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Production-Based Asset Pricing in Monetary Economies with Transactions Costs

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A general equilibrium asset pricing model for a monetary economy with capital accumulation, production and endogenous financial structure is constructed in which there is a meaningful interaction between monetary policy, inflation taxes, investment decisions and private financial arrangements. A differential stochastic liquidity premium applies in equilibrium to consumption and investment purchases. A production version of the capital asset pricing model is constructed. The presence of endogenous financial arrangements is shown to play a key role in explaining potential distortions in the equilibrium risk premia associated with technological uncertainty. Numerical work indicates (1) that return anomalies are potentially large, and (2) that the model has implications for empirical implementations for the partial equilibrium, production-based asset pricing models such as Cochrane (1991, 1996) and Braun (1993).

Introduction

The focus of this paper is on how nominal magnitudes such as inflation and money can generate asset return anomalies in production economies where there is a meaningful interaction between the monetary policies and the transaction volume of private, non-monetary financial claims. The vast empirical literature pointing to the importance of nominal magnitudes in asset pricing is surveyed in Marshall (1992). I describe a stochastic dynamic general equilibrium economy in which both fiat money and private credit-like arrangements are used in a competitive equilibrium to finance purchases of both consumption and investment goods. It is assumed that there are positive resource costs associated with the creation of these private intermediated arrangements, and therefore that these private arrangements are imperfect substitutes for fiat money. This creates a margin that allows government policies to distort asset returns.

The model produces two key results. First, it is shown that, in monetary economies with transaction costs, there is an equilibrium distortion in the stochastic discount factor for economies when monetary growth rates are sufficiently high relative to the rate of time preference and intermediation costs for market consumption and/or when investment goods are not zero. In numerical work, we find that transaction costs can be important sources of distortions in risk prices when benchmarked against frictionless asset pricing models. Second, when quantitatively assessing the size of these return anomalies, their importance can be substantial. Using a simple calibrated version of the economy, I compute (1) the magnitude of the return anomalies under different assumptions on transaction costs; (2) the size of the return distortion for moderate inflations versus risk price in a frictionless paradigm (where I use the frictionless model of Brock (1982) as a benchmark); and (3) the importance of nominal magnitudes in the production-based formulations of the stochastic discount factor and the measurement of returns as discussed for the frictionless case by Cochrane (1991, 1996) and Braun (1993).

As for results 1 and 2, I describe production-based models that are consistent with the findings in earlier work for consumption-based models with equilibrium frictions by Cochrane and Hansen (1992), Luttmer (1993) and Hansen *et al.* (1993) that exchange frictions can be important in asset pricing.[1] The focus of this paper is somewhat different from the types of friction discussed in Cochrane and Hansen, Luttmer and Hansen *et al.*, in that I focus on how distortions from binding financing constraints (endogenous cash-in-advance constraints) and transaction costs alter the structure of the stochastic discount factor and investment returns as opposed to short-selling constraints. I rewrite the asset pricing model allowing for binding financing constraints, and then use numerical methods to calculate the significance of these distortions for the comparative dynamics of the underlying asset pricing model as Donaldson and Mehra (1984). In addition my work does not emphasize the role of adjustment costs; instead, the focus is on equilibrium distortions.

In the case of result 3, by producing a production version of the capital asset pricing model where the mapping of stochastic inflation taxes to risk prices is made explicit (and can be calculated numerically), I generalize the production-based model of Cochrane (1991) to monetary economies, and then examine how the equilibrium risk premia associated with the pricing of capital goods are functions of the joint stochastic structure that governs (1) the vector of stochastic inflation taxes on consumption and investment goods, (2) the intertemporal marginal rate of substitution, and (3) technological innovations in both the production and the financial sectors of the economy. Numerical work argues that liquidity frictions associated with endogenous period financing constraints from some capital goods can be very important to the empirical implementations of production-based asset pricing models.

The remainder of the paper is organized as follows. The next section characterizes the economic environment. I describe a generalized version of Schreft (1992) which allows for (1) costly intermediation for both consumption and investment goods, and (2) capital accumulation. I define a symmetric recursive competitive equilibrium for the model. In contrast to Townsend (1987) and Lacker and Schreft (1992), I use the dynamic programming methods described in Stokey *et al.* (1989) to exploit the recursivity of the competitive equilibrium. These restrictions sharpen our ability to characterize the properties of the competitive equilibrium.

