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LIQUIDITY CONSTRAINTS IN ECONOMIES WITH AGGREGATE FLUCTUATIONS: A QUANTITATIVE EXPLORATION

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Introduction

In this paper we extend and apply computable general equilibrium methods to the study of economies where liquidity constrained agents hold nominal assets as a substitute for insurance against idiosyncratic uncertainty. By varying their holdings of these assets, agents can buffer their streams of consumption against bad draws in their individual-specific production opportunities.[1] An earlier economy with liquidity constrained agents is the Lucas (1980) pure-currency model. Imrohoroglu (1989, 1991) calibrates this economy to U.S. data and uses it to estimate the welfare costs of, respectively, business cycle fluctuations and constant inflation rate policies.[2] In this paper we generalize the Lucas pure currency structure by introducing aggregate uncertainty and by adding an interest-bearing government security. We use this extended structure to quantitatively explore some of the effects of monetary policy on real economic activity.

We focus on the substitute-for-insurance motive mainly because households hold large quantities of liquid assets in spite of the fact that their rate of return is significantly smaller than the rate of return on capital. In the U.S., during the post-Korean war period, for example, the holdings of M2 by the household sector were approximately equal to one year of private consumption. In this same period, the average real rate of return on M2 assets was near zero which is considerably less than the 6 or 7 percent average real rate of return on tangible capital in the business sector, after business taxes. These facts strongly suggest that there must be reasons other than transactions or the life-cycle to justify household liquid savings. The substitution for insurance motive is our candidate.

Previous applied general equilibrium analyses have not dealt with economies that include both aggregate uncertainty and agents who hold liquid assets as a substitute for insurance against idiosyncratic risk. In our opinion, the reason for this omission is not the lack of interest in the quantitative behavior of such economies, but rather the lack of tools to compute their equilibrium processes. When aggregate uncertainty is considered, the distribution of agents as indexed by their current asset holdings and idiosyncratic shocks is no longer invariant over time and it becomes a part of the state of the economy. The resulting high-dimensional state precludes the use of standard recursive computational methods.

We get around this problem as follows: We start out by specifying the equilibrium processes on prices for the government-issued assets. Next we find the associated equilibrium policy rules which specify the households' optimal decisions as a function of their asset holdings, and of the realizations of both their household-specific and the economy-wide Markov disturbances. Then we use these rules and the current distribution of households to determine the aggregate labor, consumption and asset accumulation behavior of the household sector. The next step is to determine the equilibrium government consumption and the government supply of assets from the corresponding market clearing conditions. Next we use the transition probabilities on the economy-wide process to randomly draw the following period's realization of the economy-wide disturbance. Finally, this realization together with the household policy rules, and the transition probabilities on the idiosyncratic shocks is used to calculate the following period's distribution of households as a function of the current period distribution and of the current and new realizations of the economy-wide disturbance. By repeating this procedure we obtain a stochastic realization of the equilibrium behavior of the economy.

A second limitation of the Lucas-type economies is that there is only one form of government debt and, therefore, these economies cannot be used to analyze the effects of sales and purchases of interest-bearing government debt carried out by the monetary authorities. If these economies are to be used to evaluate monetary policy, this is an important limitation given that such open market operations have become the principal tool of monetary policy.

To overcome this limitation, our model economies include two types of government-issued assets: a small-denomination, non-interest-bearing asset which we call currency and a large-denomination risk-free government promise for future delivery of currency which we call T-bills. T-bills sell at a discount and, therefore, implicitly bear interest. If both of these assets are to be held in equilibrium, the environment must include some feature to induce the agents to hold the lower-yielding currency. We follow Bryant and Wallace (1979) and introduce legal constraints that preclude private agents from pooling their savings and holding the large denomination, interest bearing T-bills.[3]

In the present paper we use these extensions to explore the real effects of different monetary policies. Friedman (see Friedman and Schwartz 1963) has repeatedly argued that monetary shocks are an important source of aggregate fluctuations and has presented extensive empirical evidence to support this view. Sims (1980) has shown that the innovation in the interest rate is important in forecasting future real output for vector autoregressions on M1, the price level, a measure of output and nominal interest rates. Litterman and Weiss (1985) interpret this finding as evidence in favor of monetary policy having important real effects. Some weaknesses of these empirically determined aggregate theories are that the mechanism by which the monetary policy rules affect the equilibrium processes is not specified and that the question of which monetary aggregate to use is left open. In this paper we focus on the insurance-substitution role for holding liquid assets and we provide an explicit mechanism by which monetary policy implemented through open market operations affects the economy.[4]

In Section 1 we describe our class of monetary economies. In Section 2 we define the equilibrium processes. Section 3 discusses the calibration choices for the model economy. Section 4 reports our findings and Section 5 concludes the paper and offers suggestions for future research.

1. Description of the Class of Monetary Economies

There is a continuum of agents with total measure one. The agents order their random streams of consumption and leisure according to:

$$E\sum_{t=0}^{\infty} \beta^t u(c_t, \tau - n_t)$$

where $0 < \beta < 1$ is the subjective time discount factor and $c_t \geq 0$ is a perishable consumption good. Parameter τ is the total endowment of productive time and n_t is the amount of time allocated to market activities. Consequently, $\tau - n_t$ is time allocated to household production. Here it is simply called leisure. There is an exogenous economy-wide stochastic process $\{z_t\}$. This process is a Markov chain with transition probabilities,

$$\pi(z'|z) = \Pr\{z_{t+1} = z'|z_t = z\}$$

for

$$z, z' \in Z = \{1,2,\ldots,n_z\}.$$

We assume that the Markov chain generating z has a single ergodic set, no transient states and no cyclically moving subsets.

