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# INTERTEMPORAL ASSET-PRICING RELATIONSHIPS IN BARTER AND MONETARY ECONOMIES: AN EMPIRICAL ANALYSIS

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**Abstract**

This paper empirically explores the intertemporal asset–pricing relationships implied by a variety of dynamic barter and monetary economy models. The purpose is to ascertain whether the monetary considerations — liquidity services and nonsuperneutralities — are important for and permit improved explanation of asset prices. The stochastic Euler equations, governing agents' optimal asset choices, implied by the various models are systematically estimated and tested. The generalized–method–of–moments estimation technique and monthly data on the US economy over the 1959:4–1986:12 period are employed. The stochastic Euler equations derived from the Lucas (1982) and Lucas(1984)/Svensson(1985a) cash–in–advance models are shown to be observationally equivalent to those derived from a barter–economy model under alternative assumptions about the timing of agents' consumption and investment decisions and associated information sets. The following key empirical results are established. (i) The empirical findings in Hansen and Singleton (1984) for the conventional benchmark barter–economy model, embodying an end–of–period timing convention for consumption and investment choices, are reaffirmed. (ii) A barter–economy model embodying both an end–of–period timing convention for decisions and a lagged information assumption; the Lucas (1982) cash–in–advance model and two money–in–the–utility function models do not accord any better with the data than the conventional barter model. The monetary effects embodied in the Lucas (1982) model [money–in–the–utility function models] are not [are] significant for asset pricing. (iii) The monetary influences encapsulated in the Lucas (1984)/Svensson (1985a) model are important for and permit improved explanation of stock returns only. The inconsistency of this model with treasury–bill returns seems to be the source of its inconsistency with the joint behavior of stock and treasury–bill returns.

## I. Introduction

This paper empirically explores the intertemporal asset-pricing relationships implied by a variety of dynamic general-equilibrium barter and monetary economy models. The focus of the analysis is on whether the liquidity services and nonsuperneutral effects of money, captured in different ways in different monetary models, significantly affect the dynamics of asset-pricing relationships and whether their consideration permits improved explanation of those relationships.

Here, these issues are addressed by systematically estimating, testing and comparing the stochastic Euler equations governing agents' optimal asset choices as specified by alternative barter and monetary economy models. The barter models considered are based on Rubinstein (1976), Lucas (1978) and Breeden (1979). The monetary models considered consist of cash-in-advance (CIA) models based on Lucas (1982), Lucas (1984) and Svensson (1985a) and money-in-the-utility-function (MIUF) models based on Dixit and Goldman (1970), Fama and Farber (1979), LeRoy (1984a, b), Stulz (1983) and Danthine and Donaldson (1986). Preferences are assumed to be time separable and of the constant-relative-risk-aversion type defined over either an aggregate nondurable consumption good or, in the case of the money-in-the-utility-function models, a composite good comprising aggregate nondurable consumption and real money balances. The generalized-method-of-moments estimation technique proposed by Hansen (1982) and Hansen and Singleton (1982) and monthly data on US consumption, money, prices, stock and treasury-bill returns over the 1959:4 - 1986:12 time period are employed.

A sizeable empirical literature examines asset-pricing relationships derived from barter economy models under a wide variety of specifications of preferences and household technologies for producing services from goods, estimation methods and data sets.[1] One of the upshots of this literature is that barter economy models have had some success in individually explaining stock and treasury bill returns but fall very far short of explaining both types of asset return simultaneously. This latter failure is dramatically encapsulated in the equity premium puzzle first documented by Mehra and Prescott (1985).

Recently, there also have been a few empirical studies which investigate asset–pricing relationships derived from monetary economy models. Singleton (1985) and Eckstein and Leiderman (1988) analyze an interest rate return using a Lucas(1982)–based CIA model in which preferences are defined over a composite good comprising the services from a cash and credit good. Poterba and Rotemberg (1987) analyze treasury–bill, saving–deposit and equity returns jointly using a MIUF model in which preferences are defined over a composite good comprising consumption, real money balances, real saving deposits and real short–term government debt. Eckstein and Leiderman (1988) also analyze an interest rate return using a MIUF model where preferences are defined over a composite good comprising services from consumption and real money balances. Ogaki (1988) analyzes a treasury–bill return individually and a treasury–bill and stock return jointly using a Lucas (1984)–based CIA model. Preferences are a separable function of cash–good consumption and the credit–good stock. Marshall (1989) numerically simulates a transactions–cost monetary model, at estimated parameter values for the transactions–cost technology and consumption– and money–growth processes, in order to analyze, inter alia, the predictions of the model for stock and treasury–bill returns. These studies provide some support for the importance of monetary considerations in asset pricing.[2] In particular, the estimation studies fail to reject the overidentifying restrictions implied by the models when the individual interest rate returns are considered and when the three asset returns of Poterba and Rotemberg (1987) are jointly considered. Also, Marshall (1989) finds that the predicted negative correlation between real equity returns and inflation closely matches that observed. It is not clear from Poterba and Rotemberg (1987) as to what conclusion may be drawn from their findings with respect to the equity premium. Ogaki (1988) mostly rejects his model when treasury-bill and stock return relationships are tested jointly. Marshall (1989) shows that his model fails to capture the magnitude of the equity premium.

The aforementioned empirical findings are borne in mind when discussing the findings of the present study. First, our results are compared to those obtained in other studies for identical asset-pricing relationships and similar data sets. Specifically, our barter-model [Lucas (1984)-model] results are compared to the corresponding results in Hansen and Singleton (1984) [Ogaki (1988)]. Secondly, we examine the various models' ability to explain stock and treasury-bill returns both on an individual and simultaneous basis.

The remainder of the paper is organized as follows. Section II specifies and discusses the stochastic Euler equations which serve as a basis for the empirical work. Section III discusses the estimation technique, tests and the data. Section IV presents the estimation results and Section V concludes the paper.

## II. Theoretical Background

### (a) Cash-in-Advance Models

CIA models based on Lucas (1982), Lucas (1984) and Svensson (1985a) are considered in sequence. For each of these models it is assumed that the representative agent has preferences defined over stochastic processes of consumption given by:

$$(1)\quad E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

$$u(c_t) = c_t^{\gamma}/\gamma \qquad \text{for} \qquad \gamma \neq 0$$

$$u(c_t) = \log(c_t) \qquad \text{for} \qquad \gamma = 0$$

$$0 < \beta < 1, \qquad \gamma < 1$$

where: $E_0$ is the expectations operator conditioned on information at time 0, $\beta$ is the subjective discount factor, u( ) denotes the monetary utility function, $c_t$ is real consumption at time t, log denotes the natural logarithm and $\gamma$ is a preference parameter.

In Lucas (1982) each period is envisaged as comprising of two subperiods. During the first subperiod only asset markets are open and during the second subperiod only goods markets are open. Agents trade money and assets and receive asset payoffs during the asset market subperiod. Shares held at the beginning of this subperiod entitle the owner to dividends from the sale of goods during the previous goods market subperiod — which is in the last time period. Goods–endowments materialize and are traded during the goods market subperiod. Goods must be bought with money acquired in advance. Money which is not currently spent on goods enters as a component of wealth at the beginning of the following period. This assumed sequencing of and restrictions on transactions is reflected in the representative agent's budget constraint:

$$(2)\quad a_t s_t + (1 + i_t)^{-1} b_t + M_t = (a_t + d_{t-1})\, s_{t-1} + b_{t-1} + M_{t-1} - P_{t-1}\, c_{t-1}$$

and CIA constraint:

(3) $M_t \geq P_t c_t$

where: $s_t$ is the number of shares bought at time t, $b_t$ is the number of bonds bought at time t whose payoff is one nominal money unit at time t+1, $M_t$ is nominal money chosen at time t, $a_t$ is the nominal time-t price of a share, $(1+i_t)^{-1}$ is the nominal time-t price of one unit of the bond, $d_t$ is the nominal value of the time-t dividend and $P_t$ is the time-t price level. Assume next that the agent receives full-current information at the beginning of time t and maximizes (1) by choosing $c_t$, $s_t$, $b_t$ and $M_t$ subject to (2) and (3). This optimization problem implies the following stochastic Euler equations governing share and bond choices, respectively:

$$(4) \quad u_c(t) = \beta E_t \left[ u_c(t+1) \frac{P_t}{P_{t+1}} \frac{(a_{t+1} + d_t)}{a_t} \right]$$

$$(5) \quad u_c(t) = \beta E_t \left[ u_c(t+1) \frac{P_t}{P_{t+1}} (1 + i_t) \right]$$

where: $u_c(t) \equiv c_t^{\gamma-1}$, the marginal utility of time-t consumption. Equation (4) [(5)] sets the marginal cost equal to the expected discounted future marginal benefit of acquiring an additional share [bond].

