policy regime as opposed to being in the Taylor rule regime. A positive λ therefore indicates that households prefer the alternate monetary policy to the Taylor rule.

Figure *1* provides the consumption-equivalent welfare gain under each monetary policy rule, relative to using the Taylor rule. As we can see, λ is positive under all three rules, indicating that each of the three money rules is superior to the Taylor rule. Among the three rules, the flexible money growth rule appears to be the best, followed by the Taylor rule with money and then the constant money growth rule.

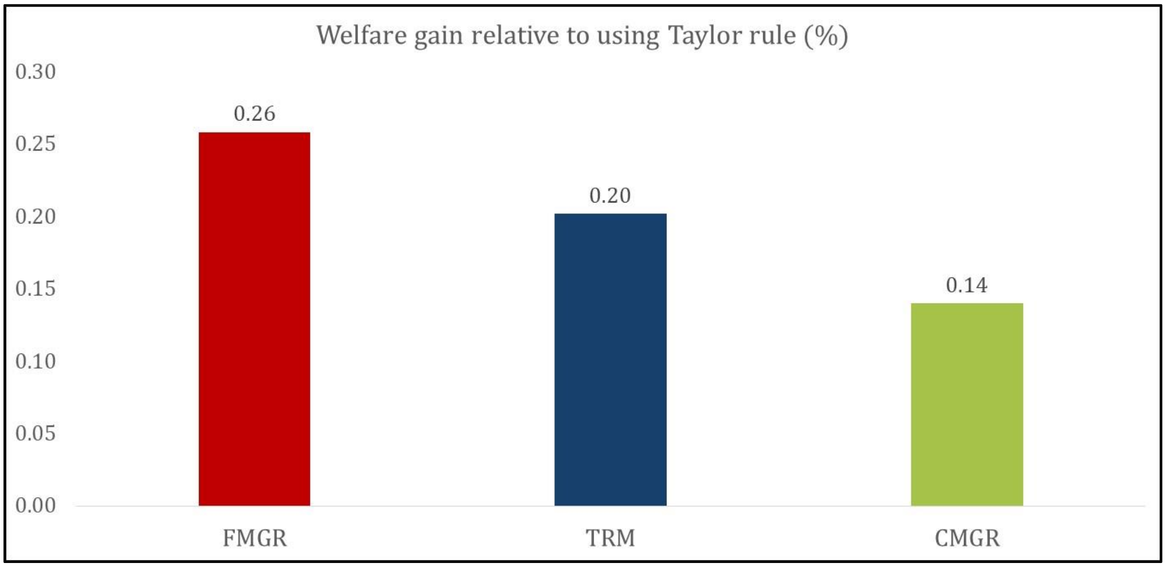

Figure 1 Welfare gain relative to using Taylor rule (%)

4.2 When do money rules increase welfare?

The analysis conducted above shows that in the baseline economy, money rules clearly dominate the Taylor rule. The next question that we have to ask is when do these rules dominate the Taylor rule? To do so, we will first quantify the impact of certain key parameters on this welfare differential. Second, we will decompose the shocks and examine how these rules perform under different shocks.

4.2.1 The impact of key monetary parameters

We will study the impact of six key monetary parameters.

Impact of ν

The first monetary parameter that we analyze is ν. This governs the share of currency to total money supply (M2). The baseline value of ν is 0.215. **Figure *2*** describes the impact of ν on the welfare gain of using the three monetary policy rules.

We can note three results from this exercise. First, we see that the value of consumption equivalent welfare gain (λ) is positive for all values of ν. This is true for all the three rules, implying that all the money rules are better than the Taylor rule even when ν changes within a 10% range. Second, for every value of ν, the welfare rankings are preserved. Flexible money growth rule (red) is still the best rule, followed by the Taylor rule with money (blue) and then the constant money growth rule (green). Third, as ν increases, the welfare gain of using money rules relative to using the conventional Taylor rule decreases. Once again, this is true for all three rules.