There are identically distributed individual specific stochastic processes $\{s_t\}$. Conditional on $\{z_t\}$, the $\{s_t\}$ processes are independent across individuals and follow a finite state Markov chain. Their conditional transition probabilities are:

$$\pi(s'|s,z') = \Pr\{s_{t+1} = s'|s_t = s, z_{t+1} = z'\}$$

for

$$s, s' \in S = \{1,2,\ldots,n_s\} \text{ and } z \in Z.$$

The joint processes on each agent's idiosyncratic shock s and on the economy-wide shock z are therefore Markov chains with $n = n_s n_z$ states. Their transition probabilities are

$$\pi[(s',z')|(s,z)] = \pi(z'|z)\pi(s'|s,z').$$

The state space $S \times Z$ of the Markov chain on (s,z) can be partitioned into a finite number of ergodic sets $S_h \times Z$, for $h = 1, \ldots, n_h$, and a transient set T. We assume that the chain on (s,z) has no cyclically moving subsets. The initial measure of agents with $s \in S_h$ is λ_h. Given that the probability that $s_t \in S_h$ given $s_0 \in S_h$ is always one, the measure of agents of type h is time-invariant. If $s_t = s$ and $z_t = z$, the agent's date t production possibility set is determined by

$$0 \leq y_t \leq w(s_t,z_t)n_t$$

where y_t is the agent's output of the date t consumption good, and w(s,z) is a technology parameter. We assume that when agents choose to work, they are paid their marginal product. Therefore, w(s,z) equals the individual agent's real wage.

Following Rogerson (1988) and Hansen (1985), we assume a labor indivisibility. Hours of labor services provided, n_t, are constrained to belong to the set {0,1}. Zero corresponds to not being employed and one to being employed.

Monetary Arrangements

The monetary arrangements for this class of economies are as follows: The government sells one period nominally denominated bills for currency at the discounted price $q_t = \gamma q(z_t)$. It also exchanges goods and currency at price p_t. This price satisfies $p_t = p_{t-1}e(z_t)$. Both the price of bills and the inflation rate are restricted to being a function of the exogenous component of the economy-wide state only. This restriction was dictated by computational considerations. An additional restriction is that $q(z)e(z') < 1/\beta$ for all z and z'. With this restriction the real rate of return on interest-bearing government debt is always less than the households' subjective time discount rate. A final restriction on the pricing processes is that the nominal interest rate must be always positive, i.e., that $q(z) < 1$ for all z.

Agents can hold integer amounts of small denomination currency

$$m \in \{0,1,2,\ldots\}.$$

They can also hold integer numbers of large denomination bills

$$b \in \{0,1,\ldots,n_b\}.$$

The denomination of bills in terms of currency is a large integer γ. Since there are no insurance technologies available, agents hold these assets for consumption smoothing and for protection against variations in their marginal productivities and therefore in their labor income.

2. Definition of Equilibrium

The *state of an individual* is the triplet (a,s,z) where variable a is the real value of an individual's beginning of period assets in terms of the previous date price level. Computational considerations led to this particular choice of the individual state. The measure of agents of type (a,s) is x(a,s). We let x denote the corresponding measure. The *economy-wide state* is the pair (x,z). Government policy determines the price of goods and the price of newly issued bills. The government implements this policy by buying goods at price $p_t = e(z_t)p_{t-1}$ and selling bills at price $q_t = \gamma q(z_t)$. The quantity of the consumption good purchased by the government is $g(x_t,z_t)$ and the value of bills issued is $b_g(x_t,z_t)$. These quantities clear both the goods and the bills markets.

Each household chooses consumption $c(a_t,s_t,z_t)$, employment $n(a_t,s_t,z_t)$, real currency balances $m(a_t,s_t,z_t)$ and real holdings of bills $\gamma b(a_t,s_t,z_t)$. A type (a,s) household's budget constraint is

$$c_t + m_t + \gamma q(z_t)b_t \leq a_t/e(z_t) + n_t w(s_t,z_t)(1-\theta)$$

where θ is the time invariant labor income tax rate. Note that $a_{t+1} = m_t + \gamma b_t$. Additional constraints are $c \geq 0$, $m \in \{0,1,2,\ldots\}$, $b \in \{0,1,2,\ldots,n_b\}$, and $n \in \{0,1\}$.

An *equilibrium* for this economy is a government policy $\{e(z),q(z),b_g(x,z),g(x,z),\theta\}$, a household policy $\{c(a,s,z),m(a,s,z),b(a,s,z),n(a,s,z)\}$, and a law of motion for the distribution of agent types $x' = f(x,z,z')$ such that

i. Given the processes on prices, the households' policy maximizes their discounted expected utility.

ii. The goods market clears:

$$\sum_{a,s} x(a,s)[c(a,s,z) - n(a,s,z)w(s,z)(1-\theta)] + g(x,z) = 0$$

for all (x,z).

iii. The bills market clears:

$$\gamma \sum_{a,s} x(a,s)b(a,s,z) = b_g(x,z)$$

for all (x,z).

iv. There is consistency of individual and aggregate behavior:

$$f_{a's'}(x,z,z') = \sum_{(a,s) \in A(a',z)} x(a,s)\pi[(s',z')\,|\,(s,z)],$$

for all (a',s',x,z,z'), where $A(a',z) = \{(a,s)\colon a' = m(a,s,z) + \gamma b(a,s,z)\}$. Note that $f_{a's'} \equiv x'(a',s')$ for all $(a',s') \in A \times S$.

The nominal interest rate on the large denomination T-bills is always positive for the policies that we consider. As a result, large-denomination T-bills dominate currency in rate of return. Given this domination, it is never optimal to hold more than γ units of m and the restriction that $m \leq \gamma$ is never binding. We impose this constraint so that the problem becomes a finite dynamic program.

