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MONETARY POLICY WITH 100 PERCENT RESERVE BANKING: AN EXPLORATION

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ABSTRACT

We explore monetary policy in a world without fractional reserve banking. In our world, banks are purely transaction institutions. Money is a form of government debt that bears interest, which can be negative as well as positive. Services of money are a factor of production. We show that the national accounts must be revised in this world. Using our baseline economy, we determine a balanced growth path for a set of money interest rate policy regimes. Besides this interest rate, the only policy variable that differs across regimes is the labor income tax rate. Within this set of policy regimes, there is a balanced growth welfare-maximizing regime. We show that Friedman monetary satiation without deflation is possible in this world. We also examine a set of inflation rate targeting regimes. Here, the only other policy variable that differs across regimes is the inflation rate.

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Section 1: Introduction

The purpose of this paper is to open a discussion on monetary policy reform in light of advancements in information processing technology. Currently, there is public discussion about whether the interest rate should be increased and what the inflation rate target should be. Our assessment is that existing monetary theory does not provide predictions about the consequences of these and other alternative monetary policy regimes.

We consider a particular monetary system with (i) interest-bearing money and (ii) a prohibition on financial institutions that borrow from one group at a low interest rate and lend to another at a higher average interest rate, thereby realizing positive net interest income. One question we will explore is the feasibility and desirability of Friedman monetary satiation. A prior question is whether following the Friedman rule is feasible in our current fiat money system. McAndrews [2015] has argued—and we think convincingly—that it is not feasible. He points out that people would not invest in securities that bear negative nominal interest rates because they could invest in currency, which bears a zero nominal rate. With our alternative monetary system, monetary satiation is feasible, even with a non-negative inflation rate.

In the alternative monetary system considered in this paper, a bank is a business that issues demand deposits. Commercial banking companies in the United States and most other countries offer a wide range of financial products in addition to demand deposits. Only a small part of commercial banks' financial activities is concerned with making payments. Banks in this payment system are pure transaction/payment financial institutions.

The key elements of this alternative financial system are as follows:

- Limited liability businesses are prohibited from both borrowing and lending, with the exception of lending to the government and to transaction/payment banks.
- Only banks can issue demand deposits, and these deposits must be 100 percent backed by reserves held at the central bank.
- The central bank holds only short-term debt on Treasury securities; therefore, demand deposits are effectively 100 percent backed by money, a form of short-term government debt.
- Reserves bear interest at a rate specified by the government. Transaction banks may pay interest on deposits; however, any interest they pay is not subject to taxes.

Demand deposits would effectively be interest-bearing government currency. There could not be bank runs with this system. There is no place to run to. Whenever a transaction takes place

between private agents, one party's demand deposit account is credited by the amount of the transaction, and the other party's demand deposit account is debited by the same amount.

This system has two forms of government debt: debt held by the central bank and debt held by private agents. The debt held by the central bank is money. The stock of money equals the stock of demand deposits or, equivalently, the stock of reserves.

The return on these two forms of government debt can be, and typically will be, different. Absent satiation, the interest rate on the government debt held by the central bank will be lower than that held by the private sector. The difference in the yields on these two forms of debt is equal to the "liquidity" services provided by holding demand deposits at transaction/payment banks. We assume that the fiscal authorities manage the term structure in such a way that the total interest paid on privately held government debt is minimized. This policy results in a flat term structure. This feature permits us to abstract from the term structure of interest rates in this study.

Prohibiting limited liability businesses from both borrowing from one group and lending to another means that there will be no financial intermediaries with this system. Financial businesses would exist and would constitute a large sector of the economy. These financial businesses would make loans to households and non-financial businesses. The lenders, and not the taxpayers, would bear all default risk.

One question is, "Will this system reduce the funding of businesses?" The answer is no. Currently, most financing of businesses in the United States is mutual and is not coming from bank deposits. In 2012, checkable and time/savings deposits were approximately 0.65 GNP, whereas business borrowing was 2.5 GNP (2012 Flow of Funds, Table L104-5). Nearly all of the rest of business borrowing is directly or indirectly from the household sector.[3] Equity is a mutual arrangement whereby the owners of the businesses share the distributions and losses.

Another part of the system is to prohibit non-mutual annuities and non-mutual pension funds. Annuities that make payments contingent on the experience of the group are mutual arrangements, which by definition cannot become insolvent. Some problems would arise when insurance companies enter into contracts that under certain contingencies cannot be honored. Permitting only mutual insurance companies would be one mechanism to mitigate this problem. Regulation of insurance companies is less than perfect, and insurance company failures would continue to occur. Such failures, however, do not give rise to systemic risk and runs on mutual insurance companies. The time-inconsistency problems would lead to taxpayers bailing out those with insured losses that are defaulted upon.

[3] There could be some borrowing by business from the government.

In this paper, a simple model is developed and used to explore the consequences of various monetary policy regimes under our alternative financial system. The model treats the services of real money as an *input* to the aggregate production function, resulting in money being incorporated into valuation theory. Others have proposed having money as an input to the aggregate production function,[4] but they have not worked out the implications of using valuation equilibrium theory, as we do here. It turns out that having money services as a factor of production necessitates significant revisions to the national accounts.