Noting the timing convention in Lucas (1982), the following empirical formulations of (4) and (5) are adopted:

$$(6) \quad u_c(t) = \beta E_{\theta_t} \left[ u_c(t+1) \frac{P_t}{P_{t+1}} \frac{(a_t^e + d_t^e)}{a_{t-1}^e} \right]$$

$$(7) \quad u_c(t) = \beta E_{\theta_t} \left[ u_c(t+1) \frac{P_t}{P_{t+1}} (1 + i_{t-1}^e) \right]$$

where use has been made of $a_t^s \equiv a_{t-1}^e$ and $i_t^s \equiv i_{t-1}^e$, superscript s(e) denotes a start-of-period (end-of-period) value and $\theta_t$ denotes an information set which includes all information through time (t-1), $c_t$ and $P_t$.[3]

It is interesting to notice the following. For the preference specification given in (1) and assuming full current-period information, Hansen and Singleton (1982) show that the stochastic Euler equations governing share and bond choices implied by a barter economy model are:

$$(8) \quad u_c(t) = \beta \underset{t}{E} \left[ u_c(t+1) \frac{P_t}{P_{t+1}} \frac{(a_{t+1} + d_{t+1})}{a_t} \right]$$

$$(9) \quad u_c(t) = \beta \underset{t}{E} \left[ u_c(t+1) \frac{P_t}{P_{t+1}} (1 + i_t) \right]$$

The barter economy model is based on Rubinstein (1976), Lucas (1978) and Breeden (1979). Further assume that agents consume and invest at the end of the period, so their empirical formulation of (8) and (9) is:[4]

$$(10) \quad u_c(t) = \beta \underset{t}{E} \left[ u_c(t+1) \frac{P_t}{P_{t+1}} \frac{(a^e_{t+1} + d^e_{t+1})}{a^e_t} \right]$$

$$(11) \quad u_c(t) = \beta \underset{t}{E} \left[ u_c(t+1) \frac{P_t}{P_{t+1}} (1 + i^e_t) \right].$$

Equations (10) and (11) will be referred to as the end-of-period barter model or barter-e model. If, instead, agents are assumed to consume and invest at the start of the period, then the empirical formulations of (8) and (9) coincide with (6) and (7), respectively. There is thus an observational equivalence between the Lucas (1982) model and the start-of-period barter model (or barter-s model) in respect to the stochastic Euler equations governing asset choices. This equivalence is "observed" for the first time in this study. Comparison of (6) and (7) with (10) and (11) reveals that the nominal asset returns in the former model are one-period lagged relative to those in the latter model.[5] The barter-e model is empirically examined in this study not only because it is a benchmark barter-economy model but also because it allows an assessment of the empirical significance of this difference in the timing of nominal asset returns.

The Lucas (1982) model can also be shown to imply:

$$(12)\quad i_t = \mu_t/\lambda_t, \qquad \mu_t \geq 0, \qquad \lambda_t > 0$$

where: $\mu_t(\lambda_t)$ is the Lagrangean multiplier associated with constraint (3) ((2)). Therefore, $\mu_t$ is the marginal utility of the liquidity component of current-period real money balances and $\lambda_t$ is the marginal utility of current-period real wealth. When $\mu_t > 0$ (=0) the current period CIA constraint binds (does not bind). Equation (12) highlights how, in the Lucas (1982) model, nominal bonds separate the liquidity services feature from other features of money. Specifically, the payoff of the nominal bond is fixed in nominal terms (like that of money) but its current period purchase results in a tightening of the current CIA constraint — a feature that encapsulates how bonds (and shares) are less liquid than money in this model. Accordingly, positive nominal interest rates emerge as a reflection of and compensation for the absence of <u>currently</u> valued liquidity services from bonds. In Lucas (1982) there is, then, a one-to-one correspondence between binding CIA constraints and positive nominal interest rates. In view of a desire to link models with reality, only equilibria with binding CIA constraints are, therefore, of interest in the Lucas (1982) model, even though equilibria with nonbinding CIA constraints may theoretically occur.[6] The former equilibria are characterized by a transactions demand for money —

i.e. the quantity theory equation, where the income velocity of money is unity. Intuitively, with positive nominal interest rates, consumers avoid the opportunity cost of excess money balances by acquiring in each period exactly the amount of money needed to finance that period's consumption.

A discussion of the nonsuperneutrality of money in the Lucas (1982) model is contained in Lucas(1982) and Svensson (1985a, 1985b). Temporary and unanticipated changes in the growth rate of money have no effect on real asset returns while permanent or anticipated future changes in the money growth rate do.[7]

The Lucas (1984) model differs from the Lucas (1982) model in one fundamental respect — namely, in the former agents are <u>not</u> assumed to receive full current information at the beginning of time t. Rather, agents are assumed to receive partial current information at the beginning of the time–t asset market subperiod — specifically, information on current asset prices — and full current information is not received until the beginning of the time–t goods market subperiod. Under this informational assumption, assume that the representative agent maximizes (1) by choosing $c_t$, $s_t$, $b_t$ and $M_t$ subject to (2) and (3). The implied stochastic Euler equations governing share and bond choices are:

$$(13) \qquad E_{I_t}\left[\frac{u_c(t)}{P_t} - \beta\,\frac{u_c(t+1)}{P_{t+1}}\,\frac{(a_{t+1} + d_t)}{a_t}\right] = 0$$

$$(14) \qquad E_{I_t}\left[\frac{u_c(t)}{P_t} - \beta\,\frac{u_c(t+1)}{P_{t+1}}\,(1 + i_t)\right] = 0$$

where: $I_t$ denotes an information set which includes all information through time (t–1), $a_t$ and $i_t$. Equations (13) and (14) set the expected marginal cost equal to the expected discounted future marginal benefit of acquiring an additional unit of the relevant asset.

Noting the timing convention in Lucas (1984), the following empirical formulations of (13) and (14) are adopted:

$$(15)\qquad \mathop{E}_{t-1}\left[\frac{u_c(t)}{P_t} - \beta\,\frac{u_c(t+1)}{P_{t+1}}\,\frac{(a_t^e + d_t^e)}{a_{t-1}^e}\right] = 0$$

$$(16)\qquad \mathop{E}_{t-1}\left[\frac{u_c(t)}{P_t} - \beta\,\frac{u_c(t+1)}{P_{t+1}}\,(1 + i_{t-1}^e)\right] = 0.$$

Comparing (6) and (7) with (15) and (16) succinctly shows that the asset–pricing implications differ across the Lucas (1982) and Lucas (1984) models only in that $c_t$ and $P_t$ are assumed to be known in the former when agents undertake their current investment decisions. This, and the earlier discussion of observational equivalence, prompts the statement that if one envisages agents in the barter–s model as choosing their investment plans prior to knowing the current price level and consumption, then (15) and (16) are also implied by such a model. The latter will be referred to as the barter–s model with lagged information. There is thus an observational equivalence between the Lucas (1984) model and the barter–s model with lagged information. This equivalence is also observed for the first time in this study. Correspondingly, a barter–e model with lagged information may also be imagined in which agents choose investment plans prior to knowing the current price level and consumption. The implied stochastic Euler equations governing share and bond choices are:

$$(17)\qquad \mathop{E}_{\Omega_t}\left[\frac{u_c(t)}{P_t} - \beta\,\frac{u_c(t+1)}{P_{t+1}}\,\frac{(a_{t+1}^e + d_{t+1}^e)}{a_t^e}\right] = 0$$

(18) $$\underset{\Omega_t}{E}\left[\frac{u_c(t)}{P_t} - \beta \frac{u_c(t+1)}{P_{t+1}} (1 + i_t^e)\right] = 0$$

where: $\Omega_t$ denotes an information set including all information through time (t-1), $a_t^e$, $d_t^e$ and $i_t^e$. Consideration of this barter-e model with lagged information is also new. It is empirically explored here in order to serve as an additional benchmark barter economy model and to enrichen the attempt of discerning the empirical significance of differences in both the timing of nominal asset returns and the timing of information flows across models.

The Svensson (1985a) model differs from Lucas (1982) in one crucial respect — namely, the sequencing of markets within the period is precisely the reverse. Agents are assumed to receive full current period information at the beginning of the period, as in Lucas (1982), and both the types of as well as restrictions on transactions are identical across the two models. It turns out that the stochastic Euler equations governing asset choices implied by the Svensson (1985a) model are identical to those implied by the Lucas (1984) model.[8] This equivalence stems from the fact that in the Svensson (1985a) model, agents are faced with the same informational structure as in Lucas (1984) when making investment decisions — and, of course, the types of and restrictions on transactions are identical across the two models. In Svensson's words the "... difference in defining periods is not important, though. It is the timing of information that matters." (Svensson, 1985b, p. 37).

Both Lucas (1984) and Svensson (1985a) emphasize that an advantage of their models is the possibility of a variable income velocity. This may be clarified as follows. The former study does not explicitly characterize the equilibrium while the latter study does.[9] In view of the aforementioned equivalence between the two of these models, conclusions reached from analyzing the equilibrium of the Svensson (1985a) model carry over to that of the Lucas (1984) model. Svensson (1985a) shows that his model implies:

$$(19) \qquad i_t = \frac{E_t\left[\mu'_{t+1}/P_{t+1}\right]}{E_t\left[\lambda'_{t+1}/P_{t+1}\right]}, \ \mu'_{t+1} \geq 0, \ \lambda'_{t+1} > 0$$

where: $\mu'_{t+1}$ ($\lambda'_{t+1}$) is the Lagrangean multiplier associated with the one-period future CIA (budget) constraint of his model. Therefore, $\mu'_{t+1}$ is the marginal utility of the liquidity component of future real money balances and $\lambda'_{t+1}$ is the marginal utility of future real wealth. When $\mu' > 0$ (= 0) the CIA constraint binds (does not bind). Equation (19) shows that the nominal interest rate is <u>always</u> positive since there is always some positive probability of the CIA constraint binding in the future. The positive nominal interest rate is a reflection of and compensation for the absence of expected <u>future</u> valued liquidity services from bonds. Inextricably involved in this is the fact that in the Svensson (1985a) model, the payoff of a nominal bond is fixed in nominal terms (like that of money) but it can only be liquidated on the future asset market — <u>after</u> the future goods market closes. Accordingly, (19) is a succinct statement of how bonds (and shares) are less liquid than money in the Svensson (1985a) model. [Notice that the Lucas (1982) and Svensson (1985a) models differ in how they capture this difference in liquidity.] It follows that, in the Svensson (1985a) and Lucas (1984) models, equilibria with currently nonbinding CIA constraints are of interest since they are consistent with positive nominal interest rates — a point on which they sharply differ from Lucas (1982). The former models are thus characterized by the possibility of a more reasonable specification of the demand for money — i.e. a combined transactions, precautionary and store-of-value demand for money and a variable income velocity — simultaneously with positive nominal interest rates.