Agent's Optimization Problem

The individuals' dynamic program is

$$v(a,s,z) = \max_{b,c,m,n} \left\{ u(c,\tau-n) + \beta \sum_{s',z'} v(\gamma b+m,s',z')\pi(s'|s,z')\pi(z'|z) \right\}$$

subject to the budget constraint

$$c + m + \gamma q(z)b \leq a/e(z) + nw(s,z)(1-\theta)$$

and to

$$n \in \{0,1\},\ c \geq 0,\ m \in \{0,1,\ldots,\gamma\},\ \text{and}\ b \in \{0,1,\ldots,n_b\}.$$

Given that the agent's problem is a finite state discounted dynamic program, an optimal stationary Markov plan always exists.

Our computational procedure determines whether an equilibrium exists. The first step of the procedure is to solve the agents' optimization problem given e(z) and q(z). The second step is to aggregate the agents' decision and to determine $b_g(x,z)$ and g(x,z) residually from the market clearing conditions, (ii) and (iii) in the definition of equilibrium. The third step is to use the agents' decision rules to find f(x,z,z'). If g(x,z) is nonnegative for all possible realizations of the process, an equilibrium exists for the given policies e(z) and q(z). If this is not the case, no equilibrium exists with inflation rate process $\{e(z_t) - 1\}$ and interest rate process $\{1/q(z_t) - 1\}$.

3. Calibration

The purpose of this paper is to begin the exploration of the aggregate implications of the insurance substitution motive for holding liquid assets. If anything quantitative is to be learned from this exercise, our model economy's preferences, technologies, and stochastic disturbances have to be restricted by observations. To this purpose we follow the real business cycle tradition and we use U.S. post Korean war averages and micro observations to restrict our model parameter choices.

Given that, ultimately, we want to compare our results with the behavior of U.S. economy aggregates, in our calibration choices we also follow the principle that the methods used to obtain the model economy aggregates should be as similar as possible to those employed to construct the corresponding U.S. time series. Our calibration choices are the following:

Time Period

Most U.S. time series are reported quarterly. Wages, however, are paid more frequently. Our model period, therefore, should be shorter than a quarter of a year. We chose the model period to be an eighth of a year. This choice enables us to have some temporal aggregation while keeping the computation costs within reasonable bounds.[5]

Transition for the Exogenous Economy-Wide Shock

In Experiments 1 and 2 below we analyze the steady states of two economies with, respectively, a high real interest rate and a low real interest rate. These two economies, therefore, have no aggregate uncertainty. In Experiment 3 we consider a policy with positive probabilities of switching between a high and a low interest rate regime.[6] In the U.S., during the last 60 years, there were 50 years of low average real rates of return on T-bills followed by 10 years of high average real rates of return on the same asset. In our model, $z = 1$ represents the high real rate of return regime and $z = 2$ represents the low real rate of return regime. We choose the transition probabilities so that the expected duration of each regime is, respectively, 50 and 10 years. Given that the expected duration of a state in a Markov chain is the reciprocal of $1 - \pi(z,z)$ where $\pi(z,z)$ is the probability of the state z occurring again the following period, we choose the following transition matrix for the economy-wide process:

	$z' = 1$	$z' = 2$
$z = 1$	0.9875	0.0125
$z = 2$	0.0025	0.9975

Preferences

Following the applied general equilibrium tradition we choose a utility function with constant elasticity of substitution in consumption and leisure. During the last 50 years, in the U.S., per capita leisure has remained virtually constant, per capita consumption has grown at an average rate of nearly 2 percent and real wages have increased by a factor of two. To match these observations we assume a unit elasticity of substitution between consumption and leisure. The utility function for our model economies is, therefore, the following:

$$U(c_t,\tau-n_t) = (1-\sigma)^{-1} \left\{ \left[c_t^{\alpha}(\tau-n_t)^{1-\alpha}\right]^{1-\sigma} - 1 \right\}$$

where $\tau - n$ is leisure.

We select preference parameters $\beta = 0.995$ and $\alpha = 0.33$. These parameter values imply an annual subjective time discount rate of 4 percent and a share of leisure of approximately two-thirds. These values for the time discount rate and for the share of leisure are in line with observations from national income and product accounts on the net real rate of return on capital and on the average fraction of productive time that households allocate to the market. We choose

$\sigma = 1.5$. This value is commonly used in applied general equilibrium exercises in public finance and business cycle theory. Our choice of τ reflects the fact that the average workweek including commuting time is roughly 45 hours or approximately 45 percent of people's weekly endowment of productive time given that we consider the productive part of a day to be 14 hours. Parameter τ is, therefore, $1/0.45 = 2.22$.

Technologies

Our objective in this paper is to begin the exploration of the effects of monetary policy shocks when liquid assets are held as a substitute for insurance and monetary policies are carried out by means of open market operations. Therefore, we need to have agents who hold both small-denomination, non-interest bearing currency and large-denomination, interest-bearing T-bills. Further, our view is that in the U.S. most people do not hold T-bills. This leads us to assume that our model economies are inhabited by two types of agents endowed with different stocks of human capital. Within each type, agents experience some periods when their production opportunities are good and others when their production opportunities are bad. These productivity variations, interacting with the agents' employment decisions, result in variable income streams and provide the incentives that induce both type of agents to hold liquid assets.

To capture these features we assume that the idiosyncratic productivity process, $\{s\}$, can take four possible values, $s \in S = \{1,2,3,4\}$. The idiosyncratic shocks for the high human capital types take values in $S_1 = \{1,2\}$ and the idiosyncratic shocks for the low human capital type take values in $S_2 = \{3,4\}$. States 1 and 3 represent high productivity draws and states 2 and 4 represent draws in which the agents' productivity is low. Given that there are no transitions possible between both human capital types, the two ergodic sets on S are, precisely, S_1 and S_2 and there are no transient states.

