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Scott Freeman

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Scott Freeman

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

DEPARTMENT OF ECONOMICS
THE UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA
N6A 5C2

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Scott Freeman*
Boston College
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Abstract

This paper presents an explicit physical environment in which optimizing agents choose the composition of their money balances. Because of their choices, changes in the nominal sum of inside and outside money precede changes in output. Nevertheless, changes in the supply of fiat money do not affect subsequent output. Moreover, an equilibrium with a fixed supply of valued fiat money is Pareto optimal despite the cyclical fluctuations of output and of the total money stock.

*Scott Freeman
Department of Economics
Boston College
Chestnut Hill, MA 02167

Introduction

The observation that changes in the nominal money stock precede changes in real output [Friedman and Schwartz (1963a,b)] has attracted a great deal of attention in the study of business cycles. This observation immediately leads one to wonder whether the monetary authority can use its control over the nominal money stock to influence output in a welfare-enhancing way.

This paper presents a model of the behavior of the money stock over the business cycle in which such welfare questions can be addressed. The model describes optimizing behavior in an explicit physical environment that is consistent with these two business cycle phenomena: (i) declines (increases) in the nominal money stock precede declines (increases) in output; (ii) these declines in the money stock take the form of an increased public preference for currency relative to deposits at intermediaries or of an increased holding of fiat money reserves relative to other assets in the portfolios of intermediaries (phenomena consistent with the observations of Cagan (1965) and Friedman and Schwartz).

The model's environment allows two assets: productive capital and fiat money. There exist financial intermediaries that issue "inside money," which is as easily exchanged as fiat money. The central choice problem is the combination of inside and outside money that will form their money holdings. The model's business cycle is driven by exogenous changes in the physical rate of return on capital. When the rate of return on capital is low, agents choose to increase their holding of fiat money relative to their holding of capital. This substitution of fiat money for intermediated capital in agents' money portfolios displays itself as a decrease in the money stock when that stock is measured as the nominal sum of inside and outside money balances. In the subsequent period, output contracts due to capital's low return and the lower level of investment. Although the monetary contraction occurs first, it is not the original cause of the output contraction. Moreover, increases in the money stock resulting from increases in the supply of fiat money do not cause subsequent changes in output. This leads one to question the prevalent practice of combining inside and outside money (even when equally useful in transactions) into a single monetary aggregate.

Like that of Sargent and Wallace (1982), the economy I present is consistent with many of the postulates and observations associated with the quantity theory of money. The model is therefore conducive to examining the welfare implications of imposing 100% reserve requirements or of manipulating the stock of fiat money to eliminate fluctuations in the price level or the money stock. I find that despite fluctuations in such aggregates as investment, output, and the total nominal money stock, there is no stationary allocation Pareto superior to the stationary monetary equilibrium in which the government does nothing but provide a fixed stock of fiat money (a policy I will call laissez-faire). There is also no efficiency justification for requiring reserves of fiat money to back all forms of money.

The model and its equilibria are described in section 1. In section 2, I suggest generalizations of the environment that would leave unchanged its central results. Section 3 examines welfare properties of the model. Concluding remarks are presented in section 5.

1. The Model Under Laissez-faire:

The model is a version of Cass and Yaari's (1966) adaptation of Samuelson's (1958) overlapping generations model. Agents live two-period lives in generations that overlap. Denote the number of agents born in generation t as N(t). Let $N(t) = nN(t-1)$ for all periods t, where n is a positive constant. Agents maximize the utility function $U(c_1, c_2)$, where c_i denotes an agent's consumption of the sole good in the i^{th} period of life. Denote derivatives with subscripts. Assume that u_i approaches infinity as c_i approaches zero. Each agent is endowed with one unit of labor when young which is used inelastically to produce y units of the consumption good. He is endowed with nothing when old. Agents have rational expectations, which take the form of perfect foresight in the non-stochastic environment.