Section II discusses asset pricing. First, I prove a condition for rate-of-return dominance in the presence of active private financial arrangements. Then I construct a capital asset pricing model and discuss how the stochastic inflation tax alters the structure of equilibrium risk prices. This model allows us to identify how monetary policies, positive inflation taxes and credit creation interact to explain the risk premia associated with technological innovation. Section III concludes.

I. Production Economy with Costly Intermediated Claims

The model is formulated in discrete time as an infinite-horizon stochastic monetary economy with capital accumulation and production. The trading environment is a version of Schreft (1992).[2] A continuum of locations arranged in a circle of unit circumference with a large number of identical households and productive firms reside, all facing identical lifetime itineraries. All markets are spatially separated. A household consists of multiple members that include the following: one shopper for consumption goods, one shopper for investment goods, one 'producer' of consumption and investment goods, one 'intermediary', which expends domestically produced output goods in order to facilitate trade for shoppers from distant households at the home location, one portfolio manager buying and selling securities in an asset market, and one worker supplying labour and capital goods. Households are indexed by type $h \in [0, 1)$, where h identifies the household's location on the circle. Output goods are location-specific. Households gain utility from consuming any location z output goods, $z \in (0, 1]$. If $C_{ht}(z)$ denotes aggregate *per capita* consumption by type h households of location z goods at date t, then let $c_{ht}(z)$ denote the corresponding individual quantity.[3]

Uncertainty is identical at each location and is represented by the vector $\theta \in \mathbb{R}^m_+$, which forms a first-order Markov process with stationary transition function χ.[4] Production requires both labour and capital goods, both of which are domestically produced ('home') goods, and therefore acquisition can be financed with complete financial markets. Households are endowed with a unit of labour, which they supply inelastically in a competitive labour market at their home location, and a location h firm, which operates a production technology employing both home capital goods and labour to produce home (location h) consumption goods. Local capital stocks k_{ht} are rented by firms from individual households residing at the home location. Households augment their home capital stocks by purchasing heterogeneous investment goods from various market locations z, indexed $i_{ht}(z)$. Investment goods acquired during the current period from various producers are transformed into home capital goods by the beginning of next period.

Let the aggregate transformation function for capital goods in *per capita* terms be given by the function

$$K_{ht} = H(\mathbf{I}_{ht-1}(z)) = \inf_{z \in [0,1]} \{I_{ht-1}(z)\}$$

where $\mathbf{I}_h$ is a vector of investment goods.[5] The technical complementarity assumption implied by our choice of $H(I)$ implies $K_{ht} = I_{ht-1}$. The production technology for finished goods is summarized by the function $Y_{ht} = F(K_{ht}, 1) = f(K_{ht})$, where Y_h is the *per capita* level of real output, $f(K)$ satisfies standard conditions, i.e. is a weakly concave, constant-returns-to-scale technology, satisfying Inada conditions and where the normalization for labour is made explicit in F.[6] Since we will consider only symmetric monetary equilibria, we will drop the h subscript on all variables where the context is understood.

Following Lancaster (1966), each household has period preferences over a composite of consumption goods $V(c_{ht}(z))$, represented by the function u where u satisfies standard Inada conditions. Each household's intertemporal preferences are then represented by

$$(1) \qquad E_0 \sum_{t=0}^{\infty} \beta^t \int_0^1 u[V(c_{ht}(z))]\,\mathrm{d}z,$$

where $\beta \in (0, 1)$, E_0 indicates the mathematical expectation taken at date 0 with the expectation defined across the 'lifetime' state space of the household, and the aggregator is $V(\mathbf{c}_{ht}(z)) = \inf_{z\in[0,1]}\{c_{ht}(z)\}$, where $\mathbf{c}_{ht}(z)$ is an infinite vector of consumption goods indexed by location.

Each household is given an initial endowment of fiat money M_0. Fiat money is used by households to facilitate the acquisition of consumption goods and investment goods in their appropriate markets. The law of motion governing the aggregate *per capita* money stock at each location is given as follows:

$$(2) \qquad M_{t+1} = J(S_{t+1})M_t.$$

Let an individual household at any location h have next-period holdings of money denoted by m^d_{t+1}. The household then begins each period with a post-transfer stock of money prior to settling last period's credit account equal to $m^d_t + L_t$.