Since in this paper we are not specifically concerned with shocks to the aggregate technology, the individual productivity processes are independent of z. The transition probability matrix for these idiosyncratic processes is the following:

	$s' = 1$	$s' = 2$	$s' = 3$	$s' = 4$
$s = 1$	0.9565	0.0435	0.0000	0.0000
$s = 2$	0.5000	0.5000	0.0000	0.0000
$s = 3$	0.0000	0.0000	0.9565	0.5000
$s = 4$	0.0000	0.0000	0.5000	0.5000

Notice that the transition probabilities between realizations in different ergodic sets are zero in all cases.

We have chosen the above probability parameters so that 92 percent of the time both types of agents experience the high productivity shock and the remaining 8 percent of the time they experience the low productivity shock. The expected duration of the low productivity shock is two model periods or a quarter of a year. These values were chosen to roughly match the average U.S. employment rate and the expected duration of unemployment in the U.S.

The fraction of agents with human capital type h is λ_h. We choose $\lambda_1 = 0.8$ and $\lambda_2 = 0.2$. Agents endowed with a large stock of human capital are eight times as productive as low human capital agents with the same production opportunities. The relative size of the marginal productivities of both human capital types in their lucky and unlucky times is three. We normalize the productivity of lucky low human capital types to be one. The rationale for these choices is that together with the denomination of bonds and the transition probability parameters, they result in reasonable average holdings of both assets.

The resulting productivity parameters for each type of agent are the following:

	s = 1	s = 2	s = 3	s = 4
w(s)	1.0	0.33	8.0	2.67

There is one dimension in which our calibrated economy fails to mimic the data: the percentage variations in household annual incomes are nearly twice as large as those found in panel studies of the U.S. economy. The reason for this divergence is the following: In the model economy, agents hold liquid assets only as a substitute for insurance against idiosyncratic income variations. It goes without saying that people hold liquid assets for many other reasons. Liquid assets are held, for instance, as a substitute for insurance against sickness and accidents, or to make large discrete payments for consumer durables, college education, and down-payments on houses. Given that our model economy abstracts from these reasons, greater income variability is needed if the average aggregate asset holdings are to match those observed in the data.

Policy Parameters

We choose the real value of a T-bill to be 4. This value approximately corresponds to 50 percent of average yearly per capita income in the model economy and matches roughly the value of the relative size of the denomination of T-bills and per capita yearly income in the U.S. In the model economy, each T-bill is a promise to deliver 100 units of currency in the period following its date of purchase. The smallest currency unit in the model economies, therefore, corresponds to approximately \$100. We find this unit to be sufficiently small for the purposes of this paper. Making this unit smaller raises computational costs significantly and has virtually no effect on the aggregate properties of the model economies. The maximum number of T-bills that a household can hold is $n_b = 4$.

With this T-bill denomination, very few T-bills are held by the relatively numerous low human capital types. These agents vary their asset holdings by changing their holdings of currency. Most of the T-bills are held by the high human capital types. These agents vary their asset holdings by changing their holdings of currency and, occasionally, of T-bills. These parameter values result in currency holdings that are approximately 10 percent of annual income and government debt holdings are approximately 20 percent of annual income in the high real interest rate economy.

In our model economies the government pegs the nominal rate of return to debt and the rate of inflation and carries out whatever exchanges of goods and debt for currency are necessary to clear these markets. The government also taxes labor income. We choose the time invariant tax rate, θ, to be equal to 20 percent. This results in an average government consumption of about 20 percent of the model economy's output. This number is close to the relative size of government purchases of goods and services for the U.S. economy.

4. The Experiments

Purpose

In Experiments 1 and 2 we consider two different constant inflation/nominal interest rate policies. In Experiment 1 the nominal interest rate is pegged at 7 percent and the inflation rate is pegged at 4 percent. Consequently the real interest rate is 3 percent. These values correspond to U.S. averages during periods of high real returns observed during the 1980s. In Experiment 2 both the nominal interest rate and the inflation rate are pegged at 4 percent. Consequently the real interest rate is zero. These values correspond to U.S. averages observed during the low real return years between 1926 and 1980. The purpose of these two experiments is to find out whether both policies are feasible for the model economy. If this is the case, variation in the average real return on T-bills can be justified: Low average real yields on T-bills and negative real returns to currency in the presence of a significantly higher subjective time discount rate can be said to result from both the nature of the monetary policies adopted and from the specific properties of the monetary mechanisms and institutions employed. In fact, in the U.S. economy, periods of low average yields to T-bills have typically coincided with times when intermediation costs were high and when there were effective interest rate ceilings on important classes of bank liabilities.

The purpose of Experiment 3 is to address the issue of whether persistent changes in the real rate of return on liquid savings have significant real effects and if so, what is the nature of these effects. In particular, we study the behavior of the model economy subsequent to policy switches that take place after long periods of policy stability. We also ask whether the behavior of the model economy with a small probability of a regime change is close to the behavior of the economy with zero probability of change.

Findings

We report the results of the three experiments in Table 1. In Experiments 1 and 2 we find that an equilibrium exists. Average values for government purchases are, respectively, 19.76 and 20.41 percent of output. Further, in every simulation of the economy, government purchases have always been far greater than zero. We also find that the two policy invariant economies converge to their steady states. This result was expected given that the stochastic process on an h-type individual is a Markov chain with a single ergodic set, no transient states and no cyclically moving subsets.

In Experiment 3 we find that an equilibrium also exists. Average government expenditures are 20.33 percent of output for this experiment. Further, in every simulation of the economy, government purchases are always far greater than zero. We also find that, in the absence of realizations of policy switches, the model aggregates converge to asymptotical values. Moreover, the asymptotes associated with each of the policies are very close to the steady state of the corresponding policy invariant economies. We therefore conclude that for this class of economies steady-state analysis is an acceptable abstraction. We report these results in Table 2.