We begin with a set of national accounts and construct a model economy that is consistent with these accounts. We examine the balanced growth path for a set of monetary policy regimes. We keep constant the public-consumption share of output and the lump-sum transfers to households share of output. We do this in order to focus on the consequences of alternative monetary policies and not on the consequences of alternative fiscal policies. Monetary and fiscal policy cannot be totally separated, as shown by Sargent and Wallace [1981].

The monetary variables we focus on are the inflation rate, the size of the money stock, and the interest rate paid on money. As the inflation rate enters the government accounts, differences in the labor income tax rate are associated with policies with different steady-state inflation rate targets. Interest rate targeting regimes will have different inflation rates, which has consequences for the key balancing condition in the government accounts that expenditures equal receipts plus the deficit. As we stated previously, it is impossible to completely separate fiscal and monetary policy because inflation has tax consequences.

We emphasize that this is an exploration study. It is designed to foster the examination of possible monetary system reforms. Before any financial reform is implemented, we should be confident as to how that monetary/financial system will operate. Currently, established theory cannot be used to make such predictions. The trial-and-error approach that characterizes current monetary policy is fraught with danger, leading us to the thesis that better theory is needed.

[4] Some of the other papers that have proposed money being introduced into the production function include Sinai and Stokes [1972], Fischer [1974], and Orphanides and Solow [1990].

Section 2: The Model Economy

The analysis is steady-state, and there is no uncertainty in living standards. Consequently, it does not matter whether an overlapping generation or an infinitely-lived family abstraction is used. We use the infinitely-lived abstraction because it is easier to use.

Preference:

There is a measure 1 of identical households with preferences ordered by

(1) $$\sum_{t=0}^{\infty} \beta^t [\log c_t + \alpha \log(1-h_t)],$$

where $c_t > 0$ is consumption and $h_t \in [0,1]$ is the fraction of the time endowment allocated to the market. The parameter $\beta = 1/(1+\rho) \in (0,1)$ is the discount factor and ρ is the discount rate. The parameter α determines the relative shares of c_t and the leisure fraction $(1-h_t)$.

For the balanced growth path with balanced growth rate γ, the steady-state real interest rate is

(2) $$i = \gamma + \rho + \gamma\,\rho\,.$$

This fact will be exploited when characterizing the steady state for policies for which it exists.

Households hold two stocks of assets that they rent to the business sector. These stocks are non-human capital k_t and (real) money m_t. They also hold nominal government bonds B_t. Therefore, the households' stock of real government bonds is $b_t = B_t / P_t$. These three stocks are the households' state variable. Households also supply labor services h_t to the business sector.

Price Level and Inflation:

There is a sequence of values of the composite output good in units of money. This is the definition of the *price level* P_t at date t. We break with tradition and define the date t *inflation rate* to be

(3) $$\pi_t = (P_{t+1} - P_t)/P_t\,.$$

We do this because it simplifies and unifies notation. When constructing the real value of a variable—whether it is a stock, flows, or prices—we simply divide its nominal value by P_t.

Technology

Technology advances at rate γ and is labor augmenting. Inputs to the business sector are the *services* of non-human capital k_t, the *services* of human capital h_t, and the *services* on real money stock m_t. The structure of the production function is as follows. Let z be an aggregate of the tangible and human capital services where

(4) $$z_t = k_t^{\theta}((1+\gamma)^t h)^{1-\theta}.$$

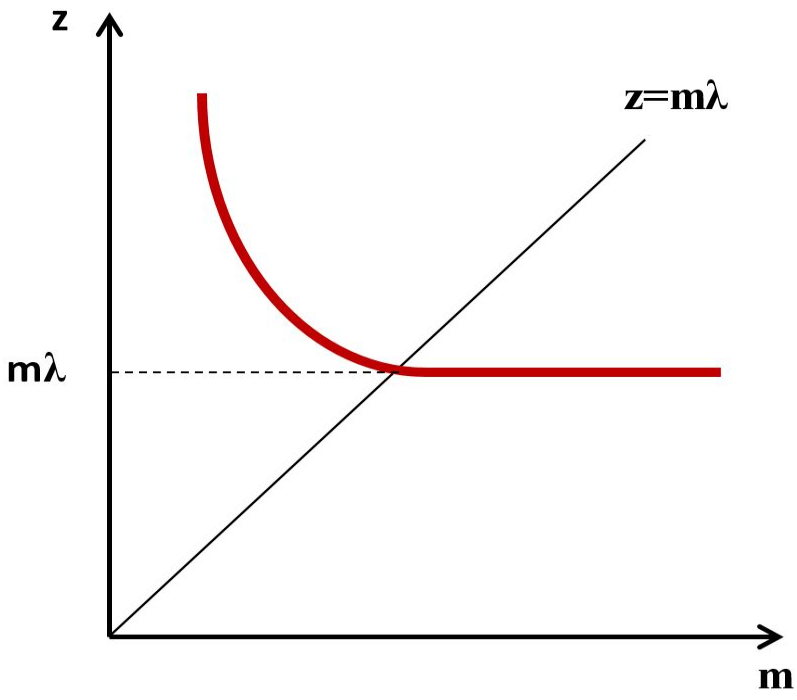
For these two capital stocks, one unit of stock provides one unit of services. We use h and k to denote both stocks and service flows.