The consumption good at time t can be transformed into the consumption good at time t+1 by the creation of what I will call capital. For every unit of the consumption good put into capital at t, x(t) units of the consumption good will be produced at t+1. [A version of this model with the capital of Diamond (1965) is presented in the appendix.] All capital created at t is used up in the production of t+1 good. Neither capital nor the consumption good can be stored. The parameter x(t) equals x_1 when t is odd and x_2 when t is even, with $x_2 > n > x_1$ and $n^2 > x_2x_1$. To motivate the existence of intermediaries in a simple fashion, I assume that capital can only be created in blocks of k* or more units of the consumption good with $k^* > y$ (the endowment of an individual). If savings are pooled through cost-free intermediaries, the minimum size of capital will not affect agents' choice problem. [This motivation for intermediation is taken from Bryant and Wallace (1980).] I will interpret these intermediated holdings of capital as inside money. Although all saving takes the form of inside money in this model, the results of the model extend to economies in which all capital is not intermediated, as I argue in section 2.

There exist M (a positive constant) units of fiat money at time t. Fiat money is unbacked, intrinsically useless pieces of paper costlessly produced by the government.

A monetary equilibrium exists in each of two equivalent institutional arrangements. In one, individual households allocate their desired money holdings between personal holdings of fiat money and deposits at an institution that costlessly intermediates illiquid capital. This represents the currency/demand-deposit choice of households. In the other, agents deposit their desired level of money holdings at a financial intermediary which chooses the portfolio of fiat money and capital with the best rate of return. Here the relevant decision is the composition of the intermediary's portfolio as reflected in its reserve to deposit ratio. Two distinct steps to the optimization problem can be distinguished. First, the individual chooses his desired level of money balances for a given rate of return on money. Next, the division of money holdings between fiat money and intermediated capital is selected. It is this choice of the composition of money holdings that is essential to the precedence of money changes to output changes. If the economy is organized according to the first of the above institutional arrangements, this portfolio choice is made by individual households. In the other institutional arrangement the portfolio choice is made by the intermediary. The two arrangements lead to exactly equivalent equilibria.

A young agent chooses his real money holdings, s(t), in order to maximize his lifetime utility. That is, his problem is

$$\max_{s(t)} \; u(y - s(t), r(t)s(t))$$

where r(t) represents the real rate of return paid on his money balances. The assumptions on the utility function ensure the existence of an interior solution with the first order condition

$$u_1(t)/u_2(t) = r(t)$$

where $u_i(t)$ represents the marginal utility of an agent born at t with respect to consumption in the i^{th} period of his life.

The individual agent or the financial intermediary chooses its portfolio of capital and fiat money to maximize its rate of return. Market clearing for money balances requires that $p(t)M = H(t) \equiv N(t)h(t)$, where p(t) is the value of a unit of fiat money in units of the consumption good at t; $H(t)$ is the economy-wide demand for fiat money in real terms; and $h(t)$ is the per capita real demand for fiat money.

In a stationary monetary equilibrium, agents face the same optimization problem every other period and $h(t+2) = h(t)$ so that the two-period rate of return on fiat money is

$$\frac{p(t+2)}{p(t)} = \frac{N(t+2)h(t+2)/M}{N(t)h(t)/M} = n^2 \tag{1}$$

For fiat money to be valued it must offer a rate of return no less than that of capital in each period. Since intermediation is assumed to be a costless and perfectly competitive activity in a stationary monetary equilibrium,

$$n^2 = r(t+1)r(t) \tag{2}$$

The condition for the existence of a monetary equilibrium, $n^2 > x_2x_1$, can now be interpreted as an assumption that the long run rate of return of fiat money exceeds that of capital. (If this is not so, only legal restrictions will ensure that fiat money is valued in the environment I present. See section 2 for a discussion of this case.)