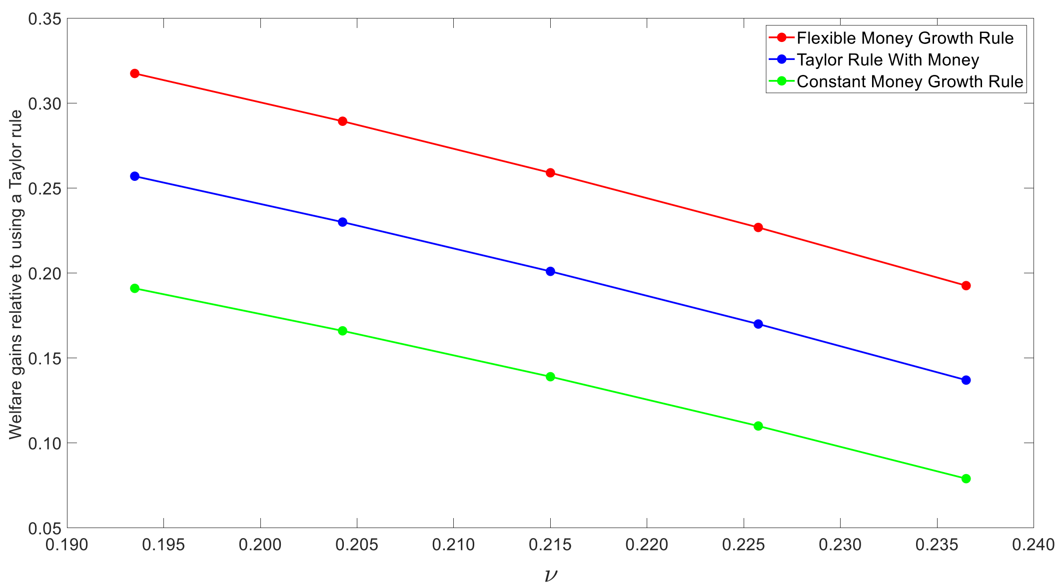

Figure 2: Impact of ν

In terms of policy implications, this would suggest that countries with a lower share of cash (most developed countries) would gain more from using a money rule as opposed to countries with a higher share of cash (most developing countries). However, this does not mean that countries with low share of cash would not gain at all by switching to money rules. To demonstrate this, we take the example of India, which is a country with a large share of currency relative to money supply. The corresponding value of ν for India is 0.39 (almost twice as the value for the US). The welfare gain for India from using a flexible money growth rule as opposed to using a Taylor rule is estimated to by 0.02%. Even though this is lower than the value for US (0.25%), it is still positive.

Impact of χ

The second monetary parameter that we study is χ. This governs the rate at which the effort required to purchase goods and services increases as the household economizes on its holdings of monetary assets. To understand how χ affect households, we can look at **Figure *3***, which traces out the impact of χ on shopping time (h^s) in the steady state. As χ increases, the shopping time for households decreases.

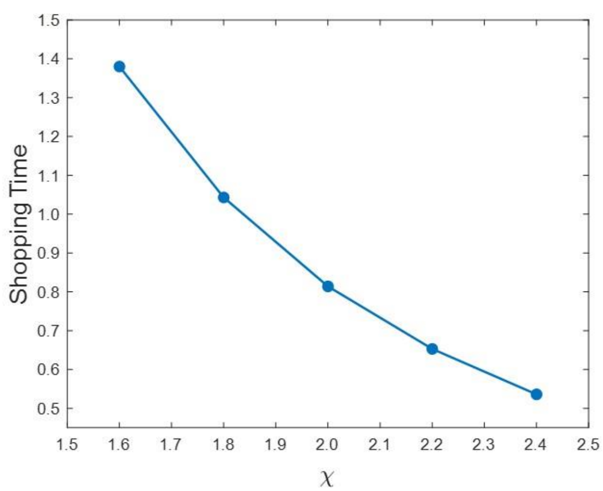

Figure 3: Impact of χ on shopping time

Figure *4* depicts the impact of χ on the welfare gain of using money rules. Once again we see that the value of consumption equivalent welfare gain (λ) is positive for all values of χ. This is true for all the three rules, implying that all the money rules are better than the Taylor rule even when χ changes within a 10% range. Second, for every value of ν, the welfare rankings are preserved. Flexible money growth rule (red) is still the best rule, followed by the Taylor rule with money (blue) and then the constant money growth rule (green). Third, as χ increases, the welfare gain of using money rules relative to using the conventional Taylor rule increases and then plateaus. Once again, this is true for all three rules.