A discussion of the nonsuperneutrality of money in the Svensson (1985a) model is contained in Svensson (1985a) and Giovannini (1989). The former shows that temporary increases in the money growth rate reduce real interest rates when the CIA constraint binds, while permanent increases in the money growth rate have an ambiguous effect. Giovannini (1989), assuming that the CIA constraint always binds, shows that a temporary increase in the conditional variance of the money growth rate process increases the real prices of stocks and bonds. Interestingly, he also shows that a temporary change in the conditional variance of the dividend process has diametrically opposite effects on real asset prices across the Svensson (1985a) model and a barter model.

## (b) Money-in-The-Utility-Function Models

Two MIUF models are investigated. The contemporaneous MIUF model, based on Dixit and Goldman (1970), Fama and Farber (1979), LeRoy (1986a,b) and Stulz (1983), assumes agents' current choices of money currently yield utility. The lagged MIUF model, based on Danthine and Donaldson (1986), assumes agents' current choices of money yield future utility.[10]

In the contemporaneous MIUF model it is assumed that the representative agent has preferences defined over stochastic processes of consumption and real money balances given by:

$$(20) \qquad E_0 \sum_{t=0}^{\infty} \beta^t u\,(c_t, M_t/P_t)$$

$$u(c_t,\ M_t/P_t) = \left[c_t^{\delta}\left[\frac{M_t}{P_t}\right]^{(1-\delta)}\right]^{\gamma} \Big/ \gamma \qquad \text{for } \gamma \neq 0$$

$$u(c_t,\ M_t/P_t) = \delta \log(c_t) + (1-\delta) \log(M_t/P_t) \quad \text{for } \gamma = 0$$

$$0 < \beta < 1, \qquad 0 < \delta < 1, \qquad \gamma < 1$$

where $\delta$ is a preference parameter capturing the relative importance of consumption and real money balances in the utility function. Assume next that the agent has full current information and maximizes (20) by choosing $c_t$, $s_t$, $b_t$ and $M_t$ subject to the budget constraint:

(21) $$P_t c_t + a_t s_t + (1 + i_t)^{-1} b_t + M_t = (a_t + d_t)\ s_{t-1} + b_{t-1} + M_{t-1}$$

This problem implies the following stochastic Euler equations, respectively, governing share, bond and money choices:

(22) $$u_c(t) = \beta\ E_t \left[u_c(t+1)\ \frac{P_t}{P_{t+1}}\ \frac{(a_{t+1} + d_{t+1})}{a_t}\right]$$

(23) $$u_c(t) = \beta\ E_t \left[u_c(t+1)\ \frac{P_t}{P_{t+1}}\ (1 + i_t)\right]$$

(24) $$u_c(t) = u_{M/P}(t) + \beta\ E_t \left[u_c(t+1)\ \frac{P_t}{P_{t+1}}\right]$$

where: $u_c(t) \equiv \delta\ c_t^{\delta\gamma-1}\ (M_t/P_t)^{(1-\delta)\gamma}$, is the marginal utility of time-t consumption and $u_{M/P}(t) \equiv (1-\delta)\ c_t^{\delta\gamma}\ (M_t/P_t)^{(1-\delta)\gamma-1}$ is the marginal utility of time-t real money balances. Equations (22), (23) and (24) respectively set the marginal cost equal to the expected discounted future marginal cost of acquiring an additional share, bond and nominal money unit.

In the lagged MIUF model it is assumed that the representative agent's preferences are defined by:

(25) $$E_0 \sum_{t=0}^{\infty} \beta^t u\,(c_t,\ M_{t-1}/P_t)$$

$$u(c_t,\ M_{t-1}/P_t) = \left[c_t^{\delta}\ (M_{t-1}/P_t)^{(1-\delta)}\right]^{\gamma} \Big/ \gamma \qquad \text{for } \gamma \neq 0$$

$$u(c_t,\ M_{t-1}/P_t) = \delta \log(c_t) + (1-\delta)\log\,(M_{t-1}/P_t) \qquad \text{for } \gamma = 0$$

$$0 < \beta < 1, \qquad 0 < \delta < 1, \qquad \gamma < 1.$$

Under full current information the maximization of (25) subject to (21) yields the following stochastic Euler equations, respectively, for share, bond, and money choices:

(26) $$u_c(t) = \beta\, E_t \left[u_c(t+1)\, \frac{P_t}{P_{t+1}}\, \frac{(a_{t+1} + d_{t+1})}{a_t}\right]$$

(27) $$u_c(t) = \beta\, E_t \left[u_c(t+1)\, \frac{P_t}{P_{t+1}}\, (1 + i_t)\right]$$

(28) $$u_c(t) = \beta\, E_t \left[(u_{M/P}(t+1) + u_c(t+1))\, \frac{P_t}{P_{t+1}}\right]$$

where: $u_c(t) \equiv \delta\, c_t^{\delta\gamma-1}(M_{t-1}/P_t)^{(1-\delta)}$, the marginal utility of time-t consumption and $u_{M/P}(t+1) \equiv (1-\delta)\ c_{t+1}^{\delta\gamma}(M_t/P_{t+1})^{(1-\delta)\gamma-1}$, the marginal utility of time-(t+1) real money balances. Equations (26), (27) and (28) have exactly the same interpretation as (22), (23) and (24). They respectively set the marginal cost equal to the expected discounted future marginal benefit of acquiring an additional share, bond and nominal money unit.

For both the contemporaneous and lagged MIUF models it is assumed that agents consume and invest at the end of each period.[11] Accordingly, we set $a_{t+1} = a^e_{t+1}$, $d_{t+1} = d^e_{t+1}$, $i_t = i^e_t$ and measure $M_t$ by the money stock at the end of time t for both models. With this timing convention for choices, it follows that when $\delta = 1$ the share and bond asset-pricing equations for both the contemporaneous and lagged MIUF models collapse to the share and bond asset-pricing equations of the barter-e model.[12]

By placing real money balances directly in the utility function, both MIUF models are consistent with a combined transactions, precautionary and store-of-value demand for money. In the contemporaneous MIUF model, the marginal value of liquidity services is directly given by the current marginal utility of nominal money, and positive nominal interest rates reflect the absence of this value from nominal bonds. Specifically, (23) and (24) imply:

$$(29) \qquad \frac{u_{M/P}(t)}{u_c(t)} = \frac{i_t}{(1+i_t)} \, .$$

In the lagged MIUF model, the marginal value of liquidity services is directly given by the expected discounted future marginal utility of nominal money, and positive nominal interest rates reflect the absence of this value from nominal bonds. In particular, (27) and (28) imply:

$$(30) \qquad \beta \, E_t \left[ \frac{u_{M/P}(t+1)/P_{t+1}}{u_c(t)/P_t} \right] = \frac{i_t}{(1+i_t)} \, .$$

Equations (29) and (30), thus, show how the MIUF models capture, in different ways, the difference in liquidity between money and nonmoney assets.

A discussion of nonsuperneutrality of money in MIUF models is contained in Sargent (1987).[13] Intuitively, real asset returns are affected by all exogenous elements which influence real money balances.

## III. Data, Estimation Technique and Tests

The sample period for the estimation is April 1959 through December 1986. US monthly data on per-capita real consumption, per-capita money supply, prices, stock and treasury-bill returns are employed. A complete description of the data and their sources is provided in Appendix 1.

The generalized-method-of-moments (GMM) estimation technique and associated J-test proposed by Hansen (1982) and Hansen and Singleton (1982) are used. These studies provide sufficient conditions under which the GMM estimator is consistent, asymptotically normal and 'optimal' in sense of having the smallest asymptotic covariance matrix among the class of GMM estimators employing alternative choices of weighting matrices and a given set of instruments. The J-test is a test of the overidentifying restrictions implied by the model. Under the null hypothesis that the restrictions are true, the above studies show that the J-statistic, based on the minimized value of the estimation-criterion function, is asymptotically distributed as a chi square with degrees of freedom equal to the sum of the number of instruments used in the estimation of each equation less the number of parameter estimates. In addition, the C-test, proposed by Eichenbaum, Hansen and Singleton (1988), is used to test a unit-value restriction on the $\delta$ parameter of the MIUF models. The C-statistic is based on the difference between the minimized value of the estimation-criterion function when the restrictions are imposed and the minimized value of that function when the restrictions are not imposed.[14] The above mentioned study shows that, under the null hypothesis that the restrictions are true, the C-statistic is asymptotically distributed as a chi square with degrees of freedom equal to the number of restrictions being tested.