This paper studies only stationary equilibria in which some capital is held when capital offers a high rate of return (x_2). (A sufficient condition for this to be the unique stationary monetary equilibrium is that the utility function be such that the derivative of saving with respect to rate of return is positive.) Then from equation (2) we have that the rate of return in odd periods equals n^2/x_2. Since $n^2/x_2 > x_1$, no capital will be held in odd periods.

The reduction in capital in odd periods reduces the output from capital in the subsequent period. A reasonable measure of the output of period t (call it GNP(t)) is the sum of the output at t of labor [N(t)y] and of capital [N(t-1)x(t-1)k(t-1)].

$$\text{Then } GNP(t) = \begin{cases} N(t)y & , t \text{ even.} \\ N(t)y + N(t-1)x_2k(t-1), & t \text{ odd.} \end{cases}$$

Deposits at intermediaries in periods of a low rate of return on capital is not investment in productive capital but increased holdings of fiat money, which does nothing to expand the next period's output. The output in the even periods of a monetary equilibrium is therefore lower than it would have been in an equilibrium without fiat money, in which case some capital would have been held in every period. However, the goods available for consumption are increased by the holding of fiat money as a substitute for capital with a poor rate of return. (See equation (10) in the proof to proposition 1.)

It is also possible to construct an aggregate analogous to the Federal Reserve measures that aggregate inside and outside money. The nominal money stock at t, MS(t), in this model is the stock of fiat money, M(t), plus the nominal stock of intermediated capital, N(t)k(t)/p(t). Because only fiat money is held in odd periods, the money stock fluctuates in the following way:

$$MS(t) = \begin{cases} M(t) + N(t)k(t)/p(t), & t \text{ even} \\ M(t) & , t \text{ odd.} \end{cases} \quad (3)$$

Recall that

$$GNP(t) = \begin{cases} N(t)y & , t \text{ even} \\ N(t)y + N(t-1)x_2k(t-1), & t \text{ odd} \end{cases} \quad (4)$$

The positive real balances of inside money held in even periods represent capital that increases output in the following periods. In this way the model displays changes in the money stock that precede changes in output. [Although a two-period cycle was chosen for its simplicity, it is clear from equation (4) that the output change is linked to the previous period's stock of inside money [k(t-1)], not the stock in the current or subsequent period.] It should be noted that the decreases in the money stock of this model occur as agents act to hold greater real balances of fiat money. Because inside and outside money are equally liquid, the demand for each is determined solely by its rate of return. When capital has a low rate of return, so has intermediated capital; as a result, the demand for fiat money increases. [This explanation differs from those considered by Tobin (1970), Sims (1980), and Litterman and Weiss (1985), who attribute the money stock changes to money supply rules that are tied to variables that change over the business cycle.]

My model also provides an explanation of the phenomena described by Cagan: a greater public demand for cash and greater excess reserves at depository institutions in periods of monetary contractions that precede output contractions. In this way the money stock fluctuations can be viewed as the results of agents' portfolio decisions. The fluctuations would occur even if agents never change their level of total real balances in response to rates of return.

Because the fluctuations in the money stock represent agents' optimal portfolio reaction to fluctuations in the rate of return on capital, the fluctuations in the nominal monetary aggregate are not the original cause of the output fluctuations. Note that despite the time series correlation between the nominal money stock and next-period output, large nominal stocks of fiat money are unrelated to next-period output. It is solely the part of the money stock backed by capital that is linked to the next period's output. This argues strongly against the common practice of aggregating inside and outside money into a simple measure of the money stock. Despite their equal usefulness for transactions in this model, changes in inside and outside money differ in their links to output. It matters whether an increase in the money stock represents endogenously determined holdings of intermediated capital or unbacked emissions of the government printing press. [King and Plosser (1984) also propose that inside and outside money differ in their links to output and present supporting evidence of the difference.]