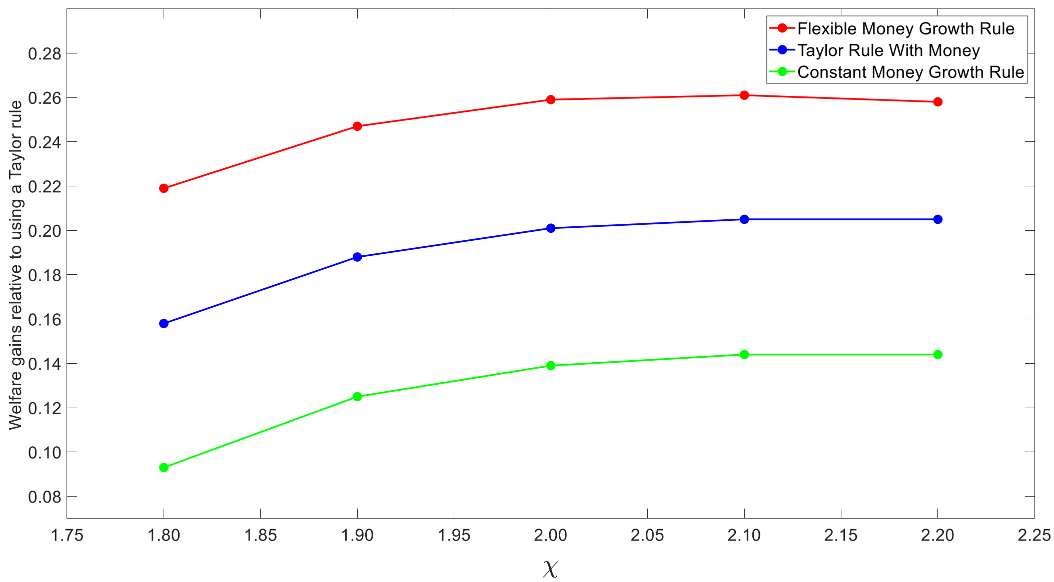

Figure 4: Impact of χ

Impact of *ω*

The third monetary parameter that we study is ω. This determines the elasticity of substitution between currency and deposits. Following Belongia & Ireland (2014), we set the baseline value of ω at 1.5. **Figure 5** captures the impact of ω on welfare gains. As ω increases, the benefit of using money rules decreases. Once again, we see that welfare gains are positive for all values of ω for all three rules and the welfare rankings remain unchanged.

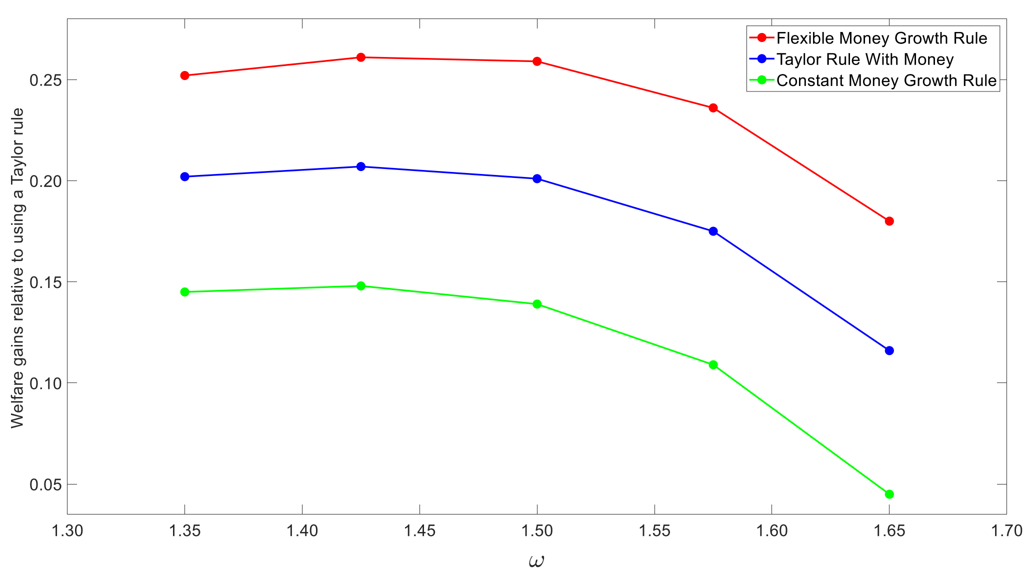

Figure 5: Impact of *ω*

Impact of τ

The fourth monetary parameter that we study is τ. This determines the elasticity of substitution between currency and deposits. Following Belongia & Ireland (2014), we set the baseline value of τ at 0.055. **Figure *5*** captures the impact of τ on welfare gains. As τ increases, the benefit of using money rules decreases.