The conditions ensuring that the GMM estimator has the aforementioned properties include that the stochastic Euler equations are functions of stationary variables and that the instrumental variables are stationary. Appendix 2 lists the stationary form of each Euler equation and associated instrument set for each of the models used in the empirical analysis. These equations and instruments involve real asset returns, ratios of real money balances to real consumption and the growth rates of real consumption, real money balances and price inflation. These variables are assumed to be stationary. For each model, except the MIUF models, the Euler equations governing stock and bond holdings are estimated and tested both on an individual basis and jointly. For the MIUF models, the Euler equations governing stock, bond and money holdings are estimated and tested jointly; in addition, each possible pair of these equations is estimated and tested jointly. The chosen instrument set for each Euler equation comprises a constant and the most recently observed values in agents' information sets of the variables entering into that Euler equation.[15]

The reported estimation results are qualitatively robust to choices over a number of alternative instrument sets, starting guesses for the models' parameters, starting guesses for the weighting matrices and to further iterations over these matrices.[16,17] The estimation results for the lagged-information versions of the barter-e and barter-s models obtain having used the Hansen and Singleton (1982) autocorrelation correction procedure to adjust for first-order serial correlation in the residuals of these models.

## IV. Estimation Results

The estimation results for the barter-e model are presented in Table 1. The discount parameter estimate, $\hat{\beta}$, is slightly less than unity, precise and significantly greater than zero.[18] The estimated coefficient of relative risk aversion, $\hat{\alpha}$, is in the concave region of parameter space (for the utility function), imprecise and significantly greater than zero in all cases but those of the individual estimation of the stock Euler equation. The J-test indicates strong rejection of the model, at most at the 3.17 percent significance level, in all cases except those of the individual estimation of the stock Euler equation when value-weighted stock returns are used.[19] The J-test in the latter cases easily indicates nonrejection at the 5 percent significance level. Hansen and Singleton (1982/1984) also estimated the barter-e model using some comparable data sets to those used here.[20] Their findings, for the joint estimation of stock and bond Euler equations and the individual estimation of the stock Euler equation, closely compare to those corresponding findings reported here — not only in terms of parameter estimates but also in terms of the patterns and strength of rejections of the overidentifying restrictions of the model.

Table 2 presents the estimation results for the barter-e model with lagged information. Sharp differences between these results and those for the barter-e model emerge in the case of the individual estimation of the stock Euler equation. In particular, for this case in Table 2, estimates of $\alpha$ are in the nonconcave region and are much more imprecise, while the J-test indicates nonrejection of the model at the 5 percent significance level — even when equally-weighted returns are used. Since, for the barter-e model with lagged information, these higher marginal significance values of the J-statistic go hand-in-hand with nonconcave estimates of $\alpha$, it is not regarded as being in better accord with the data than is the barter-e model. Therefore, the lagged-information assumption does not result in improved explanation of the data.

The estimation findings for the Lucas (1982)/barter-s model are contained in Table 3. There is one crucial difference between these findings and those for the barter-e model. It concerns the individual estimation of the stock

Euler equation. Specifically, for this case in Table 3, estimates of $\alpha$ are more imprecise and not only outside the concave region but significantly so. Therefore, the Lucas (1982)/barter–s model is not viewed to be more consistent with the data than the barter–e model; nor does it seem that the monetary effects, as captured in the former model, are important. Alternatively expressed, the one–period lagging of nominal asset returns, relative to the barter–e model, does not permit improved explanation of the data. Furthermore, the Lucas (1982)/barter–s model does not perform well either when stock and treasury–bill returns are considered individually or when they are considered jointly.

Consider next the estimation results for the Lucas (1984)/Svensson (1985a)/barter–s model with lagged information, presented in Table 4.[21] There are two striking points of difference between these findings and those for the barter–e model. Again the differences in the question concern the individual estimation of the stock Euler equation. In particular, for this case in Table 4, the point estimates and standard errors of $\alpha$ as well as the marginal significance levels of the J–statistic are much larger — so much so that the model is easily not rejected at the 5 percent level even when equally–weighted returns are used. This is evidence suggesting that the Lucas (1984) model is in better accord with the data than is the barter–e model, and that the monetary effects, as captured in the former model, are important for asset pricing. Viewed alternatively, the simultaneous lagging of information and nominal asset returns relative to the barter–e model does permit improved explanation of the data. However, the Lucas (1984) model falls short of complete success. Specifically, estimates of $\alpha$ remain imprecise (and are mostly insignificantly different from zero); while the J–test continues to reject the model, at most at the 0.68 percent significance level, both for the individual estimation of the bond Euler equation and the joint estimation of the stock and bond Euler equations. This suggests that the inconsistency of the Lucas (1984) model with the empirical behavior of treasury-bill returns is the source of its inconsistency with the joint empirical behavior of stock and treasury bill returns.

Ogaki (1988) also estimated the Lucas (1984) model using some comparable data sets to those used here.[22] His findings, for the joint estimation of the stock and bond Euler equations and the individual estimation of the bond Euler equation, are consistent with those corresponding findings reported here — in terms of the strong rejection of the overidentifying restrictions implied by the model.[23]

Tables 5 and 6 respectively show the estimation results for the contemporaneous and lagged MIUF models. These results are very similar across the two models. Consider, then, the estimation findings for any one of these models. $\hat{\beta}$ is almost always less than unity, precise and significantly greater than zero. The point estimates of $\alpha$ and $\delta$ imply concave preferences. The estimate of $\alpha$ is imprecise, mostly significantly greater than zero and always significantly smaller than unity. The latter finding is tantamount to a rejection of logarithmic separability of the utility function across consumption and real money balances. The estimate of $\delta$ is very precise and is significantly greater (smaller) than zero (unity). This latter significance result is consistent with the emphatic rejection of the restriction, $\delta = 1$, [in panels A, C, and D] using the C–test at virtually any significance level. The implication is that real money balances enter significantly into the utility function. The J–test indicates strong rejection of the overidentifying restrictions at most at the 3.46 percent (1.25 percent) level for the contemporaneous (lagged) MIUF model (with one minor exception for the former model). Comparing the results for the joint estimation of the stock and bond Euler equations across either one of the MIUF models (panel B of Tables 5 and 6) and the barter–e model (panel A of Table 1) shows that there is little difference.[24] The upshot, suggested by our evidence, is that even though real money balances enter significantly into the utility function — which augurs for the importance of monetary effects — their consideration, at least as modeled here, does not permit improved explanation of asset–pricing relationships. Furthermore, the MIUF models do not perform well either when their implications for stock and treasury–bill returns are tested individually (panels C and D respectively of Tables 5 and 6) or when they are tested jointly (panel A of Tables 5 and 6). And, since the findings are robust across panels A through D, no one Euler equation seems to be the source of this poor performance.

## V. Conclusion

This paper empirically explores the intertemporal asset–pricing relationships implied by a variety of dynamic barter and monetary economy models. The purpose is to ascertain whether the monetary considerations — liquidity services and nonsuperneutralities — are important for and permit improved explanation of asset prices. The stochastic Euler equations, governing agents' optimal asset choices, implied by the various models are systematically estimated and tested. The generalized–method–of–moments estimation technique and monthly data on the US economy over the 1959:4–1986:12 period are employed.

A number of contributions are made. First, two observational equivalence results are established with respect to the stochastic Euler equations. The Lucas (1982) cash–in–advance model is indistinguishable from a barter model embodying a start–of–period timing convention for consumption and investment decisions. The Lucas (1984)/Svensson (1985a) cash–in–advance model is indistinguishable from a barter model embodying both a start–of–period timing convention and a lagged information assumption. Second, the following empirical results are established.

(i) The empirical findings in Hansen and Singleton (1984) for the conventional benchmark barter–economy model, embodying an end–of–period timing convention for consumption and investment choices, are reaffirmed. The overidentifying restrictions, implied by this model, are emphatically rejected when they are both jointly and individually applied to stock and treasury–bill returns, with the notable exception of when they are individually applied to value–weighted stock return measures.

(ii) A barter model embodying an end–of–period timing convention and a lagged–information assumption; the Lucas (1982) cash–in–advance model and two money–in–the–utility function models do not accord any better with the data then the conventional barter model. The conclusions are as follows. The lagged–information assumption does not promote the explanatory power of the conventional barter model. Although the Lucas (1982) model has a barter interpretation, it also has a cash–in–advance interpretation — therefore, it seems that the monetary influences it embodies are not important for asset pricing. Even though real money balances enter significantly into the utility function, so that they are in turn significant for asset pricing — their consideration does not result in improved explanation.

(iii) The overidentifying restrictions, implied by the Lucas (1984)/Svensson (1985a) cash-in-advance model, are easily not rejected when individually applied to stock returns — both equally- and value-weighted measures. These restrictions are strongly rejected when individually (jointly) applied to treasury-bill (stock and treasury-bill) returns. Again, even though the Lucas (1984)/Svensson (1985a) model has a barter interpretation it also has a cash-in-advance interpretation. It seems that the monetary effects it captures are important for and permit improved explanation of stock returns only. The inconsistency of the model with treasury-bill return behavior appears to be the source of its inconsistency with the joint behavior of stock and treasury-bill returns.

The upshot of the study is that more work needs to be done before we have a theory of asset pricing that is fully consistent with the data. The above results provide some guidance. Notice that it is precisely those monetary models which are simultaneously consistent with positive nominal interest rates and the possibility of a combined transactions, precautionary and store-of-value demand for money lead to asset-pricing relationships in which monetary effects are significant. Within this set, the cash-in-advance model of Lucas (1984)/Svensson (1985a) seems to offer the most promise — since it is, additionally, consistent with stock return behavior. Perhaps this is because it models the transactions demand for money more specifically without placing restrictions on the interactions between the marginal utilities of consumption and real money balances. At an econometric level, it may be because it does not rely on accurate measurement of the money stock held by consumers. Further explorations of the monetary transactions technology in the Lucas(1984)/Svensson (1985a) model therefore seem exciting.