As the quantity theory of money would predict, the price level in this economy is positively correlated over the business cycle with this measure of money. For example, a contraction of the total money stock represents an increase in the demand for fiat money, which causes a decrease in nominal prices. It is for this reason that the nominal money stock will fluctuate even if the real demand for money does not change over the business cycle (the case of a log-linear utility function). Despite this cyclical correlation, long run price trends are determined by the stock of fiat money, not the money stock aggregate.

It is interesting to note that the model captures some of Keynes's (1936) notions of the role of money over the business cycle: (i) agents choose to hold fiat money instead of productive capital when a low rate of return on capital is anticipated; and (ii) as a result of this preference for fiat money ("liquidity preference"?), output in recessions (even periods) is lower than it would be in an economy without fiat money.

2. Alternative Environments:

Simplicity and tractability were considerations in the construction of this model's environment. Similar business cycle phenomena can nevertheless be reproduced in more general environments. The inside money of this model comprises the economy's entire capital stock but the existence of unintermediated capital need not lead to different results. Imagine, for example, a segment of the population with an endowment so high that they are not affected by the constraint of the minimum size of capital. These "rich" agents would hold unintermediated capital while the "poor" would hold intermediated capital. An anticipated fall in the rate of return of capital would cause a decline in all forms of capital, including, as before, inside money. Therefore the key feature of the model is not that all capital is inside money but that some of what is called money is intermediated capital.

The money/output correlation also does not depend on why unintermediated capital is illiquid or on why money is required for exchange. So long as some freely chosen fraction of money is backed by capital, the size of that fraction of money holdings will react to anticipated changes in the return on capital. In other words, the money/output correlation comes from the choice of the composition--not the level--of money balances.

Agent lifetimes or the business cycle could also be longer than two periods. As long as the rate of growth of population exceeds the rate of return over the length of the business cycle in the non-monetary equilibrium, there will exist a monetary equilibrium under laissez-faire in which fiat money is preferred to capital in some periods.

Even if the long-run rate of return on capital exceeds the rate of growth of population, fiat money may still have value because of government regulations. For example, the government may require that some fraction of an intermediary's assets be held in fiat money. If such fractional minimum reserve requirements are introduced into the model, agents facing a poor return on capital will elect to hold more than the required amount of fiat money, causing a decrease in the nominal money stock aggregate. This reaction is again consistent with the observation of Cagan (1965) that the ratio of deposits to reserves falls during monetary contractions that precede output contractions. Such a reserve requirement equilibrium would not be Pareto optimal but those facing a low rate of return on capital would prefer this monetary equilibrium to the non-monetary equilibrium. [See Wallace (1983) for a summary of the ideas behind the legal restrictions view of the demand for money.]

If financial institutions were required to back all liquid liabilities exclusively with fiat money reserves, there would be no fluctuations of the nominal money stock over the business cycle in this analog economy (except those caused by deliberate actions of the monetary authority). This is a requirement Friedman (1960) advocates as a means to reducing fluctuations in the money stock and the related fluctuations in prices and output. If these holdings of fiat money form the only asset in the economy, output fluctuations are also ended but only because the economy now gets no output from capital. If there is unintermediated capital held in the economy (e.g., by "rich" agents unaffected by a minimum denomination on capital), output fluctuations would exist despite the absence of fluctuations in the nominal money stock. Moreover, when the rate of return on capital falls below the rate of return of fiat money, agents will substitute fiat money for capital, increasing the price of fiat money in those periods. In this way, the stability of the nominal money stock need not lead to the stability of output or prices.

An economy with Diamond's (1965) production technology can also display a preference for fiat money when the rate of return on capital is low. Diamond's technology supposes that the production of the consumption good results from combining current labor with the capital accumulated by the previous period. Therefore, a reduction of the capital stock will affect the wages, savings, and utility of the next generation, greatly expanding the set of possible effects of policy on endogenous variables. However, there is again no stationary allocation Pareto superior to the monetary equilibrium under laissez-faire, as demonstrated in the appendix.