For all consumption and investment purchases, the household has available an alternative to the use of fiat money. Assume it can issue a private claim through an intermediary that resides at the home location at a resource cost.[7] Since these costs might differ in general for consumption and investment purchases, let this resource cost be x_1D and x_2D units of output goods respectively for consumption goods and investment goods, where x_1 and x_2 are strictly positive and D is the shortest distance between the two agents' home locations. Given $\mathbf{x} = [x_1, x_2]$ is a strictly positive, continuous and bounded function of that aggregate state $S \in \mathbb{S}$, letting D^*_1 and D^*_2 each be the minimum distance from home where households cease to use private financial arrangements to finance consumption and investment purchases respectively, and defining P to be the money price of consumption and investment goods in some period, $D^*_i(S)$ must satisfy in equilibrium

$$(3) \qquad D^*_i(S) = \min\{[r(S)/x_i(\theta)], 1/2\}, \qquad i = 1, 2,$$

where $r(S)$ is the interest rate.

To formalize representative decision problems, begin by normalizing the beginning of trading cash position to $\hat{m}_t = m_t/M_t$, where m_t is the amount of cash available to the household prior to the beginning of each trading session. If τ_1 denote the amount of consumption goods sold via the intermediary on credit at location and τ_2 are a similar measure for investment goods, and assuming that all credit accounts must be settled at the beginning of each period, prior to making current-period decisions and after the monetary transfer L is made at the beginning of the period, then $\hat{m}$ is given by

$$(4) \qquad \hat{m}_t \le (m^d_t + L_t)/M_t + \{[2D^*_1(S_t) + x_1(\theta_{t-1})D^*_1(S_t)^2][\tau_{1t-1} - c_{ht-1}]p(S_{t-1}) + [2D^*_2(S_t) + x_2(\theta_{t-1})D^*_2(S_t)^2][\tau_{2t-1} - i_{ht-1}]p(S_{t-1})\}/J(S_t),$$

where $\hat{m}$ is the stock of money available to the household for transactions purposes prior to the opening of goods markets, and $p = P/M$ is the inverse of real balances. Here, I assume that P takes the following homogeneous form:

$$(5) \qquad P(S_t) = p(S_t)M_t,$$

where p is continuous and strictly positive. Households assume that aggregate *per capita* investment evolves recursively according to the following law of motion:

$$(6) \qquad K_{t+1} = G(S_t),$$

where G is a bounded, continuous function.

To describe each representative household's decision problem, let the state of a household at the beginning of time t be denoted by $s_t = (k_t, \hat{m}_t, S_t) \in \mathbb{S}_h$, where $\mathbb{S}_h := [0, B_t] \times \mathbb{R}_{++} \times \mathbb{S}$ is the state space for the household's decision problem. Under the constant-returns-to-scale assumption, the household's budget constraint is

$$\begin{aligned}(7) \qquad p(S_t)[(1-2D_1^*(S_t))c_t + (1-2D_2^*(S_t))i_t] + m_{t+1}^d/M_t = \hat{m}_t \\ + p(S_t)\{[f(K_t, \theta_t) - \Sigma 2D_j^*(S_t) + x_j(\theta_t) D_j^*(S_t)^2]\tau_{jt} \\ + (k_t - K_t)[f'(K_t, \theta_t)]\}.\end{aligned}$$

Assume that the household at the beginning of each period gives the consumption good shoppers n_{1t} units of $\hat{m}_t$, while the remainder goes to the investment shoppers, say n_{2t}. The household then faces a pair of endogenous cash-in-advance constraints: a portfolio constraint and the standard non-negativity constraint. It follows that

$$(8) \qquad p(S_t)[1-2D_{1t}^*]c_t \le n_{1t}$$

$$(9) \qquad p(S_t)[1-2D_{2t}^*]i_t \le n_{2t}$$

$$(10) \qquad n_{1t} + n_{2t} \le \hat{m}_t$$

$$(11) \qquad c_t, k_t, n_{1t}, n_{2t}, m_{t+1}^d \ge 0 \qquad \text{for all } t.$$

If the household's feasible correspondence for stationary plans is $\Phi(s) \quad \mathbb{R}_+^5$, which is the set of $\mathbf{q}(s) = [c, g, \mathbf{n}, m^d]$ that satisfy (4) and (7)–(11) with $\mathbf{D}^*$ satisfying (3), then the household's decision problem can be stated as maximizing (1) subject to $\mathbf{q}(s) \in \Phi(s)$ given the functions governing the behaviour of the aggregate economy. A Bellman equation for studying the competitive equilibrium for this environment can be stated as a function $V(s)$ that satisfies the following functional equation:

$$V(s) = \sup_{\mathbf{q}(s) \in \Phi(s)} \left\{ u(c) + \beta \int_{\Theta} V(s') \chi(\theta, \mathrm{d}\theta') \right\}$$

where s' is the next-period state of the individual.