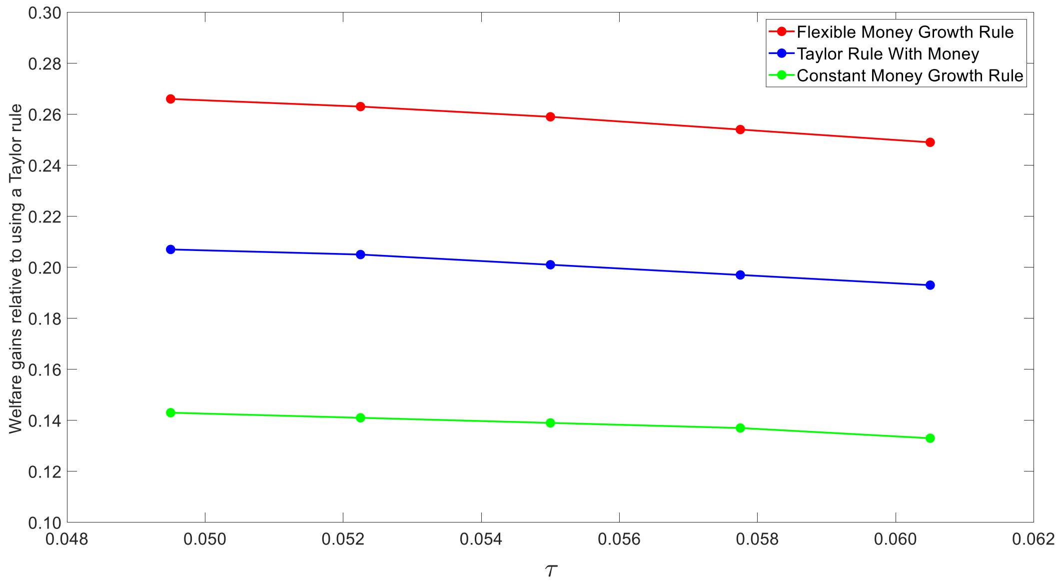

Figure 6: Impact of τ

Impact of x

The fifth monetary parameter that we study is x. This determines the elasticity of substitution between currency and deposits. Following Belongia & Ireland (2014), we set the baseline value of x at 0.01. **Figure *5*** captures the impact of x on welfare gains. As x increases, the benefit of using money rules decreases. Welfare gains are positive for all values of x for all three rules and the welfare rankings remain unchanged.

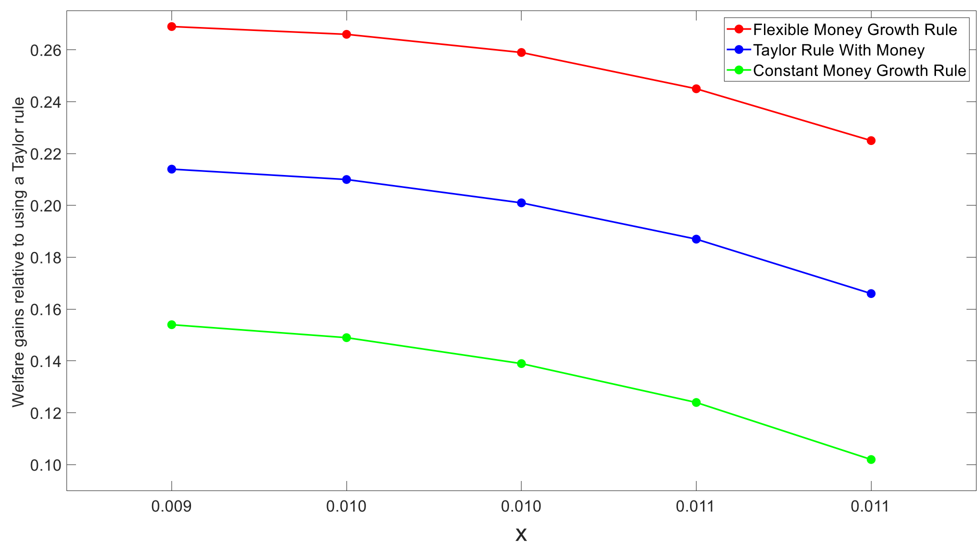

Figure 7: Impact of x

Impact of υ

The final monetary parameter that we study is υ. This determines the elasticity of substitution between currency and deposits. Following Belongia & Ireland (2014), we set the baseline value of υ at 0.425. **Figure 5** captures the impact of υ on welfare gains. As υ increases, the benefit of using money rules decreases. Once again, we see that welfare gains are positive for all values of υ for all three rules and the welfare rankings remain unchanged.