The *aggregate production function* is

(5) $$y_t = A z_t^{\phi} \mathrm{m}_t^{1-\phi} \quad \text{if } m_t < \lambda z_t$$
$$y_t = A\lambda^{1-\phi} z_t \quad \text{if } m_t \geq \lambda z_t \text{ (satiation region)}$$

The aggregate production function is increasing and concave and displays constant returns to scale. The marginal product of m is zero if $m \geq \lambda z$. Figure 1 depicts an isoquant of the aggregate production function.

Figure 1: A Production Function Isoquant



Budget Constraints

Household

The assets held by the household are money, government debt, and capital. The inflation rate, possibly negative, is π; government lump-sum transfers in cash or in kind are ψ; r_k and r_m are the rental price of capital k and real cash balances m; i_b and i_m are the interest rates paid on the two forms of government debt. A primed variable is the next-period value of that variable. With these notational conventions, the household real budget constraint is

$$\begin{aligned} c + x + m'(1+\pi) + b'(1+\pi) \\ = (1-\tau)wh + r_k k + r_m m + i_b b + i_m m + b + m + \psi, \end{aligned}$$

where *x* is capital investment given by

$$x = k' - (1-\delta)k .$$

This states that expenditures are for consumption, investment, currency acquisition, and government debt acquisition and that the receipts are equal to the after-tax labor income, rental income on (non-human) capital k, rental income on money, interest payments on the two forms of government debt, and lump-sum transfers received from the government.

We use capital letters to denote nominal quantities. In nominal terms, the date *t* household's budget constraint is

$$C_t + X_t + M_{t+1} + B_{t+1} = (1-\tau_t)W_t h_t + r_k K_t + r_m M_t + i_m M_t + i_b B_t + M_t + B_t + \Psi_t .$$

Here, X_t is investment, so $K_{t+1} = K_t + X_t - \delta K_t$.

Firm

Given constant returns to scale, revenue is equal to costs, so

$$y = w\,h + r_k k + r_m m .$$

Government

The government's pure public good consumption is g. The interest rates on the two types of government debt are i_m and i_b. The government's budget constraint (expenditures equal revenue plus deficit) is

$$g + \psi + i_m m + i_b b = \tau\, w h + [m'(1+\pi) - m] + [b'(1+\pi) - b] .$$

Equivalently, the government budget constraint, using capital letters to denote nominal quantities, is

$$G_t + \Psi_t + i_{mt} M_t + i_{bt} B_t = \tau W_t h_t + (M_{t+1} - M_t) + (B_{t+1} - B_t).$$

Equilibrium

Prices are $\{w_t, r_{kt}, r_{mt}, i_{bt}, i_{mt}\}_{t=0}^{\infty}$. Equilibrium conditions are

(1) Households choose an optimal sequence of $\{c_t, h_t, k_{t+1}, m_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ given prices and their budget constraints.

(2) Firms choose at each date t the value maximizing $\{h_t, k_t, m_t\}$, given period t factor rental prices.

(3) The government selection of $\{g_t, \psi_t, \tau_t, m_{t+1}, b_{t+1}, i_{mt}, \pi_t\}_{t=0}^{\infty}$ is such that its budget constraints for all t, given prices and the households' decision variables, are satisfied.

Comment 1: The firm faces a sequence of static problems.

Comment 2: The list of elements specifying government policy includes both the prices and the quantities of money it issues. It will not be possible to target both the price and the quantity of money.

Section 3: Balanced Growth Analysis

The state of the household is its holdings at the beginning of the period real money stock, real government debt stock, and real capital stock. One important point is that interest rates are nominal. Nominal values of stocks and flows grow at the rate of inflation. Prices, with the exception of the interest rates on government bonds and money, grow at the inflation rate.

In a balanced growth equilibrium, output, consumption, investment, capital stock, money stock, debt stock, government expenditure, and transfers all grow at rate γ.

There are 19 variables to be determined. They are

$$\{w, r_k, r_m, i_b, i_m, h, k, m, b, k', m', b', g, \psi, \tau, \pi, \phi_g, \phi_b, \phi_\psi\}.$$

The following set of equilibrium conditions are necessary and sufficient for a steady state for a given policy and are used to find the steady state.

From the firm's maximization problem: three marginal conditions are that the marginal products (MPs) of the factors of production are equal to their rental prices. There is the zero profit condition given constant returns to scale. Aggregate feasibility is another condition.