A symmetric, recursive competitive equilibrium can be defined in a standard manner. Specifically, it is a collection of identical price functions for each location $p(S)$, $r(S)$, $W_I(S)$ and $W_L(S)$, with $0 < P(S) < \infty \ \forall S \in \mathbb{S}$, and a collection of aggregate *per capita* functions for investment $G(S)$, consumption decisions $C(S)$, cash portfolios $\mathbf{N}^*(S)$ (and corresponding identical individual decisions), a size for the credit market $\mathbf{D}^*(S)$ satisfying (4), cash portfolios $\mathbf{N}^*(S)$, a monetary policy function and a value function $V(s)$, such that

Bellman's equation is satisfied and markets clear. That last condition is then

$$C(S)+G(S)=f(S)-[2D_1^*(S)-x_1(\theta)D_1^*(S)^2]C(S) + [2D_2^*(S)-x_2(\theta)D_2^*(S)^2]G(S). \tag{12}$$

Assuming the equilibrium functions exist, and carrying out the maximization on the right-hand side of Bellman's equation by invoking the envelope theorem, the equilibrium policy functions imply that the following hold:[8]

$$u'(C(S))=p(S)\left\{[1-2D_1^*(S)][\lambda_2(s)+\lambda_3(s)] + \beta[2D_1^*(S)+x_1(\theta)D_1^*(S)^2]\int_\Theta \lambda_1(s')/J(S')\chi(\theta,\mathrm{d}\theta')\right\}; \tag{13}$$

$$[\lambda_2(s)+\lambda_4(s)][1-2D_2^*(S)]p(S) = \beta\left\{\int_\Theta \lambda_2(s')p(S')f'(G(S))\chi(\theta,\mathrm{d}\theta') - p(S)[2D_2^*(S)+x_2(\theta)D_2^*(S)^2]\int_\Theta \lambda_1(s')/J(S')\chi(\theta,\mathrm{d}\theta')\right\}; \tag{14}$$

$$\lambda_2(s)+\lambda_5(s)-\lambda_1(s)\le 0 \qquad (=\text{ if } \hat{m}(s)>0); \tag{15}$$

$$-\lambda_2(s)+\beta\int_\Theta \lambda_1(s')/J(S')\chi(\theta,\mathrm{d}\theta')\le 0 \qquad (=\text{ if } m^d(s)>0); \tag{16}$$

$$-\lambda_5(s)+\lambda_3(s)\le 0 \qquad (=\text{ if } n_{1t}>0); \tag{17}$$

$$-\lambda_5(s)+\lambda_4(s)\le 0 \qquad (=\text{ if } n_{2t}>0). \tag{18}$$

where $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ and λ_5 are the Lagrange multipliers associated with (4), (7)–(10) respectively, $s'=[g(s), \hat{m}(s'), G(S)]$ where $\hat{m}'$ is given by (4), and $\mathbf{D}^*$ satisfies (3).

II. The Inflation Tax and Asset Pricing Anomalies

We begin by constructing an intertemporal valuation equation for investment good. To accomplish this, we first construct measures of the liquidity premium (which is simply a scaled version of the inflation tax) applied to typical consumption and investment goods in equilibrium. Combining (13), (15) and (16), we obtain

$$u'[C(S)]=p(S)[(1+x_1(\theta)D_1^*(S)^2)\lambda_2(S)+(1-2D_1^*(S))\lambda_5(S)]. \tag{19}$$

Then define the *per capita* liquidity premium associated with consumption and investment purchases respectively in state S, $\phi(S)=[\phi_C(S), \phi_I(S)]$, to be:[9]

$$\phi_C(S)=[x_1(\theta)D_1^*(S)^2\lambda_2(S)+(1-2D_1^*(S))\lambda_5(S)], \tag{20}$$

$$\phi_I(S)=[x_2(\theta)D_2^*(S)^2\lambda_2(S)+(1-D_2^*(S))\lambda_5(S)]. \tag{21}$$