This optimistic note seems in sharp contrast to the conclusion in Hodrick, Kocherlakota and Lucas (1988). These authors calibrate a version of the Lucas (1984)/Svensson (1985a) model, using US time series data on consumption and money growth processes, to find that the model, in practice, implies that the cash-in-advance constraint almost always binds. In their words: "We conclude that there is little practical gain in using these more complicated informational specifications (than the Lucas (1982)-type model) in future applications of a cash-in-advance technology" (Hodrick, Kocherlakota and Lucas (1988), abstract). Of course there is no necessary inconsistency. Our conclusion is predicated on evidence that the monetary effects as captured by the Lucas (1984)/Svensson (1985a) and Lucas (1982) models are, at an empirical level, significantly different for asset-pricing relationships. The Hodrick, Kocherlakota and Lucas (1988) conclusion is based on evidence that the two models have the same (and implausible) empirical implications for monetary velocity. Further exploration of the Lucas(1984)/Svensson (1985a) model which simultaneously improves on its predictions for asset pricing and velocity constitutes an ambitious and interesting agenda.

## Footnotes

1. See for example: Hansen and Singleton (1982, 1983, 1984), Grossman, Melino and Shiller (1985), Mehra and Prescott (1985), Singleton (1985), Dunn and Singleton (1986), Eichenbaum, Hansen and Singleton (1988), Eichenbaum and Hansen (1987), Epstein and Zin (1987), Hansen and Singleton (1987), Ogaki (1988).

2. Singleton (1985) uses US data on a monthly basis for all variables except the interest rate which is a three-month rate. Poterba and Rotemberg (1987) and Marshall (1989) use quarterly US data. Ogaki (1988) uses both monthly and quarterly US data. Eckstein and Leiderman (1988) use quarterly Israeli data.

3. Strictly speaking $\theta_t$ also includes $d_t^e$ for the Lucas (1982) model. We exclude $d_t^e$ from $\theta_t$ for the results reported in the text since it turns out to be irrelevant in constructing instruments for estimating and testing the orthogonality conditions implied by (6) and (7).

4. Subsequent empirical studies of the barter economy model also adopted this timing convention.

5. Singleton (1985) also pointed out this timing difference between the barter–e and Lucas (1982) models.

6. Lucas (1982) confines his discussion to equilibria with binding CIA constraints.

7. Changes in the money growth rate are effected through monetary transfers occurring at the start of the period in the Lucas (1982) model. Temporary and unanticipated changes in the money growth rate are tantamount to once–and–for–all and instantaneous helicopter drops of money. The only effect is a contemporaneous increase in the price level proportionate to the increase in the money supply. In contrast, permanent or anticipated future increases in the money growth rate cause an anticipated future price inflation which erodes the real value of assets' future nominal payoffs — accordingly, real asset returns are affected. Neither Lucas (1982) nor Svensson (1985a,b) explicitly characterize the latter effects.

8. See Svensson (1985a) and/or Finn, Hoffman and Schlagenhauf (1988) for further details.

9. Svensson (1985a) presents an explicit solution to his model in the case of temporary shocks to real income and the money growth rate. This solution is characterized by two regions in the real income and money growth space — one in which the CIA binds and one in which it does not. In the nonbinding region, real money balances are decreasing (increasing) in the money growth rate (real income).

10. For the contemporaneous (lagged) MIUF model, the timing considerations relevant for money choices are reminiscent of those for the Lucas (1982) [Svensson (1985a)] model.

11. Clearly, it is also possible to investigate versions of these models under the assumption that agents consume and invest at the start of each period. It is, furthermore, possible to consider lagged–information counterparts to the contemporaneous and lagged MIUF models for both a start– and end–of–period timing convention for consumption and investment choices. Such investigations are not pursued here as we have isolated the effects of the alternative timing conventions for choices and of the alternative assumptions with regard to information flows by examining the alternative barter models.

12. If a start–of–period timing convention for choices were adopted in the MIUF models they would "nest" the barter–s / Lucas (1982) model. Further, if lagged–information counterparts to the start–of–period and end–of–period MIUF models were specified, they would, correspondingly, "nest" the barter–s model with lagged information (or the Lucas (1984)/Svensson (1985a) model) and barter–e model with lagged information.

13. Danthine and Donaldson (1986) show that real asset returns are negatively correlated with inflation in the lagged MIUF model.

14. The consistent estimate of the weighting matrix obtained from the unconstrained estimation must be used in evaluating both minimized values of the estimation–criterion function.

15. One exception to this rule arises in the case of the MIUF models. The Euler equations governing money holdings in these models include $[(M_t/P_{t+1})/c_{t+1}]$ while the associated instrument sets exclude its one–period lag. This exclusion is immaterial for the results due to the inclusion of $[(M_t/P_t)/c_t]$.

16. The alternative instrument sets investigated expanded those listed in Appendix 2 in the following ways.

    (1) For the barter–e and the two MIUF models: $[(P_{t-1}/P_t)(d^e_t/a^e_{t-1}) - 1]$ and $[(1+i^e_t)/(1+i^e_{t-1}) - 1]$ are respectively added to the instrument sets for the stock and bond Euler equations.

    For the Lucas (1982)/barter–s model: $[(P_{t-1}/P_t)(d^e_{t-1}/a^e_{t-2}) - 1]$ and $[(1+i^e_{t-1})/(1+i^e_{t-2}) - 1]$ are respectively added to the instrument sets for the stock and bond Euler equations.

For the barter–e model with lagged information:

$$[(P_{t-2}/P_{t-1})(d^e_{t-1}/a^e_{t-2}) - 1], \left\{\frac{[(a^e_t+d^e_t)/a^e_{t-1}]}{[(a^e_{t-1}+d^e_{t-1})/a^e_{t-2}]} - 1\right\} \text{ and}$$

$[(d^e_t/a^e_{t-1})/(d^e_{t-1}/a^e_{t-2}) - 1]$ are added to the instrument set for the stock Euler equation while $[(1+i^e_t)/(1+i^e_{t-1}) - 1]$ is added to the instrument set for the bond Euler equation.

For the Lucas (1984)/Svensson (1985a)/barter–s model with lagged information:

$$[(P_{t-2}/P_{t-1})(d^e_{t-2}/a^e_{t-3}) - 1], \left\{\frac{[(a^e_{t-1}+d^e_{t-1})/a^e_{t-2}]}{[(a^e_{t-2}+d^e_{t-2})/a^e_{t-3}]} - 1\right\},$$

$[(d^e_{t-1}/a^e_{t-2})/(d^e_{t-2}/a^e_{t-3}) - 1]$ is added to the instrument set for the stock Euler equation while $[(1+i^e_{t-1})/(1+i^e_{t-2}) - 1]$ is added to the instrument set for the bond Euler equation.

(2) The one–period lag of the instruments in the listed sets were added to the corresponding set for each model except the MIUF models. In the case of the MIUF models, only some one–period lagged instruments were added to the corresponding set because of programming restrictions.

(3) The union of the listed instrument sets for each Euler equation within a model was used as the instrument set for each of those equations. An exception to this again arose in the case of the MIUF models because of programming restrictions. Instead, for these models, the return in the relevant Z1 (Z2) set was added to the Z2 (Z1) set.

Each of the three alternative instrument sets was used in the joint estimation (of all Euler equations within a model) of each model for at least one set (NDS and VWR) of data choices. In addition, for the two CIA models, each of the three alternative instrument sets was used in the individual estimation of the stock Euler equation for all sets of data choices.

17. The reported estimation results use the following starting guesses for the model's parameters:

$$\beta = 1 \qquad\qquad \gamma = -1 \qquad\qquad \delta = 0.9$$

These parameter guesses were used to construct the initial weighting matrix for the reported estimation results. The associated estimate of the weighting matrix generally converged after two iterations.

For other (unreported) estimations, the identity matrix is used as the initial weighting matrix. The associated estimate of the weighting matrix generally converged after three iterations.

18. More precisely, statements of significant differences pertaining to parameter estimates mean significant differences at the 5 percent level from the value indicated based on a one-tail t test.

19. The marginal significance level (MSL) is one minus the probability that a $\chi^2$(df) random variable has a smaller value than the computed value of the test statistic under the null hypothesis that the overidentifying restrictions implied by the model are true.

20. For the comparable data sets, the present study uses a longer sample period and different data sources than Hansen and Singleton (1982/1984).

21. Henceforth, this model will be referred to as the Lucas (1984) model.

22. For the comparable data sets, the present study uses a longer sample period and different data sources than Ogaki (1988).

23. Although, Ogaki (1988) does find one case (out of three) of marginal nonrejection of the model (at the 8.7 percent level) when the bond Euler equation is estimated individually using the comparable data set. Also, the statement in the text pertains to Ogaki's (1988) restricted joint estimation of the stock and bond Euler equations using the comparable data set. Specifically, he easily does not reject the overidentifying restrictions implied by the model (at the 5 percent level) for the joint estimation when $\alpha$ and $\beta$ are freely estimated. But, in the latter case, the estimate of $\beta$ turns out to be much larger than unity (sometimes significantly so). Since this is implausible theoretically, $\beta$ is subsequently restricted to values at or below unity — this gives rise to the aforementioned restricted estimations. Finally note, the differences between Ogaki's and our findings (for the comparable data sets and estimations) arise to a small extent because of differences in sample period, data sources and instrument sets. Our investigation revealed that the main source of the differences is whether or not the underlying estimate of the weighting matrix has converged. In the case of our estimation results (with $\alpha$ and $\beta$ freely estimated) this convergence obtains.