(E1) $$MP_k = r_k$$

(E2) $$MP_h = w$$

(E3) $$MP_m = r_m$$

(E4) $$c + x + g = r_k k + r_m m + wh$$

(E5) $$y = c + x + g$$

There is an issue as to what the marginal product of money is when $m / y = \lambda$ as the production function is not differentiable at points along that line. The MP of money is bounded away from zero above the line and is zero below the line. The derivative from below is the value of the MP of money for points on this line.

Variable *y* is the output of the business sector and does not include the government production of money.

From the households' maximization problem: the intra-temporal marginal condition is that the marginal rate of substitution between consumption and leisure is equal to the ratio of their

after-tax prices. The inter-temporal condition is that the marginal rate of substitution between this and next period's consumptions equals the ratio of their prices. These conditions are:

(E6) $$\alpha c \setminus (1-h) = (1-\tau)w$$

(E7) $$1 + r_k = (1+\gamma)(1+\rho) + \delta$$

(E8) $$1 + i_b = (1+\rho)(1+\pi)(1+\gamma)$$

(E9) $$i_b = i_m + r_m$$

(E10) $$c + [k' - (1-\delta)k] + m'(1+\pi) + b'(1+\pi) = (1-\tau)wh + r_k k + (1+i_b)b + (1+i_m+r_m)m + \psi .$$

E8 and E9 are no-arbitrage conditions. Because there is no uncertainty, the household return on money and government bonds must be equal, and the return on government bonds must be equal to the return on investing in *k*.

Balanced growth requires

(E11) $$b' = (1+\gamma)b$$

(E12) $$m' = (1+\gamma)m$$

(E13) $$k' = (1+\gamma)k .$$

The law of motion of capital is

(E14) $$k' = (1-\delta)k + x .$$

In each of the sequence of valuation equilibria, there are three government policy constraints and a government budget constraint (expenditures equal revenue plus deficit):

(E15) $$g = \phi_g y$$

(E16) $$\psi = \phi_\psi y$$

(E17) $$b = \phi_b y$$

(E18) $$g + \psi + i_m m + i_b b = \tau w h + [m'(1+\pi) - m] + [b'(1+\pi) - b] .$$

The set of policy variables is $\{i_m, \mathrm{m/y}, \tau, \pi\}$. Values for two of these four variables are chosen. A restriction is that variables i_m and m/y are not *both* chosen. This adds two equations to our set of necessary equations. Thus, there are 20 equations in 19 unknowns. By Walras' law, one of the budget constraints is redundant.

Baseline Economy for Balanced Growth Analyses

A parametric set of economies has been specified. For the baseline economy, a parameter vector is chosen so that the baseline economy has a balanced growth that roughly matches the U.S. economy in consumption and investment shares, fraction of time worked, asset stocks to output ratios, factor income shares, inflation rate, and after-tax return on capital. Table 1 displays the national accounts for our chosen baseline economy.

Table 1 – National accounts for the baseline economy

Product and Income Accounts	
Product	**1.08**
Household Consumption	0.68
Government Consumption	0.05
Capital Investment	0.27
Money Investment	0.08
Income	**1.08**
Wages	0.64
Depreciation of Capital	0.15
Capital Rental Income	0.19
Money Rental Income	0.01
Central Bank Profits	0.08
Government Accounts	
Receipts	**0.43**
Tax Revenue	0.33
Money Issuance	0.08
Debt Issuance	0.03
Expenditures	**0.43**
Government Consumption	0.05
Transfers to Household	0.25
Bond Services	0.04
Money Services	0.10
Asset Stocks	
Capital	**3.81**
Money	**1.50**
Bonds	**0.50**
Other	
Hours Worked	**0.40**
Labor Income Share	**0.64**

The annual growth rate is 3 percent.

The size of the stock of money may seem large. The 1.5 times annual GNP stock is much larger than M2, which is about 0.6. As pointed out by Williamson [2012], two types of money are used for transaction purposes. Much of the liquid government debt is held as cash reserves, and in 2015 the nominal return on this debt in the major advanced industrial countries was near zero. Businesses make large payments using the shadow banking sector and small payments using the commercial banking system. The proposed arrangement has only one type of money.

Because money services are a factor of production, the national accounts must be revised so that they are consistent with the theoretical framework being used. Money, like capital, provides services to the business sector; therefore, there must be a "Money Rental Income" entry on the income side of the accounts and a "Money Investment" entry on the product side of the accounts. The government costlessly produces money and earns monopoly profits. These profits are entered on the income side of the national accounts as the entry "Central Bank Profits."

Table 2 displays the set of government policy parameters for the baseline economy. Note that the total factor productivity (TFP) parameter *A* is chosen for convenience so that *y* is one, and thus levels and levels relative to *y* are the same in the baseline economy. Also, the value of the satiation parameter λ is somewhat arbitrary. It was set high enough so that the baseline economy is not satiated with money.

Table 2 – Policy parameter values for the baseline economy

Policy Parameters	
g/y government public goods share	.05
ψ/y transfer share	0.25
m/y money-output ratio	1.5
b/y privately held gov. debt to output	0.5
τ labor tax rate	0.52
i_m interest rate on money	6.54%
i_b interest rate on gov. bonds	7.21%
π inflation rate (annual %)	2.00%

Table 3 lists the calibrated values of the preference and technology parameters.