We can now relate these liquidity premia to the structure of both physical and monetary stores of value.[10]

The structure of the stochastic discount factor and liquidity premia

Since each liquidity premium is a function of the costs associated with issuing intermediating private claims $\mathbf{x}(\theta)$, then, given $\phi(S)$, we can formulate the fundamental asset pricing equation incorporating equilibrium distortions for investment goods. Restating the optimality condition for consumption by combining (19) and (20), we find:

$$(22) \qquad u'[C(S)] = p(S)[\lambda_2(S) + \phi_C(S)].$$

Substituting (16), (18) and (22) into (14), the intertemporal valuation equation for investment goods in terms of marginal utilities and the vector of differential liquidity premia $\phi(S)$ is:

$$(23) \qquad u'[C(S)] - \beta \int_{\Theta} \{u'[C(S')]f'(G(S), \theta')\}\chi(\theta, \mathrm{d}\theta')$$
$$= -p(S)\{\phi_I(S) - \phi_C(S)\} - \beta \int_{\Theta} p(S')\phi_C(S')f'(G(S), \theta')\chi(\theta, \mathrm{d}\theta').$$

Equation (23) is the fundamental equation for valuing investment goods in this model. The left-hand side of the equation consists of the standard terms that appear in standard equilibrium production economies without distortions. What is new in (23) is the appearance on the right-hand side of two cost terms associated with the payments system. The first term is the net liquidity costs associated with investment versus consumption purchases in the current period, while the second term measures the anticipated liquidity costs associated with consuming next-period returns to current-period investment.

For the sake of the numerical work below, briefly comparing one-period returns from the two stores of value, the difference between investment returns and rate of return on fiat money is obtained by combining (15), (16), (20), (22) and (23) to obtain

$$(24) \qquad \beta \int_{\Theta} \{u'[C(S')]f'(G(S), \theta') - u'[C(S')]/\pi(S')\}\chi(\theta, \mathrm{d}\theta') = p(S)\phi_I(S)$$
$$+ \beta \int_{\Theta} \{p(S)[2D_1^*(S')\lambda_5(S') - x_1(\theta')D_1^*(S')^2\lambda_2(S')]$$
$$+ p(S')\phi_C(S')f'(G(S), \theta')\}\chi(\theta, \mathrm{d}\theta') \geq 0,$$

with the right-hand side of (24) quantifying return difference. The first term reflects the current-period payments system costs associated with making investment purchases. The second term is comprised of three parts: the first two are the net discounted expected intermediation costs associated with using trade credit to purchase consumption goods instead of cash, while the third term is the next-period liquidity premium associated with consuming the returns from current-period investment.

We can now use the valuation equation in (23) to study how inflation taxes might alter the equilibrium pricing of risk in a standard asset pricing framework. It is well known that any asset pricing model can be written in the following form:

$$(25) \qquad 1=\int_{\Theta} M(S')R(S')\chi(\theta, \mathrm{d}\theta'),$$

where $M(S)$ is the stochastic discount factor and $R(S)$ is a vector of real one-period asset returns.[11] By studying the appropriate expressions for the discount factor in the present economy with different assumptions on $\mathbf{x}$, we can determine how the stochastic inflation tax changes the structure of the equilibrium risk prices. Therefore, given various assumptions for the vector of intermediation costs $\mathbf{x}$, some important special cases come to mind. For example, for the symmetric transaction costs case, i.e. $x_i(\theta)=x(\theta)$ for $i=1,2$, the first term on the right-hand side of (23) disappears. In such a case, the only distortion in (25) is the liquidity premium for investment purchases, which essentially taxes the payoffs to capital investment valued when payoffs are stated in next-period consumption. Then (25) is

$$(26) \qquad 1=\int_{\Theta} M^1(S')R(G(S), \theta')\chi(\theta, \mathrm{d}\theta'),$$