Associated with a persistent change from a regime with a high real interest rate to one with a low real interest rate, that is with a switch from regime 1 to regime 2, there are large real effects and these effects are distributed over a long period of time (see Figure 1). Given the new lower real return on T-bills, high human capital agents gradually lower their average real holdings of these assets (see Figure 2). This lowering is accomplished primarily by reducing the time which they allocate to the market (see Figure 3). Consumption changes are small (see Figure 4). The effects on output and employment, on the other hand, are surprisingly large. Output declines by 5 percent one year after a change from regime 1 to regime 2. After that, conditional on no further regime change occurring, output converges to a level which is about 0.2 percent higher than the initial level. The pattern of response when there is a persistent switch from regime 2 to regime 1 is not the mirror image of this response. Output increases by less than 3 percent and this increase persists for more than two years. After that, output declines relatively smoothly to an asymptote that is about 0.2 percent less than the initial level. These results suggest that monetary policy can have significant real effects and that these effects can be distributed over an extended period of time.

Another result of some interest is the behavior of unemployment rate. We say that agents are unemployed if they have a low productivity shock and choose not to work but would work if their productivity shocks were high. With the higher real interest rate, steady state output is lower and steady state unemployment is higher. When there is a persistent change from the low real interest rate to a high real interest rate regime, there is an initial large drop in the unemployment rate (see Figure 5). Subsequently the unemployment rate increases to a level about 0.5 percentage points below the original level conditional on there not being another regime switch.

5. Concluding Comments

We analyze the effects of monetary policy shocks in economies where agents hold liquid assets as a substitute for insurance and where monetary policies are carried out by means of open market operations. We find that in this class of economies the average real rate of return on T-bills is not completely tied down by the agents' willingness to substitute consumption intertemporally. It also depends on the monetary policy regime. We study two different policy regimes. In the first policy regime, the real rate of return on interest-bearing government debt is 3 percent and in the second one this rate of return is zero. These values correspond to the U.S. T-bill average real interest rate during the 1980s and the 1930–1980 period respectively. We find that these real interest rates are sustainable in equilibrium. We also study an economy where policy regime switches are possible but unlikely and where the expected duration of each regime is chosen to match the observed duration in the U.S. We find that these persistent changes in real interest rates have large real effects and that these effects are distributed over a multi-year period.

We emphasize that at the present stage in this research program it is premature to use these results as a basis for policy discussions. We think, however, that these early findings are conclusive enough to suggest that applied monetary theory should not abstract from the precautionary motive for holding liquid assets and that this line of inquiry warrants further development. A straight-forward and important extension is to introduce banks that pool individual savings and effectively divide up the large denomination interest-bearing government debt. Another important extension to this theory is to allow for banks to intermediate between households with some households borrowing to finance the purchase of houses and to finance their small businesses. A final extension that is still probably beyond the computation technology available is to include full-fledged capital accumulation in this class of economies.

Footnotes

[1]This is part of what Keynes called the "precautionary motive" for holding monetary assets. Other authors, such as Bewley (1980), term this the "self-insurance" motive. We take "insurance" to mean the "pooling of risk between two or more individuals." Under this interpretation, when agents accumulate monetary assets to protect themselves against future income uncertainty they are *substituting* for insurance.

[2]Imrohoroglu's (1991) economy differs from Lucas' (1980) in that she does not include a cash-in-advance constraint for consumption expenditures and in that the idiosyncratic uncertainty affects the households' endowments instead of their preferences. An economy similar to ours but with a finite number of liquidity constraints agents can be found in Bewley (1980). Deaton (1991) studies the behavior of precautionary savings of a single, liquidity constrained agent.

[3]Wallace (1983) identifies this non-divisibility as a necessary condition for the coexistence of both interest-bearing and non-interest-bearing government debt. Marimón and Wallace (1987) assume a costly intermediation technology. For our purposes it suffices to suppose that the intermediation technology is such that the interest rate differentials are not large enough to cover the intermediation costs.

[4]Cooley and Hansen (1989) use the representative agent transactions approach as their explicit monetary mechanism. They find that the high frequency consequences of monetary policy rules are small.

[5]During the calibration stage of this project we experimented with shorter model periods and we found that they did not result in significant changes in the aggregate properties of the model.

[6]In a strict sense (see Cooley and LeRoy 1985) there is only one policy regime which consists of two persistent policy rules and a small probability of switches. We will, however, informally refer to the periods in which the different policy rules are followed as different regimes.

Table 1

	Experiment 1	Experiment 2	Experiment 3
PRODUCT ACCOUNT			
Output	17.137	17.289	17.269
Consumption	13.751	13.760	13.757
Government Purchases	3.386	3.529	3.512
LABOR INPUT			
Hours	3.062	3.141	3.129
Productivity (y/h)	5.597	5.505	5.519
INTEREST RATES			
Nominal i	0.0700	0.0400	0.0460
Real i	0.0300	0.0000	0.0060
Inflation Rate	0.0400	0.0400	0.0400
ASSET RATIOS			
m/y	0.0796	0.1040	0.1012
b/y	0.1855	0.0426	0.0682
(m+b)/y	0.2651	0.1466	0.1694
GOVERNMENT RATIOS			
Tax Receipts /y	0.2000	0.2000	0.2000
Government Purchases /y	0.1976	0.2041	0.2033
Int. Payments /y	0.0125	0.0017	0.0031
Deficit /y	0.0101	0.0058	0.0064
LABOR STATISTICS			
Employment Rate	0.8510	0.8720	0.8690
Unemployment Rate[a]	0.0695	0.0712	0.0710
Participation Rate	0.9205	0.9432	0.9400

[a]Unemployment is defined to be those who would work if their idiosyncratic shock were high.