Table 3 – Preference and technology values for baseline economy

Preference and Technology Parameters		**Values**
α	relative preference for leisure	0.68
β	discount rate (annual)	0.98
δ	depreciation rate (annual)	0.04
γ	technical growth rate	0.03
θ	capital cost share	0.35
ϕ	money cost share	0.01
A	TFP	1.13
λ	money satiation parameter	2.00

Explorations

In this section, we will explore the consequences of various monetary policy regimes under our alternative financial system. Our assessment is that technology has changed sufficiently so that existing monetary theory does not provide predictions as to the consequences of monetary policy regimes. Currently, there is public discussion as to whether the interest rate should be increased and what the inflation rate target should be. Exploration 1 will explore the consequences of various money supply—or, equivalently, money interest rate—policy regimes. Exploration 2 will explore the consequences of various inflation rate targeting regimes.

For this analysis, we focus only on monetary policy and therefore minimize the role of fiscal policy. This is done by keeping fiscal policy parameters as fixed as possible. Thus, the lump-sum transfers and the size of public goods consumption relative to output are held fixed. We also keep the value of non-monetary government debt at a fixed fraction of output. The inflation rate has tax consequences; this requires that the labor tax rate be endogenous when comparing the balanced growth paths of policies with different inflation rates. The three remaining policy variables enter the government budget constraint and therefore have some fiscal consequences.

For our explorations, the set of government policy variables includes the inflation rate, the tax rate, and the interest paid on money. In each exploration, two of these policy variables are fixed, and two are endogenous.

Our measure of welfare across policy regimes is consumption equivalent (CE) welfare. We report the percentage change in consumption that must be given to an individual to make him indifferent among worlds with different policy regimes. We acknowledge that this measure of welfare is a steady-state comparison for one type and does not take into account transitional concerns. But given that the ratio of non-human capital to output is the same for all balanced growth paths, the consequences of transition for the policy regimes comparisons we consider should be small.

Exploration 1 – Money Supply Policy Regimes

In response to the recession of 2008, those who make U.S. monetary policy have experimented with new monetary policy approaches. One of these approaches was quantitative easing, which increased the Federal Reserve's assets and liabilities fourfold to over 4 trillion USD. The other approach was paying interest on excess reserves, which was permitted beginning in 2010. These experiments resulted in a large increase in private sector deposits and therefore in the money supply.

For the set of regimes considered in this exploration, the following policy variables are held constant at the following values:

$$\{\mathrm{g}/\mathrm{y} = 0.05, \psi = 0.25,\ b/y = 0.5\}.$$

The government spends 5 percent of output and transfers 25 percent of output. The stock of government debt is 50 percent of output. This system keeps fiscal policy as fixed as possible.

The set of policy variables whose value varies across the regimes considered is

$$\{i_m, m/y, \pi, \tau\}.$$

Two of these policy variables are held fixed, and two are endogenous. In the model, money stock and interest on money are tied together and cannot be chosen independently.

1.a Interest on Money Regimes

First, we explore interest on money policies. The inflation rate is held fixed at 2 percent. The tax rate varies endogenously in order to have government expenditures equal to government receipts.

Figure 2 shows that a higher tax rate is associated with a higher interest rate on money. Increasing the interest on money increases the stock of money relative to output. Thus, the total interest paid to owners of money is larger. Since the inflation rate is fixed, a higher labor tax rate is needed for government expenditure to be equal to the sum of government receipts and the deficit. With these policy regimes, the deficit-to-output ratio is fixed.

Figure 2: Labor tax rates for different interest rate targets

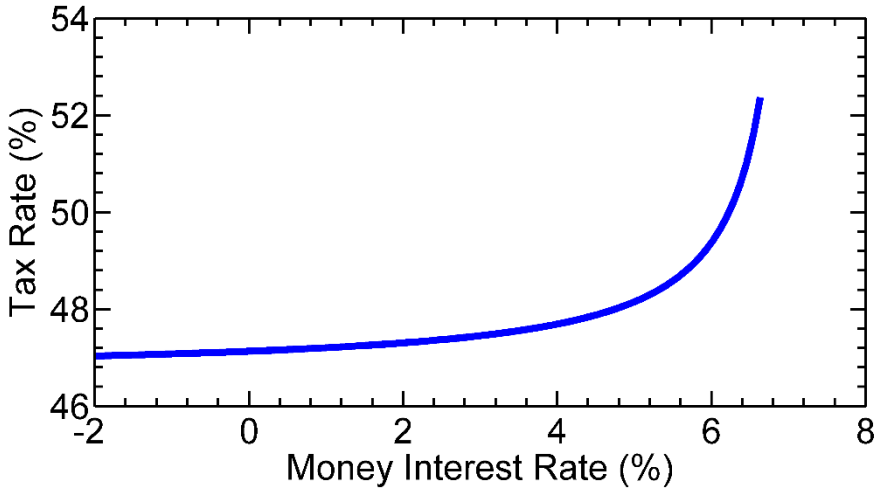
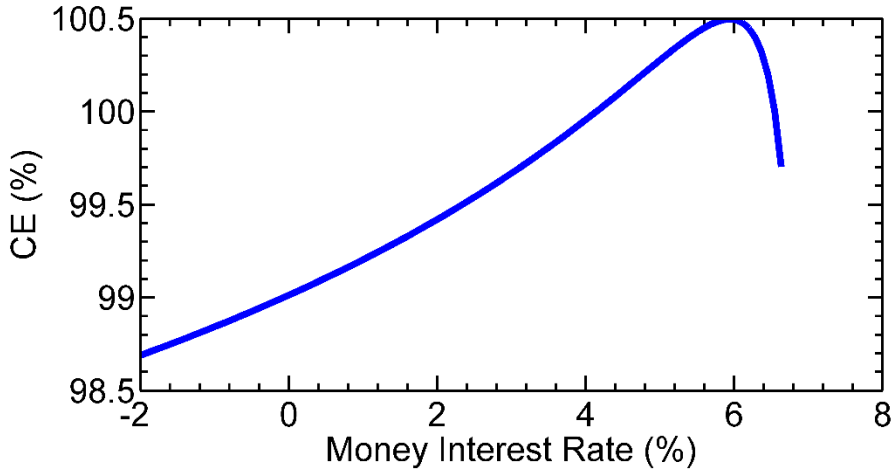