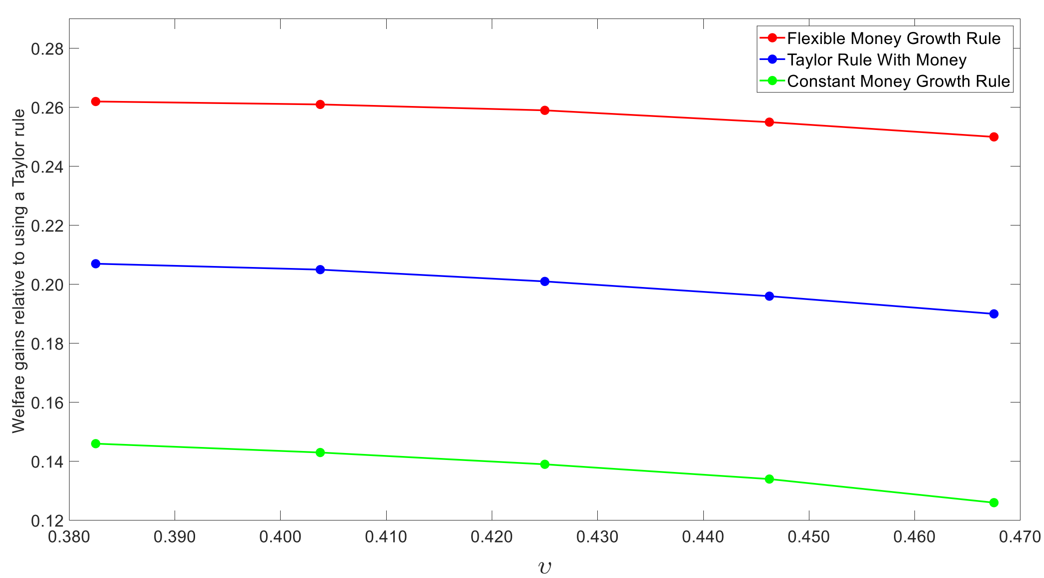

Figure 8: Impact of υ

4.2.2 The impact of different shocks

Under which shocks do money rules perform better? To understand this, we will segregate the shocks into two categories and analyze them separately. The first category of shocks are the standard demand and supply shocks. In our model these refer to the preference (a) and productivity (z) shocks and we can identify them as *real* shocks. The second category of shocks are *monetary* shocks. In our model these refer to the money demand shock (υ), reserve shock (τ) and deposit cost shock (x).

Real shocks

Figure *9* shows the welfare gain of using money rules relative to using the Taylor rule under real shocks. The flexible money growth rule is marginally better than the Taylor rule (0.001% consumption equivalent welfare gain). On the other hand, the Taylor rule with money and the constant money growth rule are worse than the conventional Taylor rule.

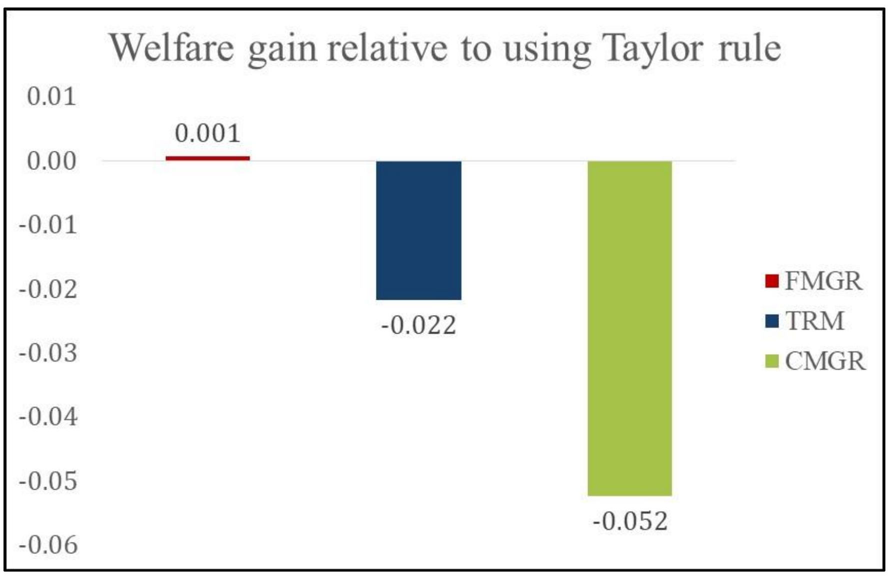

Figure 9: Welfare gain under real shocks

Figure 10 shows the standard deviations of output, inflation, and interest rate for all four monetary policy rules when the economy is hit by real shocks. The Taylor rule generates higher standard deviations for inflation and interest rates compared to the money rules. On the other hand, it produces the lowest standard deviation for output.