Table 2

Comparison of the Steady States of Economies 1 and 2 and the Asymptotes Associated with the Corresponding Policies in Economy 3

	Economy 1	Economy 3 : Regime 1
Output	2.1422	2.1438
Consumption	1.7188	1.7198
Asset Holdings	4.5429	4.5053
	Economy 2	**Economy 3 : Regime 2**
Output	2.1612	2.1616
Consumption	1.7200	1.7202
Asset Holdings	2.5331	2.5469

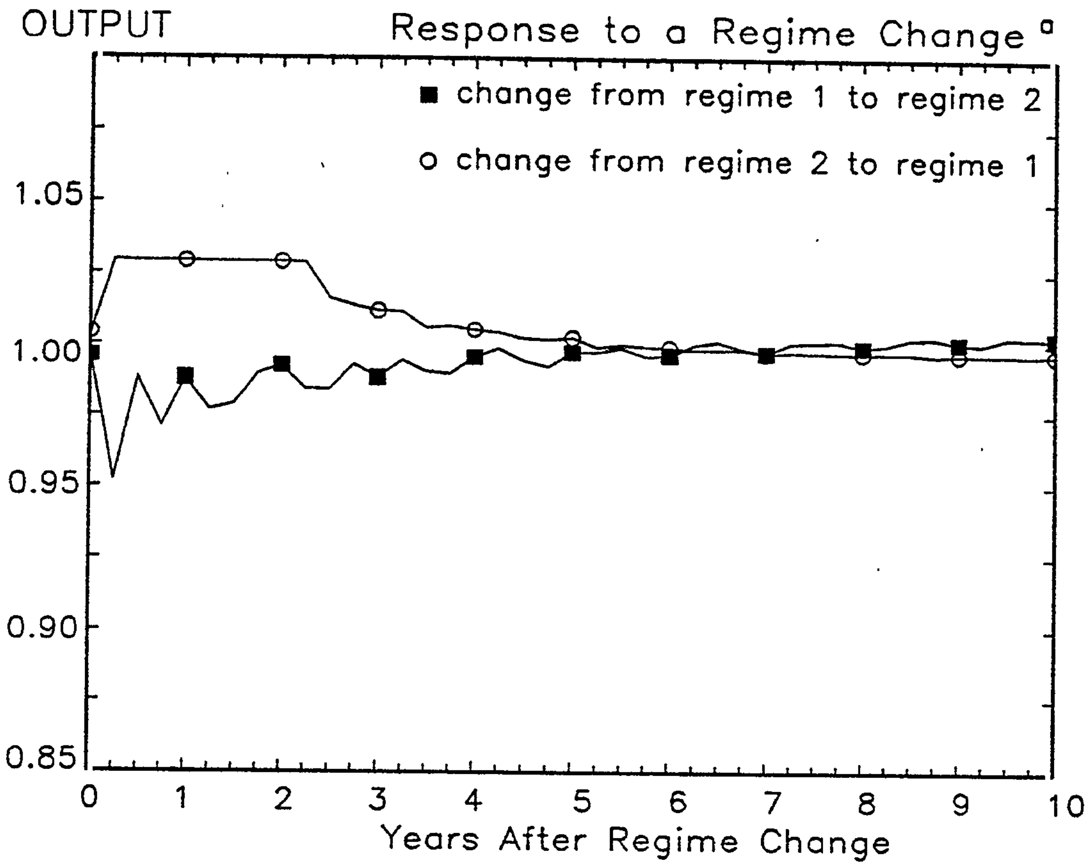

OUTPUT
Response to a Regime Change [a]
■ change from regime 1 to regime 2
○ change from regime 2 to regime 1
1.05
1.00
0.95
0.90
0.85
0
1
2
3
4
5
6
7
8
9
10
Years After Regime Change