3. The Welfare Properties of Laissez-Faire

Despite its lower levels of capital and output, this monetary equilibrium is Pareto superior to the non-monetary equilibrium. When compared to the non-monetary equilibrium, the monetary equilibrium offers agents a better rate of return in odd periods and the same rate of return in even periods.

Moreover, despite its fluctuations in such aggregates as output, investment, and the total money stock, there is no stationary allocation Pareto superior to the monetary equilibrium under laissez-faire, as shown in Proposition 1 below. I have restricted my proposition to avoid cumbersome non-stationary allocations. A proof of the Pareto optimality of laissez-faire that considered non-stationary allocations would be a straightforward but lengthy application of the proof of proposition 3 in Wallace (1980).

Proposition 1: There exists no stationary allocation Pareto superior to the monetary equilibrium with a fixed stock of fiat money.

Proof: The budget set of a generation born at t in the monetary equilibrium can be formulated as

$$y = c_1(t) + c_2(t)/r(t) \tag{5}$$

where $c_i(t)$ denotes the consumption of generation t in the i^{th} period of life. The convexity of the indifference curves implies that if a generation born at t prefers an allocation $(c_1(t),c_2(t))$ to the monetary equilibrium, then

$$[c_1(t) - c_1^*(t)] + [c_2(t) - c_2^*(t)]/r(t) > 0 \tag{6}$$

where * denotes the monetary equilibrium value. Recall that under laissez-faire $r(t) = x_2$ for t even and $r(t) = n^2/x_2$ for t odd.

The inequality constraining the economy to feasible allocations at any time t is

$$\begin{aligned} &N(t)y + N(t-1)x(t-1)k(t-1) \\ &> N(t)c_1(t) + N(t-1)c_2(t-1) + N(t)k(t) \end{aligned} \tag{7}$$

for stationary allocations. This becomes (after dividing through by N(t)):

$$y + (x_2/n)k_2 > c_1{}^1 + c_2{}^2/n + k_1 \text{ for t odd} \tag{8}$$

and

$$y + (x_1/n)k_1 > c_1{}^2 + c_2{}^1/n + k_2 \text{ for t even} \tag{9}$$

where $c_j{}^1$ is consumption in the j^{th} period of life for members of odd generations ($c_j{}^2$ for even generations) and where k_1 is the amount stored per capita by odd generations (k_2 by even generations). I will consider only allocations that satisfy the above at equality. (If there is no Pareto superior allocation that satisfies them with equality, there will be no Pareto superior allocation that satisfies them without equality.) We can now solve one equation for k_2 and substitute the expression into the other equation to get

$$(1 + x_2/n)y + (x_1x_2/n^2 - 1)k_1$$
$$= c_1{}^1 + (x_2/n^2)c_2{}^1 + (x_2/n)c_1{}^2 + c^2/n \qquad (10)$$

Since $n^2 > x_1x_2$, positive values of k_1 serve only to reduce the goods available for consumption. Therefore let us consider only allocations with $k_1 = 0$.

$$(1 + x_2/n)y = c_1^1 + (x_2/n^2)c_2^1 + (x_2/n)c_1^2 + c_2^2/n \qquad (11)$$

Using equation (5) and $r(t) = x_2$, t even and $r(t) = n^2/x_2$, t odd, it can be verified that the monetary equilibrium satisfies equation (11) with equality. Therefore, a Pareto superior allocation exists only if

$$(c_1^1 - c_1^{1*}) + (x_2/n^2)(c_2^1 - c_2^{1*})$$
$$+ (x_2/n)(c_1^2 - c_1^{2*}) + (c_2^2 - c_2^{2*})/n = 0 \qquad (12)$$

However, by equation (5) both

$$(c_1^1 - c_1^{1*}) + (x_2/n^2)(c_2^1 - c_2^{1*})$$

and

$$(x_2/n)(c_1^2 - c_1^{2*}) + (c_2^2 - c_2^{2*})/n$$

must be positive in a Pareto superior allocation. Q.E.D.