Figure 3 shows that there is a steady-state welfare-maximizing interest rate on money. A regime with a higher interest rate on money has a larger money services input to aggregate production. However, a higher interest rate regime also has a smaller labor input to aggregate production. For low interest rate regimes, the output increases because the larger money service input exceeds the output reduction arising from lower labor supply. For high interest rate regimes, output decreases because the reduction in output from lower labor supply exceeds the increase in output from larger money services. Figure 3 shows that, for our model economy, welfare is highest in a world where the interest rate on money is approximately 6 percent.

Figure 3: Steady-state welfare indicator for various interest rate targets



The nominal interest rate on government bonds is 7.2 percent. Why would the welfare-maximizing interest rate policy regime not completely eliminate the gap between the interest on money and bonds; that is, why is monetary satiation not optimal? Because we have fixed inflation and government spending, a labor tax rate change is needed for balance in the government accounts.

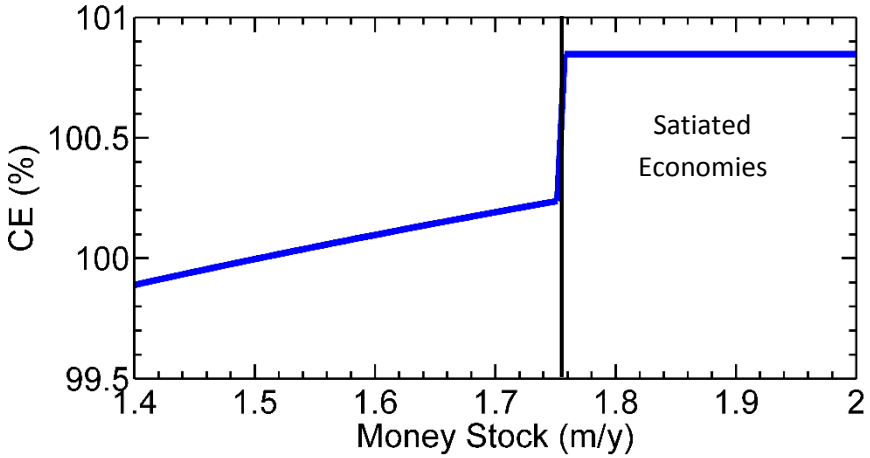
This highlights the importance of fiscal response to monetary policy. In a regime that targets the inflation rate, fiscal policy must respond to changes in interest rate policy.

1.b Money Stock Regimes

Next, we explore money stock policy regimes. We fix the labor tax rate at 52 percent and allow the inflation rate to vary endogenously to ensure that government expenditures are equal to government receipts. We consider money stock policies associated with both satiation and non-satiation.

Figure 4 shows that a larger money stock regimes has a higher steady-state welfare. However, increasing the money stock increases welfare only up to the satiation point, beyond which increasing the money stock does not increase welfare. For policy regimes with satiation, money and government debt are equivalent. In these regimes, money plus government debt is a constant, and consequently there is an unimportant indeterminacy.