FIGURE 1

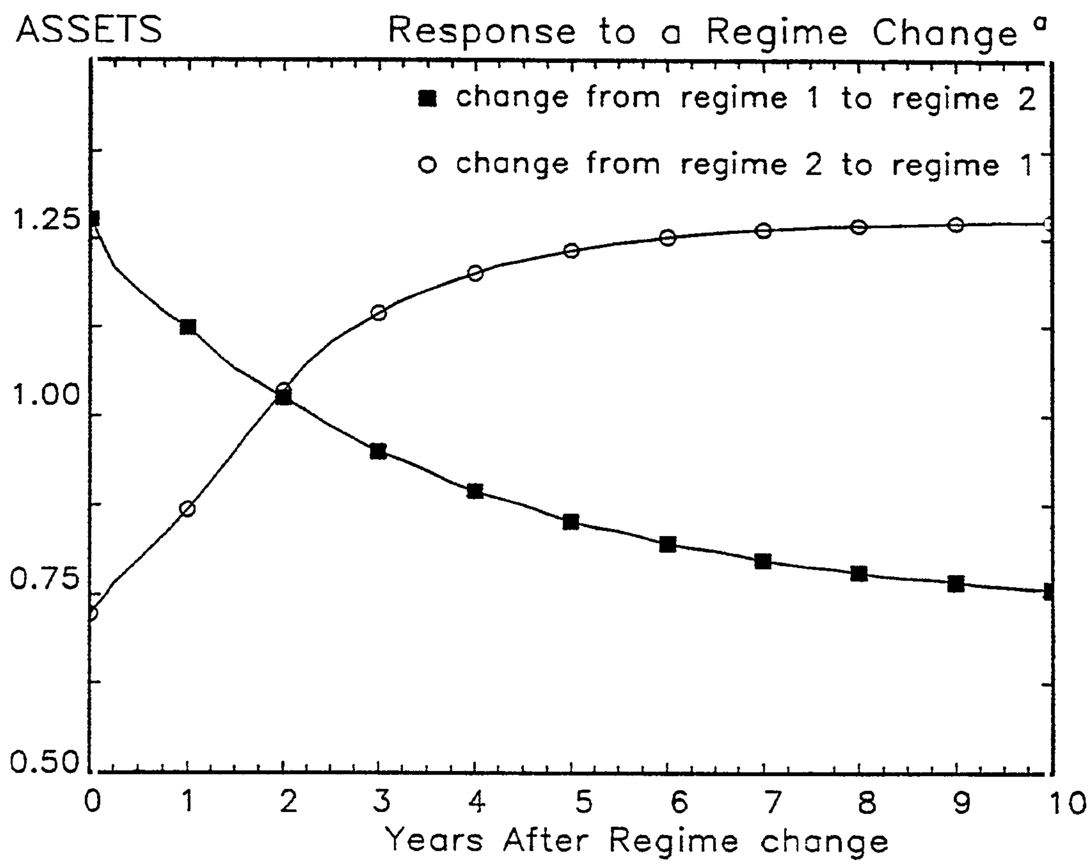

ASSETS
Response to a Regime Change a
■ change from regime 1 to regime 2
○ change from regime 2 to regime 1
1.25
1.00
0.75
0.50
0
1
2
3
4
5
6
7
8
9
10
Years After Regime change

FIGURE 2

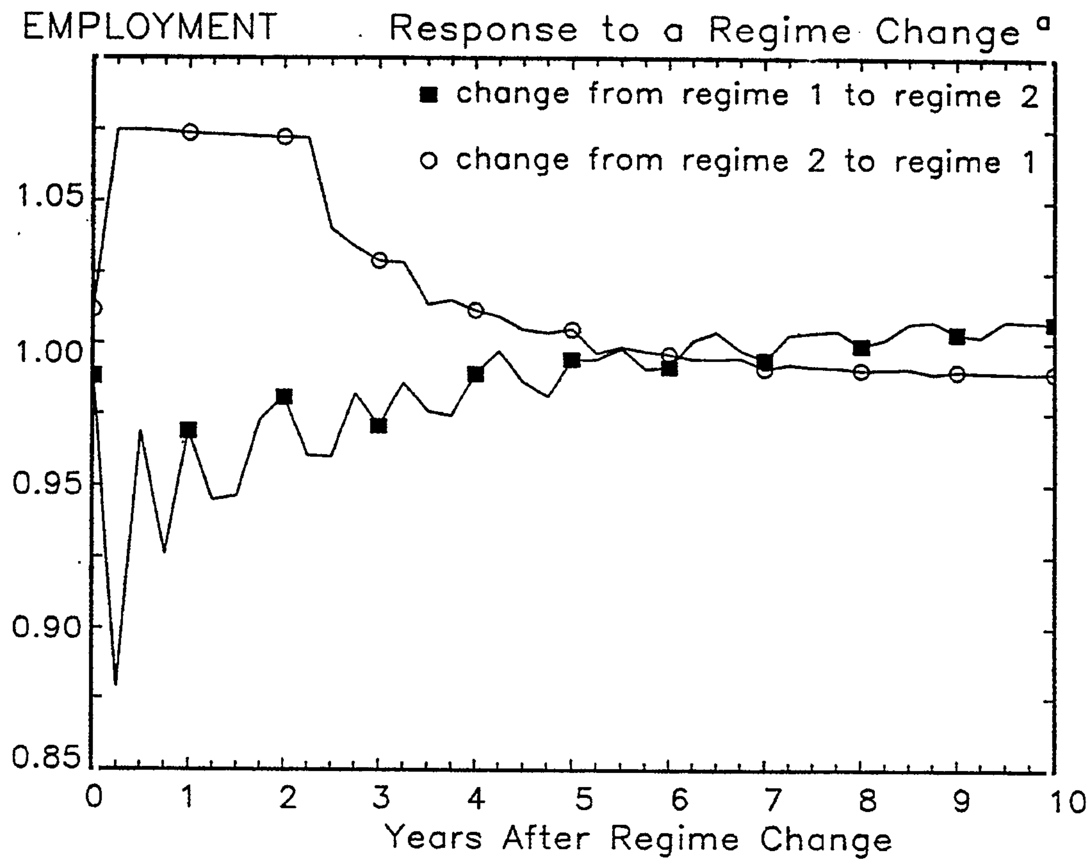

EMPLOYMENT
Response to a Regime Change a
change from regime 1 to regime 2
change from regime 2 to regime 1
1.05
1.00
0.95
0.90
0.85
0
1
2
3
4
5
6
7
8
9
10
Years After Regime Change