with the stochastic discount factors $M^1(S)$ and $R(S')$ given by

$$M^1(S')=\beta\{u'[C(S')]/u'[C(S)]\};$$

$$R(S')=\{f'(G(S), \theta')[1-p(S')\phi_C(S')]\}.$$

In this case the stochastic discount factor is as in Brock (1982), but the return function is distorted by the inflation tax on next-period returns. Another case in the literature occurs when $x_2(\theta)\equiv 0$ and $x_1(\theta)=x_1>0\ \forall\theta\in\Theta$. This cost structure is studied by Townsend (1987) and Lacker and Schreft (1992). For this parameterization of $x(\theta)$, $\phi_I(S)=0$ and $\phi_C(S)>0$ for cash–credit economies. Then (25) becomes in this case

$$(27) \qquad 1=\int_{\Theta} M^2(S')R(G(S), \theta')\chi(\theta, \mathrm{d}\theta'),$$

where

$$M^2(S')=\beta\{u'[C(S')]\}/\{u'[C(S)]-p(S)\phi_C(S)\},$$

with $R(S)$ is as before. Of course, generally, we simply have

$$(28) \qquad 1=\int_{\Theta} M^3(S')R(G(S), \theta')\chi(\theta, \mathrm{d}\theta'),$$

where

$$M^3(S')=\beta\{u'[C(S')]\}/\{u'C(S)-p(S)[\phi_I(S)-\phi_C(S)]\}.$$

with $R(S)$ as in (26). In this case, the vector $\mathbf{x}$ is not symmetric, and is a strictly positive function; therefore we must account for the effect of current and future liquidity premia on future investment returns. For the numerical work below, we will study all three cases.

Capital asset pricing

We are now prepared to examine how inflation taxes can alter the equilibrium price of risk. Our benchmark is the frictionless model described in Donaldson and Mehra (1984). They formalize the equilibrium price of risk exclusively in terms of various patterns of uncertainty associated technological innovations in production. Brock (1982) suggests that equilibrium distortions be integrated into the model so that broader classes of uncertainty can be mapped into the equilibrium risk price associated with frictionless environments. To facilitate such a discussion, identify $\theta_T = [1, \theta_p]$ to be the uncertainty associated with technological innovation, where θ_T is a component of the vector θ. In addition, restrict the technology to be the one studied in Brock (1982).

Assumption 1. The technology f is given as follows: $f(K_t, \theta_t) = f(K_t, \theta_{Pt}) = (A_0 + A_1\theta_{Pt}) f(K_t)$, where $= \ln \theta_{Pt} = \rho \ln \theta_{Pt-1} + \varepsilon_{Pt}$ where ε_{Pt} is i.i.d. normal with variance σ_P^2, and $A_i > 0$ for $i = 0, 1$.

This technology in Brock (1982) is essentially a scaled version of a standard real business cycle technology. Let the remaining sources of uncertainty be denoted by θ_m, $\theta = [1, \theta_p, \theta_m]$.

For the general transaction cost case, the asset pricing model in (28) under Assumption 1 is

$$(29) \qquad 1 = \int_\Theta M^3(S')(A_0 + A_1\theta'_P) f'(G(S))[1 - p(S')\phi_C(S')]\chi(\theta, \mathrm{d}\theta'),$$

where $M^3(S)$ is as in (28), and θ'_P indicates the next-period value for the technology shock. Recall that the state dependence of the vector of inflation taxes ϕ is a function of the next-period private intermediation cost vector $\mathbf{x}(\theta')$.

The risk prices can be constructed by manipulating (23). Let Γ_1 be the risk price associated with technological uncertainty θ_P. Rewriting (23) under Assumption 1, we obtain the following:

$$(30) \qquad u'[C(S)] + p(S)[\phi_I(S) - \phi_C(S)] = \beta \int_\Theta \{u'[C(S')] - p(S')\phi_C(S')\}(A_0 + A_1\theta'_p) f'(G(S))\chi(\theta, \mathrm{d}\theta').$$

By defining $b_i = A_i f'(G(S))$ for $i = 0, 1$, we then solve (30) for the risk-free rate and the equilibrium price of market risk as in Donaldson and Mehra (1984):

$$(31) \qquad \Gamma_0 = \frac{u'[C(S)] + p(S)[\phi_I(S) - \phi_C(S)]}{\beta \int_\Theta \{u'[C(S')] - p(S')\phi_C(S')\}} \chi(\theta, \mathrm{d}\theta')$$

$$\Gamma_1 = \frac{\int_\Theta \{u'[C(S')] - p(S')\phi_C(S')\}\theta'_P \chi(\theta, \mathrm{d}\theta')}{\int_\Theta \{u'[C(S')] - p(S')\phi_C(S')\}} \chi(\theta, \mathrm{d}\theta')$$
$$= \Gamma_0 \operatorname{Cov}\{M^3(S'), \theta'_P[1 - p(S')\phi_c(S')]\}$$