Figure 4: Steady-state welfare indicator for various money stock regimes



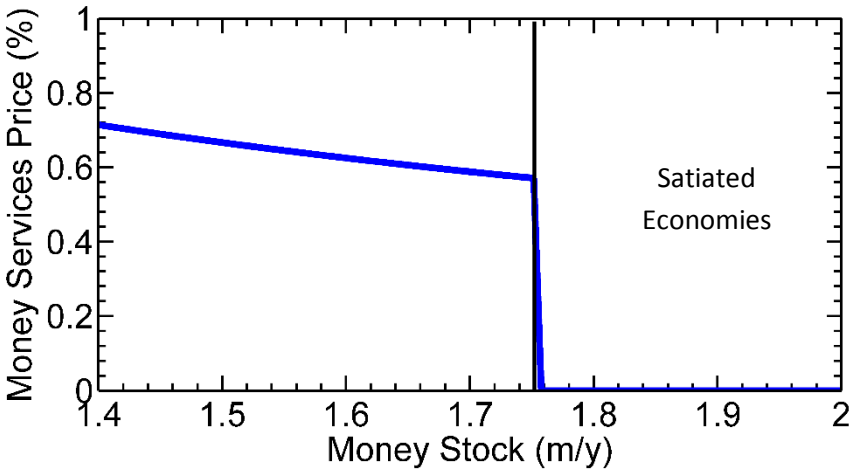
In figure 5, we see that for satiated money stock regimes, the rental price of money services is zero. For these regimes, the marginal product of money is equal to the marginal cost of producing money (assumed to be zero). Interest rates on money and bonds are equal, and money and bonds are identical government debt instruments.

In the United States, policies that increase the money stock are enacted by the central bank purchasing government bonds from banks in exchange for money. Since money and bonds are identical in satiated economies, the split of total government debt between money and bonds is indeterminate. In the satiated region, the sum of money and bonds is constant.

The Friedman rule leads to satiation in economies in which money is not a factor of production. The Friedman rule is to deflate at the real interest rate [Friedman, 1960]. The return on currency is then equal to the return on capital. In the monetary system considered here, we eliminate the inefficiency not by deflating at the real interest rate but by choosing a money stock regime that leads to a satiated economy. We call this state "Friedman satiation."

When money is a factor of production, Friedman satiation can occur with a range of inflation targets, including positive inflation. This feature allows for Friedman satiation without the difficulties associated with negative inflation rates [see McAndrews, 2015]. For example, Friedman satiation occurs when the target inflation rate is 2 percent, the tax rate is 53.5 percent, and the ratio of money stock to output is 1.75.

Figure 5: Marginal product of money for various money stock regimes



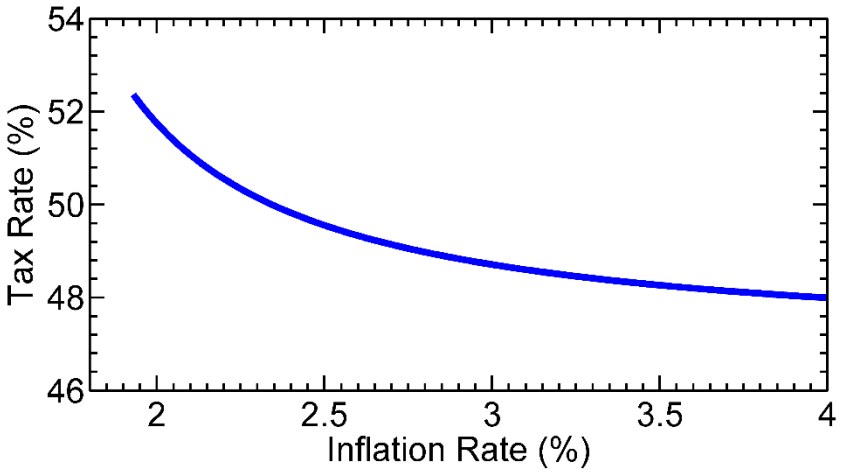
Exploration 2 – Inflation Rate Targeting

The inflation rate has been of particular interest of late. The U.S. Federal Reserve Board has been vocal about wanting to increase the inflation rate to the "normal" rate of 2 percent. Many have been puzzled by the persistently low inflation rate, which is currently near zero and is expected to stay under 2 percent for the next 30 years.[5] However, is low inflation a bad thing? Since price stability is part of a Federal Reserve congressional mandate, a theory that can address inflation rate targeting regimes is needed.

In this section, the interest rate on money is held fixed so that we can focus on the consequences of inflation rate targeting regimes. Various inflation rate policies are chosen. We consider only policies for which there is not satiation. This restricts the inflation rate target to be greater than or equal to 1.9 percent. The tax rate varies endogenously in order to have government expenditures equal to government receipts. Since interest on money is held fixed, the money stock also varies endogenously across policies.

Figure 6 shows that a higher labor tax rate is associated with a lower inflation rate regime. Inflation is a form of tax on money. A higher inflation rate regime has a lower labor income tax rate, higher labor supply, and higher consumption. This raises the interesting possibility of using a money tax to reduce the labor distortion created by financing the government through labor income tax.