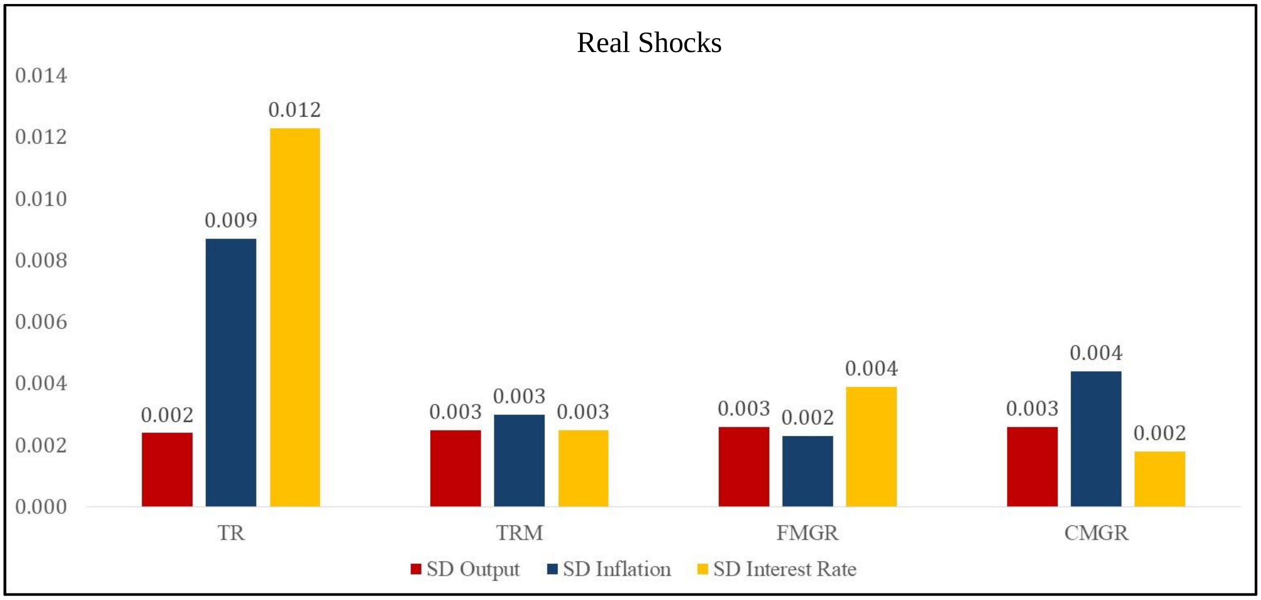

Figure 10: Standard deviations under real shocks

Monetary shocks

Figure *11* shows the welfare gain of using money rules relative to using the Taylor rule under monetary shocks. All three money rules are significantly better than the Taylor rule. The welfare rankings remain the same.

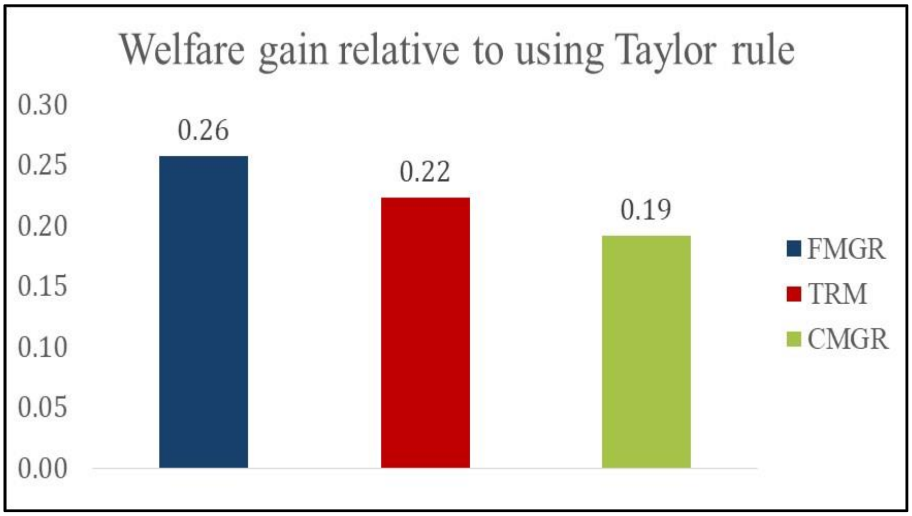

Figure 11: Welfare gain under monetary shocks

Figure 12 shows the standard deviations of output, inflation, and interest rate for all four monetary policy rules when the economy is hit by monetary shocks. The Taylor rule generates higher standard deviations for inflation and output compared to the money rules. On the other hand, it produces the lowest standard deviation for interest rates.