FIGURE 3

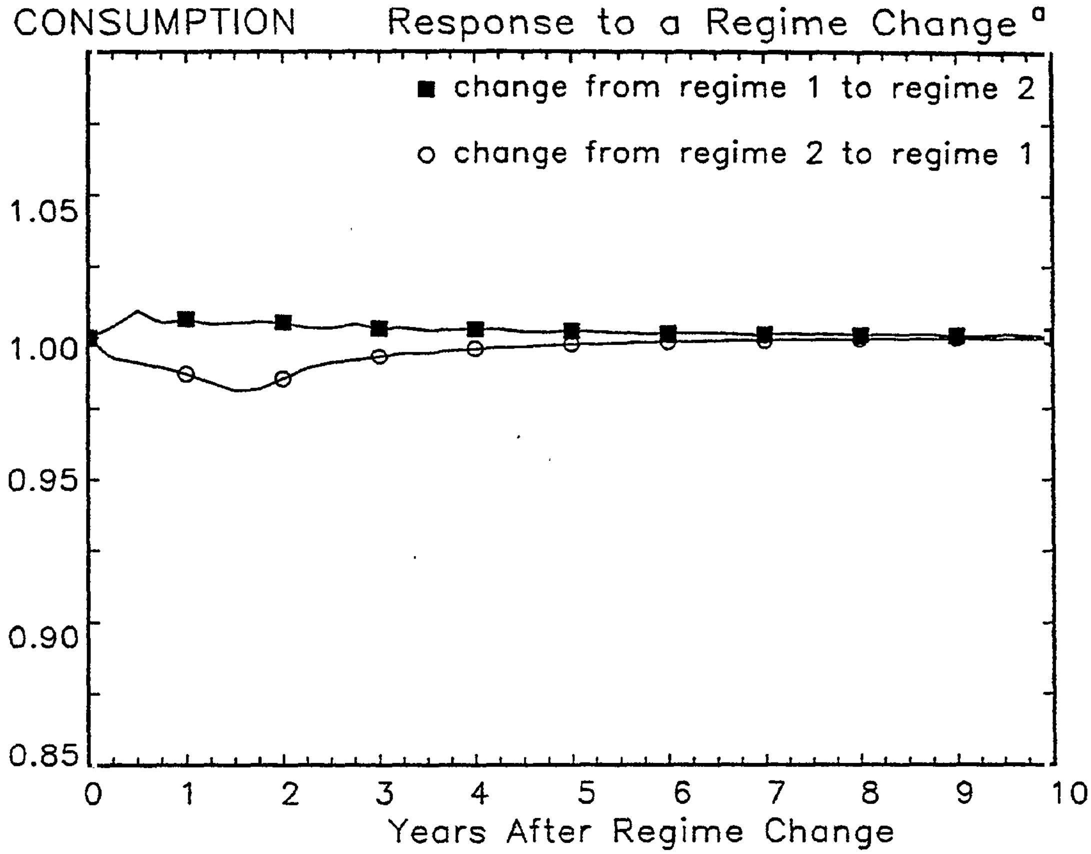
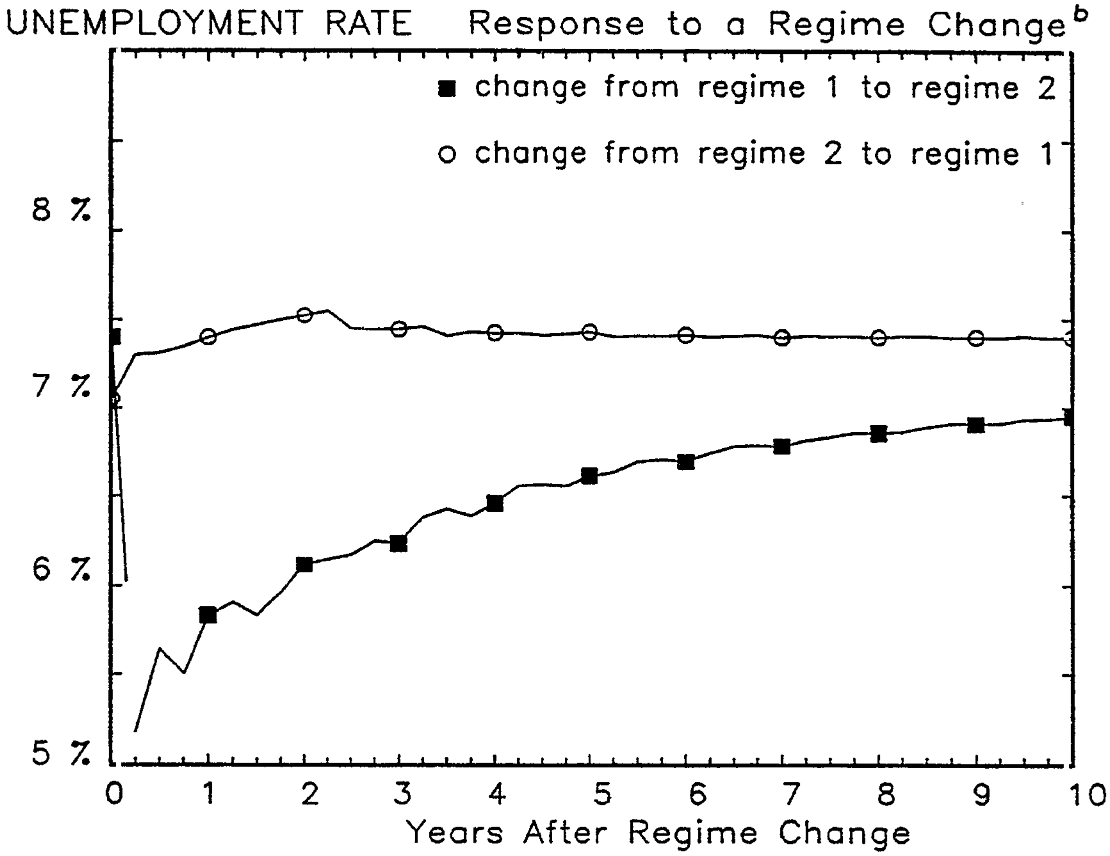

CONSUMPTION Response to a Regime Change [a]
change from regime 1 to regime 2
change from regime 2 to regime 1
1.05
1.00
0.95
0.90
0.85
0
1
2
3
4
5
6
7
8
9
10
Years After Regime Change

FIGURE 4



UNEMPLOYMENT RATE Response to a Regime Change[b]
change from regime 1 to regime 2
change from regime 2 to regime 1
8 %
7 %
6 %
5 %
0
1
2
3
4
5
6
7
8
9
10
Years After Regime Change

FIGURE 5

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