24. The restriction, $\delta = 0.95$, is imposed for the joint estimation of the stock and bond Euler equations. Some restriction on $\delta$ was necessary since it appears to be largely identified by the money Euler equation. The value of $\delta = 0.95$ was chosen in view of the reported $\delta$ estimates.

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## APPENDIX 1

The data set consists of monthly observations on US variables from 1958:01 through 1986:12. Allowing for lagged variables, the estimation sample period begins in 1959:4.

### Consumption

Two measures of seasonally-adjusted real consumption expenditure are used: real purchases of nondurable goods and real purchases of nondurable goods plus services. These data are taken from the CITIBASE data tape. The former series is listed under GMCN82 and the latter series under GMCS82. Both series are based on constant 1982 prices.

### Prices

Prices are defined as the implicit deflators of the two consumption series. These deflators are calculated from the real and corresponding nominal consumption measures. Nominal purchases of nondurables and nondurables plus services are listed, respectively, under GMCN and GMCS on the CITIBASE data tape.

### Population

The total population (age sixteen and over) series is taken from the CITIBASE series P016.

### Money Supply

The money supply is measured as the end-of-period seasonally-adjusted value of M1 and is obtained from the CITIBANK data tape (Series FM1).

### Asset Returns

Monthly stock returns are obtained from the Center for Research in Security Prices (CRSP). These are alternatively measured as a value-weighted (VWRD) and equally-weighted (EWRD) return on stocks traded on the New York Stock Exchange. The treasury-bill return is the return on a one-month treasury bill constructed from Fama's (1984a,b) data set.

## Appendix 2

This appendix lists the stationary form of each stochastic Euler equation and associated instrument set used in the empirical analysis.

(a) Barter–e Model [Equations (10) and (11)]

$$(10') \qquad \underset{t}{E}\left[\beta\left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1}\frac{P_t}{P_{t+1}}\frac{\left[a^e_{t+1}+d^e_{t+1}\right]}{a^e_t}-1\right]=0$$

$$(11') \qquad \underset{t}{E}\left[\beta\left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1}\frac{P_t}{P_{t+1}}\left[1+i^e_t\right]-1\right]=0$$

(10') and (11') are respectively obtained by dividing (10) and (11) by $u_c(t)$ and rearranging.

$$Z1=\left\{1,\ c_t/c_{t-1}-1,\ \frac{P_{t-1}\left[a^e_t+d^e_t\right]}{P_t\quad a^e_{t-1}}-1\right\}$$

$$Z2=\left\{1,\ c_t/c_{t-1}-1,\ \frac{P_{t-1}\left[1+i^e_{t-1}\right]}{P_t}-1\right\}$$

Z1 (Z2) is the instrument set used in the estimation and testing of (10') [(11')].

(b) Barter–e Model With Lagged Information [Equations (17) and (18)]

$$(17') \qquad \underset{\Omega_t}{E}\left[\left[\frac{c_t}{c_{t-1}}\right]^{\gamma-1}\frac{\left[P_{t-1}/P_t\right]}{\left[P_{t-2}/P_{t-1}\right]}\left\{1-\beta\left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1}\frac{P_t}{P_{t+1}}\frac{\left[a^e_{t+1}+d^e_{t+1}\right]}{a^e_t}\right\}\right]=0$$

$$(18') \qquad \underset{\Omega_t}{E}\left[\left[\frac{c_t}{c_{t-1}}\right]^{\gamma-1}\frac{\left[P_{t-1}/P_t\right]}{\left[P_{t-2}/P_{t-1}\right]}\left\{1-\beta\left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1}\frac{P_t}{P_{t+1}}(1+i^e_t)\right\}\right]=0$$

(17') and (18') are respectively obtained by dividing (17) and (18) by $[(u_c(t-1)/P_{t-1})(P_{t-2}/P_{t-1})]$ and rearranging.

$$Z1 = \left\{1,\ \frac{c_{t-1}}{c_{t-2}} - 1,\ \frac{\left[P_{t-2}/P_{t-1}\right]}{\left[P_{t-3}/P_{t-2}\right]} - 1,\ \frac{P_{t-2}}{P_{t-1}} \frac{\left[a^e_{t-1} + d^e_{t-1}\right]}{a^e_{t-2}} - 1\right\}$$

$$Z2 = \left\{1,\ \frac{c_{t-1}}{c_{t-2}} - 1,\ \frac{\left[P_{t-2}/P_{t-1}\right]}{\left[P_{t-3}/P_{t-2}\right]} - 1,\ \frac{P_{t-2}}{P_{t-1}} \left[1 + i^e_{t-2}\right] - 1\right\}$$

Z1 (Z2) is the instrument set used in the estimation and testing of (17') [(18')].

(c) Lucas (1982)/Barter-s Model [Equations (6) and (7)]

$$(6')\quad \underset{\theta_t}{E}\left[\beta \left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1} \frac{P_t}{P_{t+1}} \frac{\left[a^e_t + d^e_t\right]}{a^e_{t-1}} - 1\right] = 0$$

$$(7')\quad \underset{\theta_t}{E}\left[\beta \left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1} \frac{P_t}{P_{t+1}} \left[1 + i^e_{t-1}\right] - 1\right] = 0$$

(6') and (7') are respectively obtained by dividing (6) and (7) by $u_c(t)$ and rearranging.

$$Z1 = \left\{1,\ c_t/c_{t-1} - 1,\ \frac{P_{t-1}}{P_t} \frac{\left[a^e_{t-1} + d^e_{t-1}\right]}{a^e_{t-2}} - 1\right\}$$

$$Z2 = \left\{1,\ c_t/c_{t-1} - 1,\ \frac{P_{t-1}\left[1 + i^e_{t-2}\right]}{P_t} - 1\right\}$$

Z1 (Z2) is the instrument set used in the estimation and testing of (6') [(7')].

(d) Lucas (1984)/Svensson (1985a)/Barter-s Model With Lagged Information [Equations (15) and (16)]

$$(15')\qquad \underset{t-1}{E}\left[\left[\frac{c_t}{c_{t-1}}\right]^{\gamma-1}\frac{\left[P_{t-1}/P_t\right]}{\left[P_{t-2}/P_{t-1}\right]}\left\{1-\beta\left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1}\frac{P_t}{P_{t+1}}\frac{\left[a_t^e+d_t^e\right]}{a_{t-1}^e}\right\}\right]=0$$

$$(16')\qquad \underset{t-1}{E}\left[\left[\frac{c_t}{c_{t-1}}\right]^{\gamma-1}\frac{\left[P_{t-1}/P_t\right]}{\left[P_{t-2}/P_{t-1}\right]}\left\{1-\beta\left[\frac{c_{t+1}}{c_t}\right]^{\gamma-1}\frac{P_t}{P_{t+1}}\left[1+i_{t-1}^e\right]\right\}\right]=0$$

(15') and (16') are respectively obtained from (15) and (16) by dividing the latter equations by $[(u_c(t-1)/P_{t-1})\ (P_{t-2}/P_{t-1})]$ and rearranging.

$$Z1=\left\{1,\ \frac{c_{t-1}}{c_{t-2}}-1,\ \frac{\left[P_{t-2}/P_{t-1}\right]}{\left[P_{t-3}/P_{t-2}\right]}-1,\ \frac{P_{t-2}}{P_{t-1}}\frac{\left[a_{t-2}^e+d_{t-2}^e\right]}{a_{t-3}^e}-1\right\}$$

$$Z2=\left\{1,\ \frac{c_{t-1}}{c_{t-2}}-1,\ \frac{\left[P_{t-2}/P_{t-1}\right]}{\left[P_{t-3}/P_{t-2}\right]}-1,\ \frac{P_{t-2}\left[1+i_{t-3}^e\right]}{P_{t-1}}-1\right\}$$

Z1 (Z2) is the instrument set used in the estimation and testing of (15') [(16')].