4. Concluding Remarks

In their (1982) challenge to the quantity theory of money, Sargent and Wallace demonstrate that important insights into the behavior of prices and money and into the welfare implications of policies to stabilize these variables are available from models that generate business cycle behavior and the demand for money as the results of optimizing behavior in explicit physical environments. [See also Lucas, (1980).]

In this paper I follow the example of Sargent and Wallace in proposing a completely specified environment in which money stock contractions precede--but are not the first cause of--output contractions. The model's key assumption is that inside and outside money differ by definition in their backing, even if they are equally useful in conducting transactions. Agents face, therefore, a portfolio choice independent of their choice of the size of their money balances. When the rate of return on capital falls in anticipation of a period of low output, agents rationally decide to back less of their money with capital and more with fiat money, lowering the nominal measure of the total money holdings. A significant implication of the model is that while changes in the exogenously determined stock of fiat money will also change the total nominal money stock, they are not linked to subsequent changes in output. This result follows from the fundamental difference in the backing of intermediated capital and fiat money and leads one to question the widespread attention paid to monetary aggregates that ignore this difference.

Appendix

Consider the overlapping generations model described in section one with the following version of Diamond's (1965) production technology.

Output at t equals $F(K(t-1),L(t))$ for t odd

$\overline{F}(K(t-1),L(t))$ for t even

where F and $\overline{F}$ are twice differentiable, homogeneous of degree one and have positive marginal products and diminishing marginal rates of substitution. $K(t-1)$ is the capital formed at t-1 and $L(t)$ is the labor supplied at t.

Output at t per young person equals $F(k(t-1)/n,1)$ for t odd

$\overline{F}(k(t-1)/n,1)$ for t even

when each young person is endowed with one unit of labor.

Proposition: There is no stationary allocation Pareto superior to the equilibrium with a fixed stock of valued fiat money.

Because the production technology alternates, a stationary allocation is one in which

$$(c_1(t),\ c_2(t),\ k(t)) = \begin{cases} (c_1,\ c_2,\ k) & \text{for t odd} \\ (\overline{c}_1,\ \overline{c}_2,\ \overline{k}) & \text{for t even} \end{cases}$$

where c_1, c_2, k, $\overline{c}_1$, $\overline{c}_2$, and $\overline{k}$ are non-negative constants. (Recall) that $c_i(t)$ is consumption of a member of generation t in the i^{th} period of life and $k(t)$ is capital per young person found at t. There is no stationary allocation Pareto superior to any allocation that maximizes the following Lagrangian:

$$
\begin{aligned}
U(c_1, c_2) &+ \gamma[U(\bar{c}_1, \bar{c}_2) - \bar{U}] \\
&+ \lambda[F(\bar{k}/n, 1) - c_1 - \bar{c}_2/n - k] \\
&+ \bar{\lambda}[\bar{F}(k/n, 1) - \bar{c}_1 - c_2/n - \bar{k}]
\end{aligned}
$$

where $\bar{U}$ is some constant.

The first order conditions with respect to c_1, c_2, $\bar{k}$, c_1, $\bar{c}_2$, and $\bar{k}$ can be expressed:

$$\frac{U_1}{U_2} = \bar{F}' \quad \text{and} \quad \frac{\bar{U}_1}{\bar{U}_2} = F' \quad \text{and} \quad F'\bar{F}' = n^2,$$

where

$$U_i = \frac{\partial U}{\partial c_i} \; ; \; \bar{U}_i = \frac{\partial U}{\partial \bar{c}_i} \; ; \; F' = \frac{\partial F}{\partial \bar{k}} \; ; \; \text{and } \bar{F}' = \frac{\partial F}{\partial k} \; .$$

(Note that the assumptions concerning preferences will guarantee an interior maximum.) Since the two-period rate of return in a stationary monetary equilibrium is n^2 under laissez-faire, the above conditions are also the first order conditions of such a monetary equilibrium if it exists.

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