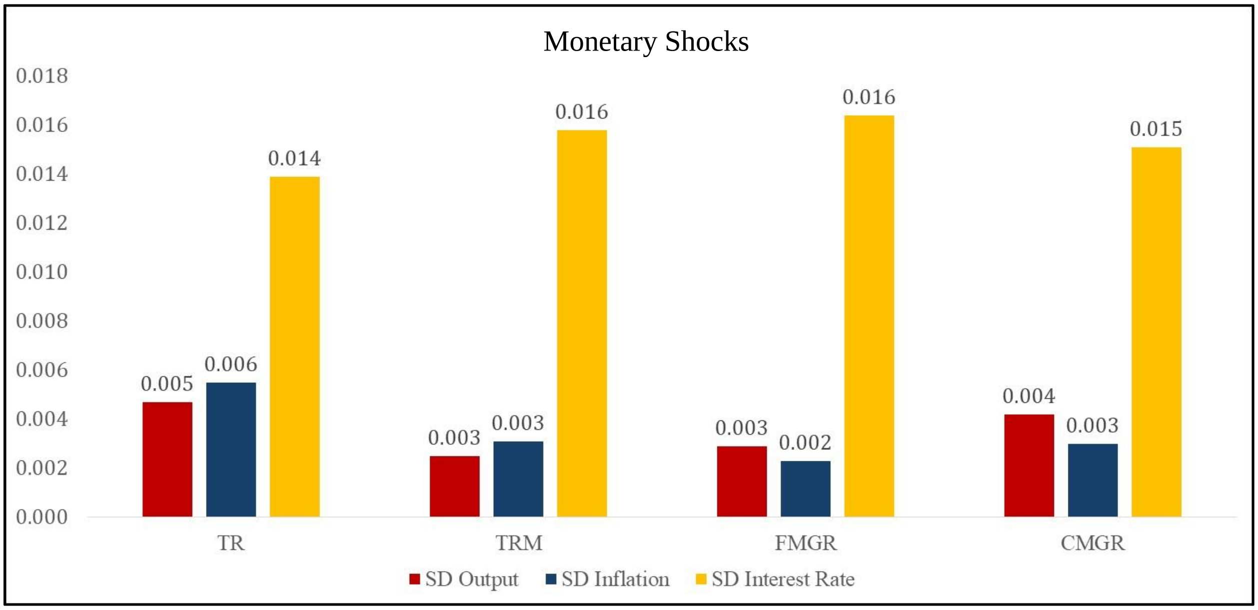

Figure 12: Standard deviations under monetary shocks

Individual shocks

Table 3 shows the welfare gains under each of the five shocks for all three rules. Money rules are better than the Taylor rule under a preference shock (a) and a deposit costs shock (x), while the Taylor rule is better under a productivity shock (z) and a reserve shock (τ). In the case of a money demand shock (υ), the flexible money growth rule is marginally better than the Taylor rule. On the other hand, consistent with Poole (1970), Taylor rule is better than the other two money rules.

Table 3: Welfare gains under individual shocks

Shocks	**Welfare gain relative to using Taylor rule**		
	FMGR	**TRM**	**CMGR**
$\boldsymbol{a}$	0.012	0.011	0.010
$\boldsymbol{z}$	-0.010	-0.032	-0.062
$\boldsymbol{\tau}$	-0.091	-0.095	-0.097
$\boldsymbol{\upsilon}$	0.001	-0.003	-0.009
$\boldsymbol{x}$	0.347	0.322	0.299

Clearly, welfare gains of using money rules are highest under a deposit cost shock. To understand why this happens, we can look at **Figure *13***, which traces out the impulse responses of key macroeconomic variables to a deposit cost shock. The black line represents the responses under a Taylor rule regime, while the blue dashed line represents the responses under the flexible money growth rule regime.

The cost shock decreases bank profits, which consequently decreases lending. In the economy with Taylor rule, the money supply (mA) plummets when the deposit cost shock hits. This has two effects. First, it reduces economic activity. We can see this in the form of a decline in consumption. Second, the decrease in money supply (as measured by the true monetary aggregate m^A), leads to an increase in shopping time (hs). The fall in consumption, coupled with the rise in shopping time causes a decline in the household utility.

In contrast, in the economy where the central bank follows a flexible money growth rule, the money supply is not allowed to fall because the FMGR has a significant money growth smoothing component which does not allow money supply to fluctuate too much. The central bank follows a more expansionary monetary policy. This leads to a far lesser increase in shopping time and an *increase* in consumption.