(e) Contemporaneous MIUF Model [Equations (22), (23) and (24)]

$$(22')\qquad \underset{t}{E}\left[\beta\left[\frac{c_{t+1}}{c_t}\right]^{\delta\gamma-1}\left[\frac{M_{t+1}/P_{t+1}}{M_t/P_t}\right]^{(1-\delta)\gamma}\frac{P_t}{P_{t+1}}\frac{\left[a_{t+1}^e+d_{t+1}^e\right]}{a_t^e}-1\right]=0$$

$$(23')\qquad \underset{t}{E}\left[\beta\left[\frac{c_{t+1}}{c_t}\right]^{\delta\gamma-1}\left[\frac{M_{t+1}/P_{t+1}}{M_t/P_t}\right]^{(1-\delta)\gamma}\frac{P_t}{P_{t+1}}\left[1+i_t^e\right]-1\right]=0$$

$$(24')\qquad \underset{t}{E}\left[\beta\left[\frac{c_{t+1}}{c_t}\right]^{\delta\gamma}\left[\frac{M_{t+1}/P_{t+1}}{M_t/P_t}\right]^{(1-\delta)\gamma}\left[\frac{M_t/P_{t+1}}{c_{t+1}}\right]+\frac{(1-\delta)}{\delta}-\frac{(M_t/P_t)}{c_t}\right]=0$$

(22') and (23') are respectively obtained by dividing (22) and (23) by $u_c(t)$ and rearranging. (24') is obtained by dividing (24) by $u_c(t)$, multiplying the resultant equation by $[(M_t/P_t)/c_t]$ and rearranging.

$$Z1 = \left\{1, \quad \frac{c_t}{c_{t-1}} - 1, \quad \frac{\left[M_t/P_t\right]}{\left[M_{t-1}/P_{t-1}\right]} - 1, \quad \frac{P_{t-1}}{P_t}\,\frac{\left[a_t^e + d_t^e\right]}{a_{t-1}^e} - 1\right\}$$

$$Z2 = \left\{1, \quad \frac{c_t}{c_{t-1}} - 1, \quad \frac{\left[M_t/P_t\right]}{\left[M_{t-1}/P_{t-1}\right]} - 1, \quad \frac{P_{t-1}}{P_t}\left[1 + i_{t-1}^e\right] - 1\right\}$$

$$Z3 = \left\{1, \quad \frac{c_t}{c_{t-1}} - 1, \quad \frac{\left[M_t/P_t\right]}{\left[M_{t-1}/P_{t-1}\right]} - 1, \quad \frac{\left[M_t/P_t\right]}{c_t} - 1\right\}$$

Z1, Z2 and Z3 are the instrument sets respectively used in the estimation and testing of (22'), (23') and (24').

(f) Lagged MIUF Model [Equations (26), (27), (28)]

$$\text{(26')} \qquad E_t\left[\beta\left[\frac{c_{t+1}}{c_t}\right]^{\delta\gamma-1}\left[\frac{M_t/P_{t+1}}{M_{t-1}/P_t}\right]^{(1-\delta)\gamma}\frac{P_t}{P_{t+1}}\,\frac{\left[a_{t+1}^e + d_{t+1}^e\right]}{a_t^e} - 1\right] = 0$$

$$\text{(27')} \qquad E_t\left[\beta\left[\frac{c_{t+1}}{c_t}\right]^{\delta\gamma-1}\left[\frac{M_t/P_{t+1}}{M_{t-1}/P_t}\right]^{(1-\delta)\gamma}\frac{P_t}{P_{t+1}}\left[1 + i_t^e\right] - 1\right] = 0$$

$$\text{(28')} \qquad E_t\left[\beta\left[\frac{M_t/P_{t+1}}{c_{t+1}}\right]\left[\frac{c_{t+1}}{c_t}\right]^{\delta\gamma}\left[\frac{M_t/P_{t+1}}{M_{t-1}/P_t}\right]^{(1-\delta)\gamma}\left\{1 + \frac{(1-\delta)}{\delta}\,\frac{c_{t+1}}{\left[M_t/P_{t+1}\right]}\right\} - \frac{\left[M_t/P_t\right]}{c_t}\right] = 0$$

(26') and (27') are respectively obtained by dividing (26) and (27) by $u_c(t)$ and rearranging. (28') is obtained by dividing (28) by $u_c(t)$, multiplying the resulting equation by $[(M_t/P_t)/c_t]$ and rearranging.

$$Z1 = \left\{1,\ \frac{c_t}{c_{t-1}} - 1,\ \frac{\left[M_{t-1}/P_t\right]}{\left[M_{t-2}/P_{t-1}\right]} - 1,\ \frac{P_{t-1}}{P_t}\frac{\left[a_t^e + d_t^e\right]}{a_{t-1}^e} - 1\right\}$$

$$Z2 = \left\{1,\ \frac{c_t}{c_{t-1}} - 1,\ \frac{\left[M_{t-1}/P_t\right]}{\left[M_{t-2}/P_{t-1}\right]} - 1,\ \frac{P_{t-1}}{P_t}\left[1 + i_{t-1}^e\right] - 1\right\}$$

$$Z3 = \left\{1,\ \frac{c_t}{c_{t-1}} - 1,\ \frac{\left[M_{t-1}/P_t\right]}{\left[M_{t-2}/P_{t-1}\right]} - 1,\ \frac{\left[M_t/P_t\right]}{c_t} - 1\right\}$$

Z1, Z2 and Z3 are the instrument sets respectively used in the estimation and testing of (26'), (27') and (28').

TABLE 1

Estimation Results For Barter–e Model
(1959:4 – 1986:12)

| CONS | RETURN | $\hat{\beta}$ | $\hat{SE}(\hat{\beta})$ | $\hat{\alpha} \equiv 1-\hat{\gamma}$ | $\hat{SE}(\hat{\alpha})$ | J(df) | MSL |
|---|---|---|---|---|---|---|---|
| | | | A. Stock and Bond Euler Equations (10) and (11) | | | | |
| NDS | EWR | 0.9998 | 0.0003 | 0.5593 | 0.1829 | 32.23(4) | 0.0001 |
| NDS | VWR | 0.9999 | 0.0003 | 0.4925 | 0.1629 | 24.74(4) | 0.0001 |
| ND | EWR | 0.9989 | 0.0003 | 0.2539 | 0.0955 | 30.68(4) | 0.0001 |
| ND | VWR | 0.9991 | 0.0003 | 0.2273 | 0.0919 | 19.56(4) | 0.0006 |
| | | | B. Stock Euler Equation (10) | | | | |
| NDS | EWR | 0.9917 | 0.0042 | 1.2912 | 2.4458 | 4.61(1) | 0.0317 |
| NDS | VWR | 0.9949 | 0.0032 | 0.1463 | 1.9177 | 0.49(1) | 0.4857 |
| ND | EWR | 0.9904 | 0.0026 | 1.5842 | 1.0471 | 6.05(1) | 0.0138 |
| ND | VWR | 0.9947 | 0.0022 | 0.7798 | 0.7821 | 0.76(1) | 0.3837 |
| | | | C. Bond Euler Equation (11) | | | | |
| NDS | | 0.9999 | 0.0003 | 0.4984 | 0.1609 | 20.20(1) | 0.0001 |
| ND | | 0.9990 | 0.0003 | 0.2343 | 0.0913 | 13.92(1) | 0.0001 |

Notes: (1) CONS denotes consumption. NDS (ND) denotes the nondurables plus services (nondurables) measure of real per-capital consumption. EWR (VWR) denotes the equally- (value-) weighted stock return measure.

(2) ˆ denotes an estimate. SE is the standard error of the corresponding parameter estimate. J(df) is the J-statistic whose degrees of freedom are indicated in parenthesis. MSL is the marginal significance level of the J-statistic.

TABLE 2

Estimation Results for Barter–e Model with Lagged Information
(1959:4 – 1986:12)

| CONS | RETURN | $\hat{\beta}$ | $\hat{SE}(\hat{\beta})$ | $\hat{\alpha} \equiv 1-\hat{\gamma}$ | $\hat{SE}(\hat{\alpha})$ | J(df) | MSL |
|---|---|---|---|---|---|---|---|
| | | | A. Stock and Bond Euler Equations (17) and (18) | | | | |
| NDS | EWR | 0.9999 | 0.0003 | 0.3599 | 0.1603 | 24.94(6) | 0.0004 |
| NDS | VWR | 0.9999 | 0.0003 | 0.3684 | 0.1631 | 23.85(6) | 0.0006 |
| ND | EWR | 0.9994 | 0.0003 | 0.4189 | 0.2506 | 19.16(6) | 0.0039 |
| ND | VWR | 0.9994 | 0.0003 | 0.4894 | 0.2692 | 16.94(6) | 0.0095 |
| | | | B. Stock Euler Equation (17) | | | | |
| NDS | EWR | 0.9874 | 0.0070 | –3.8713 | 4.6528 | 0.04(2) | 0.9824 |
| NDS | VWR | 0.9929 | 0.0052 | –1.8666 | 3.4954 | 0.10(2) | 0.9526 |
| ND | EWR | 0.9904 | 0.0037 | –2.1656 | 2.5061 | 0.83(2) | 0.6597 |
| ND | VWR | 0.9942 | 0.0029 | –0.9894 | 1.9819 | 0.59(2) | 0.7446 |
| | | | C. Bond Euler Equation (18) | | | | |
| NDS | | 1.0000 | 0.0003 | 0.4261 | 0.1804 | 18.45(2) | 0.0001 |
| ND | | 0.9995 | 0.0003 | 0.7917 | 0.3675 | 10.49(2) | 0.0053 |

Notes: as for Table 1.

TABLE 3

Estimation Results for Lucas (1982)/Barter-s Model
(1959:4 – 1986:12)

| CONS | RETURN | $\hat{\beta}$ | $\hat{SE}(\hat{\beta})$ | $\hat{\alpha} \equiv 1-\hat{\gamma}$ | $\hat{SE}(\hat{\alpha})$ | J(df) | MSL |
|---|---|---|---|---|---|---|---|
| A. Stock and Bond Euler Equations (6) and (7) | | | | | | | |
| NDS | EWR | 1.0002 | 0.0004 | 0.7127 | 0.2242 | 37.98(4) | 0.0001 |
| NDS | VWR | 1.0002 | 0.0003 | 0.6071 | 0.1993 | 31.99(4) | 0.0001 |
| ND | EWR | 0.9992 | 0.0003 | 0.2842 | 0.1102 | 35.37(4) | 0.0001 |
| ND | VWR | 0.9990 | 0.0009 | 0.3702 | 0.3262 | 25.47(4) | 0.0001 |
| B. Stock Euler Equation (6) | | | | | | | |
| NDS | EWR | 0.9801 | 0.0048 | –6.9243 | 2.5850 | 5.95(1) | 0.015 |
| NDS | VWR | 0.9867 | 0.0040 | –5.9484 | 2.1691 | 1.35(1) | 0.245 |
| ND | EWR | 0.9875 | 0.0031 | –3.0566 | 1.0490 | 5.56(1) | 0.018 |
| ND | VWR | 0.9927 | 0.0025 | –2.1211 | 0.8317 | 0.83(1) | 0.360 |
| C. Bond Euler Equation (7) | | | | | | | |
| NDS | | 0.9999 | 0.0003 | 0.4604 | 0.1623 | 25.88(1) | 0.0001 |
| ND | | 0.9991 | 0.0003 | 0.2234 | 0.0920 | 16.87(1) | 0.0001 |

Notes: as for Table 1.