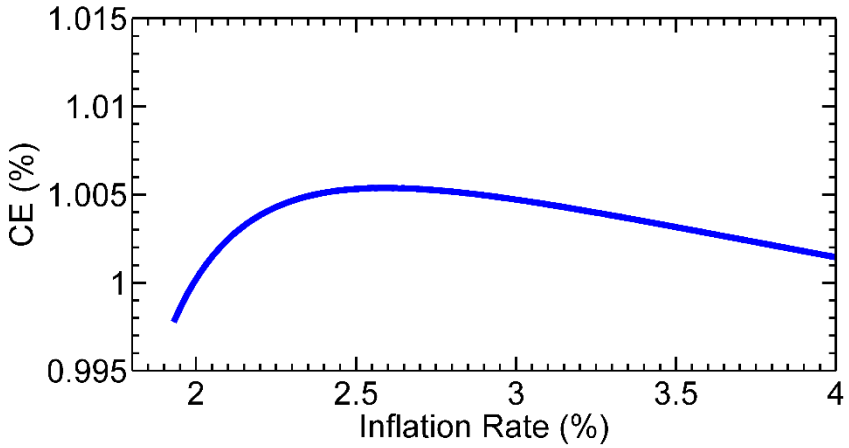
Figure 6: Labor tax rates for inflation rate targeting regimes



[5] Subtract the expected return on inflation-indexed Treasury securities from the expected return on nominal Treasury securities to see this.

Figure 7 shows steady-state welfare as measured by consumption equivalents (CEs) for various inflation rate targeting regimes. Since higher inflation is associated with lower labor income tax, in a higher inflation rate regime, more labor is supplied and the consumption level is higher. The higher inflation increases hours worked (decreasing welfare) but also increases consumption (increasing welfare). This exploration shows that different inflation rates have, in fact, very little impact on steady-state welfare.

Figure 7: Steady-state welfare indicator for various inflation rate targets



Possible Problems and Advantages

Some problems with this system are apparent. Privacy protection would need to be considered. We will not deal with this more general problem here. Also, in an environment in which banks are purely transactional institutions, shadow banking could be an issue.

We offer a possible solution to the shadow banking issue. To effectively eliminate businesses that borrow low from one group and lend high to another, the government could tax net interest income at a 100 percent rate for limited liability businesses. This approach would remove any incentive to engage in shadow banking.

Our proposed reforms also have possible advantages. First, bank runs would be prevented because banks would have nowhere to run.[6] Whenever a transaction takes place between private agents, one party's demand deposit account is credited by the amount of the transaction, and the other party's demand deposit is debited by the same amount. Second, our reforms would eliminate the need for costly regulations, as is associated with the U.S. deposit insurance system. A 100 percent reserve requirement would eliminate the need for stress tests and regulatory entities to ensure that banks are not taking on excessive risk. These activities cost about one-half percent per year per dollar deposited at commercial banks. This amount represents a non-negligible cost.

One claimed cost of the monetary system we explore is that it would increase the cost of financing because of the higher commercial bank equity cost. This argument is that with 100 percent reserve banking, bank equity would be higher and bank equity is costly. Admati, DeMarzo, Hellwig, and Pfleiderer [2011] point out, however, that bank equity is not costly. With our monetary system, demand deposits are what are households and the businesses choose to hold. Another claim often made is that fractional reserve banking is valuable in providing maturity transformation, because agents want to lend short and borrow long. The agents in our world can hold as much money as they want; that is, they can lend as much as they want to short. There is no need for maturity transformation.

We emphasize that much needs to be done before the theory can be used to make predictions as to the consequences of alternative policy. As done in McGrattan and Prescott [2016] for the consequences of an alternative tax policy regime, demographic projections must be made and introduced into the model economy being used. In addition, the equilibrium transition path to the balanced growth path for the alternative policy regime must be determined.

[6] A number of economists have proposed a 100 percent reserve for demand deposits as an arrangement that is not prone to bank runs. They include Fisher [1936] and Friedman [1960], and more recently Cochrane [2014], Prescott [2014], and Smith [2013].

Concluding Comments

We explore an alternative financial system that is possible given the current state of information processing technology. Before this system could be implemented, existing law would have to be changed to permit business enterprises to hold interest-bearing money.

This exploration is necessary because, in our assessment, existing theory does not provide predictions about the consequences of alternative monetary policy regimes. The trial-and-error approach that characterizes current monetary policy is fraught with danger; therefore, better theory is needed. We hope that this paper fosters fruitful theoretical work on reforming the payment system.

By integrating money into valuation theory, the tools of aggregate public finance can be and are applied. This is not the first use of these tools to quantitatively predict the consequences of alternative monetary policy regimes. These studies modeled the households' holding of M1, which was held for transaction purposes. It was motivated by Meltzer's [1963] finding of a reasonably stable M1 velocity depending on the short-term interest rate. Lucas and Stokey [1987] develop a transaction-based theory of this transaction demand for money. Cooley and Hansen [1989] introduced the Lucas-Stokey theory with cash and credit goods into the neoclassical growth model and carried out a quantitative general equilibrium analysis of the cost of modest inflation.

This transaction-based theory does not account for the large holding of cash reserves by businesses. Hodrick [2013] reports that in 2013, the cash reserves of American business were nearly equal to annual GNP. This does not include the cash reserves of businesses in the household sector. Households accumulate cash reserves in order to be able to make a down payment on a residence or a car. One implication is that much of M3 is made up of the cash reserves held by household businesses. Cash reserves are held by businesses because they are productive assets that facilitate the operation of the business sector.

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