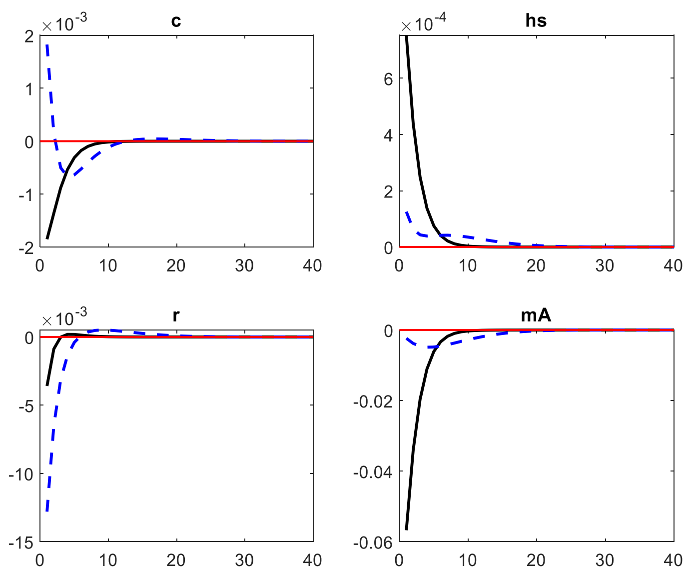

Figure 13: Impulse responses under a deposit cost shock

4.3 Determinacy

The welfare analysis suggests that the flexible money growth rule is the best policy rule for a central banker in our model. In this context, it would be important to dig deeper into the properties of such a rule. One such important dimension is the determinacy property of an FMG rule. To the best of our knowledge, this is the first study to define a determinacy condition for a flexible money growth rule.

We find that the determinacy rule for an FMGR is as follows:

$$\rho_{mm} + \rho_{m\pi} < 1 \tag{34}$$

Graphically, the determinacy - indeterminacy regions can be seen in **Figure *14***. The red shaded region depicts the region where the FMGR is indeterminate. Intuitively, much like the Taylor principle, here we see that a sufficiently strong reaction to inflation is required to ensure determinacy. Interestingly, the weight on output growth (ρ_{mgy}) does not affect determinacy.

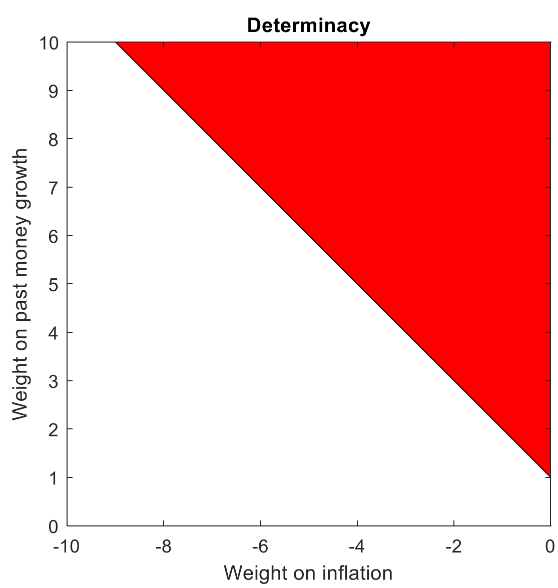

Figure 14: Determinacy conditions for flexible money growth rule

5. Conclusion

This paper answers two questions: 1) Do money rules increase welfare as opposed to using the conventional Taylor rule and 2) If so, *when* do these rules increase welfare? In an economy based on US data, we find that money rules do outperform the Taylor rule in terms of welfare. Among money rules, we see that a flexible money growth rule generates the highest welfare. This is followed by the Taylor rule with money and then the constant money growth rule. We also find that these results are robust to changes in key parameters of the model.

Next, we look at the impact of these key parameters on the aforementioned welfare gains. We find that a low currency to deposit ratio, elasticity of substitution, reserves to money supply ratio, ratio of banking activities, and money supply to nominal consumption ratio are associated with higher welfare gains. Furthermore, the gains of using money rules are higher under monetary shocks as opposed to real shocks.

Three policy implications arise from our analysis. First, the advantage of using money rules depends on the type of economy. Even though welfare gains are always positive within the range of parameters that we have chosen, their magnitude varies with certain structural features of the economy. For instance, a country with a lower share of currency appears to benefit more than a country with a higher share of currency all else being equal. Second, money rules work better under conditions that we typically associate with recessions. This follows from our finding that the gain of using money rules is higher under monetary shocks as opposed to real preference and productivity shocks. These monetary shocks are typically felt under recessionary conditions. Third, our study once again argues that economists cannot afford to ignore money and monetary aggregates while constructing DSGE models. Doing so leads to incorrect policy prescriptions.

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