TABLE 4

Estimation Results for Lucas (1984)/Svensson(1985a)/Barter–s Model with Lagged Information
(1959:4 – 1986:12)

| CONS | RETURN | $\hat{\beta}$ | $\hat{SE}(\hat{\beta})$ | $\hat{\alpha} \equiv 1-\hat{\gamma}$ | $\hat{SE}(\hat{\alpha})$ | J(df) | MSL |
|---|---|---|---|---|---|---|---|
| | | | A. Stock and Bond Equations (15) and (16) | | | | |
| NDS | EWR | 0.9998 | 0.0003 | 0.2793 | 0.1963 | 25.17(6) | 0.0003 |
| NDS | VWR | 0.9998 | 0.0003 | 0.2640 | 0.1869 | 23.96(6) | 0.0005 |
| ND | EWR | 0.9993 | 0.0003 | 0.5722 | 0.3123 | 18.35(6) | 0.0054 |
| ND | VWR | 0.9992 | 0.0003 | 0.5261 | 0.2985 | 18.21(6) | 0.0057 |
| | | | B. Stock Euler Equation (15) | | | | |
| NDS | EWR | 0.9980 | 0.0062 | 5.0821 | 4.6301 | 0.57(2) | 0.7513 |
| NDS | VWR | 1.0007 | 0.0046 | 4.2877 | 3.5651 | 0.44(2) | 0.8041 |
| ND | EWR | 0.9938 | 0.0032 | 2.3634 | 2.2184 | 0.94(2) | 0.6248 |
| ND | VWR | 0.9964 | 0.0024 | 1.9262 | 1.6472 | 1.27(2) | 0.5291 |
| | | | C. Bond Euler Equation (16) | | | | |
| NDS | | 1.0003 | 0.0005 | 0.6277 | 0.4225 | 13.50(2) | 0.0012 |
| ND | | 0.9995 | 0.0003 | 0.9516 | 0.4142 | 9.97(2) | 0.0068 |

Notes: as for Table 1.

TABLE 5

Estimation Results for the Contemporaneous MIUF Model
(1959:4 – 1986:12)

| CONS | RETURNS | $\hat{\beta}$ | $\hat{SE}(\hat{\beta})$ | $\hat{\alpha} \equiv 1-\hat{\gamma}$ | $\hat{SE}(\hat{\alpha})$ | $\hat{\delta}$ | $\hat{SE}(\hat{\delta})$ | J(df) | MSL | C(df)* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A. Stock, Bond and Money Euler Equations (22), (23) and (24) | | | | | | |
| NDS | EWR | 0.9999 | 0.0002 | 0.5143 | 0.1058 | 0.9792 | 0.0004 | 51.95(9) | 0.0001 | 2674.05(1) |
| NDS | VWR | 1.0000 | 0.0002 | 0.4823 | 0.1104 | 0.9806 | 0.0003 | 38.59(9) | 0.0001 | 4762.97(1) |
| ND | EWR | 0.9991 | 0.0002 | 0.2465 | 0.0889 | 0.9578 | 0.0007 | 41.22(9) | 0.0001 | 3256.22(1) |
| ND | VWR | 0.9991 | 0.0003 | 0.2196 | 0.0835 | 0.9588 | 0.0007 | 29.54(9) | 0.0005 | 3500.36(1) |
| | | | | B. Stock and Bond Euler Equations (22) and (23) [$\delta = 0.95$] | | | | | | |
| NDS | EWR | 0.9997 | 0.0002 | 0.3537 | 0.1301 | | | 40.35(6) | 0.0001 | |
| NDS | VWR | 0.9998 | 0.0002 | 0.3261 | 0.1293 | | | 29.58(6) | 0.0001 | |
| ND | EWR | 0.9991 | 0.0003 | 0.1887 | 0.0990 | | | 34.04(6) | 0.0001 | |
| ND | VWR | 0.9991 | 0.0003 | 0.1566 | 0.0930 | | | 22.80(6) | 0.0001 | |
| | | | | C. Stock and Money Euler Equations (22) and (24) | | | | | | |
| NDS | EWR | 0.9979 | 0.0008 | 0.2725 | 0.1176 | 0.9730 | 0.0031 | 21.13(5) | 0.0007 | 70.5596(1) |
| NDS | VWR | 0.9981 | 0.0008 | 0.2570 | 0.1147 | 0.9741 | 0.0029 | 12.01(5) | 0.0346 | 71.8896(1) |
| ND | EWR | 0.9947 | 0.0014 | 0.0552 | 0.1013 | 0.9246 | 0.0107 | 19.07(5) | 0.0018 | 42.4904(1) |
| ND | VWR | 0.9959 | 0.0013 | 0.0625 | 0.0973 | 0.9345 | 0.0101 | 10.09(5) | 0.0720 | 36.8388(1) |
| | | | | D. Bond and Money Euler Equations (23) and (24) | | | | | | |
| NDS | | 1.0000 | 0.0002 | 0.4849 | 0.1105 | 0.9808 | 0.0003 | 32.73(5) | 0.0001 | 4429.32(1) |
| ND | | 0.9991 | 0.0003 | 0.2266 | 0.0835 | 0.9593 | 0.0007 | 21.79(5) | 0.0001 | 3205.55(1) |

Notes: 1) as for Table 1.
2) C(df) is the C–statistic whose degrees of freedom are indicated in parenthesis.
*3) The C–test tests the restriction $\delta = 1$ for the sets of equations listed in panels A, C and D.

TABLE 6

Estimation Results for the Lagged MIUF Model
(1959:4 – 1986:12)

| CONS | RETURNS | $\hat{\beta}$ | $\hat{SE}(\hat{\beta})$ | $\hat{\alpha} \equiv 1-\hat{\gamma}$ | $\hat{SE}(\hat{\alpha})$ | $\hat{\delta}$ | $\hat{SE}(\hat{\delta})$ | J(df) | MSL | C(df)* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A. Stock, Bond and Money Euler Equations (26), (27) and (28) | | | | | | |
| NDS | EWR | 1.0000 | 0.0003 | 0.5860 | 0.1457 | 0.9792 | 0.0004 | 44.00(9) | 0.0001 | 2613.76(1) |
| NDS | VWR | 1.0000 | 0.0002 | 0.5110 | 0.1339 | 0.9804 | 0.0004 | 36.39(9) | 0.0001 | 4539.49(1) |
| ND | EWR | 0.9991 | 0.0003 | 0.2661 | 0.0912 | 0.9575 | 0.0007 | 38.86(9) | 0.0001 | 3154.11(1) |
| ND | VWR | 0.9991 | 0.0003 | 0.2379 | 0.0833 | 0.9585 | 0.0007 | 28.50(9) | 0.0001 | 3551.74(1) |
| | | | | B. Stock and Bond Euler Equations (26) and (27) [$\delta$ = 0.95] | | | | | | |
| NDS | EWR | 0.9998 | 0.0003 | 0.4897 | 0.1757 | | | 36.22(6) | 0.0001 | |
| NDS | VWR | 0.9999 | 0.0003 | 0.4162 | 0.1598 | | | 28.65(6) | 0.0001 | |
| ND | EWR | 0.9989 | 0.0003 | 0.2193 | 0.0995 | | | 33.33(6) | 0.0001 | |
| ND | VWR | 0.9991 | 0.0003 | 0.1899 | 0.0965 | | | 22.84(6) | 0.0008 | |
| | | | | C. Stock and Money Euler Equations (26) and (28) | | | | | | |
| NDS | EWR | 0.9973 | 0.0008 | 0.1359 | 0.1528 | 0.9714 | 0.0031 | 23.17(5) | 0.0003 | 77.21(1) |
| NDS | VWR | 0.9976 | 0.0009 | 0.1339 | 0.1474 | 0.9728 | 0.0030 | 15.36(5) | 0.0089 | 78.00(1) |
| ND | EWR | 0.9946 | 0.0014 | 0.0705 | 0.1035 | 0.9231 | 0.0109 | 21.86(5) | 0.0006 | 43.45(1) |
| ND | VWR | 0.9959 | 0.0014 | 0.0888 | 0.0992 | 0.9336 | 0.0103 | 14.53(5) | 0.0125 | 36.96(1) |
| | | | | D. Bond and Money Euler Equations (27) and (28) | | | | | | |
| NDS | | 1.0000 | 0.0002 | 0.5168 | 0.1329 | 0.9806 | 0.0003 | 28.52(5) | 0.0001 | 4304.70(1) |
| ND | | 0.9991 | 0.0002 | 0.2341 | 0.0831 | 0.9588 | 0.0007 | 18.44(5) | 0.0025 | 3130.32(1) |

Notes: as for Table 5.
*see Table 5 notes