So the equilibrium price of risk is simply a scaled version on the covariance between the stochastic discount factor and the distorted return structure. Of course, the capital asset pricing model predicted then by this version of (25) does not correspond to the frictionless paradigm. Imagine introducing a fictitious riskless asset with net supply zero, say asset Z. The return on such an asset would be $b_{Z1} = A_{Z1} f'(G(S)) = 0$, so $A_{Z1} = 0$. Therefore $b_Z = \Gamma_0$. The securities market line for these two assets would then be

$$(32) \quad \begin{aligned} b_0 &= \Gamma_0 + \Gamma_1 b_1 \\ &= \Gamma_0 + \Gamma_1 A_i f'(G(S)), \end{aligned}$$

where now the risk-free rate is $b_Z = \Gamma_0$ and the return on a generic risky claim to investment is b_0. Notice that, since the inflation tax alters the vector of risk prices $\Gamma = [\Gamma_0, \Gamma_1]$, the slope and intercept of the security market line is altered by distortionary monetary policies. Further, the asset pricing model is now written in terms of not only the primitives of taste and technology, but also transaction cost parameters. The following simple example will allow us to consider the importance of transaction costs for empirical implementations of production-based asset pricing.

Calibration results and production based asset pricing implementations

Equation (24) has important implications for empirical implementations of production-based asset pricing models such as Cochrane (1991, 1996). In these papers, investment returns are constructed merely from the first term on the right-hand side of (24) under the assumption that a no assets rate of return dominates investment goods in equilibrium. In the present case, this claim is not true. In the presence of positive inflation taxes associated with $\int_A \phi_i(S')\chi(\theta, d\theta') > 0$ for $i = c, I$, the partial-equilibrium-production-based asset pricing relationships used to construct investment returns in papers such as Cochrane (1991, 1996) are misspecified. But the question is, how much do nominal magnitudes matter?

Let us explore quantitative issues relating to investment return anomalies discussed above in the context of an example economy. Although the example is simply illustrative, we do parameterize it in a manner that facilitates comparison with standard real business cycle models. Therefore, assume power utility and Cobb–Douglas technologies as follows:

$$u(c) = \begin{cases} c^{\psi}/\psi, & \psi \neq 0 \\ \ln(c) & \psi = 0 \end{cases}$$

$$(33) \quad f(K, L, \theta) = \theta(L)^{1-\alpha}(K)^{\alpha} + (1-\delta)K, \qquad \alpha = 0{\cdot}34,\ \beta = 0{\cdot}99;\ \delta = 0{\cdot}078$$

$$\ln\theta_t = 0{\cdot}95\, ln\, \theta_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim N(0, \sigma_\varepsilon^2), \qquad A_0 = 100,\ A_1 = 1,$$

where for simplicity the parameters $\sigma_\varepsilon^2 = 0{\cdot}0072$ as in the real business cycle literature. We specialize the money rule in (3) as in Cooley and Hansen (1989):

$$M_{t+1} = \mu_t M_t, \qquad \log(\mu_t) = 0{\cdot}48 \log(\mu_{t-1}) + \eta_{Mt},$$

with $\eta_{Mt} \sim N[0{\cdot}52 \log(\bar{\mu}), \sigma_M^2 = 0{\cdot}009)$.

As for the transaction costs function $\mathbf{x}$, we restrict attention to deterministic, state-independent transaction costs. Following the approach in Lacker and Schreft (1992), we use their quarterly estimates from long-run money demand for consumption transaction costs of $x_1(\theta) = 0{\cdot}107$. Briefly, they construct their estimates as follows. Given long-run historical estimates over 1959–90 for interest rates and the semi-elasticity of money demand with respect to nominal rates estimated in Lucas (1988), they use the implied velocity estimate to set transaction costs such that the mean quarter percentage of consumption goods purchased with money is 67%. I use a similar procedure for constructing estimates of investment transaction costs. I use two numbers.[12] The first number is based on firms using cash to finance 20% of their investment purchases in the deterministic steady state of the economy. Using the steady-state benchmarks described in Marquis and Reffett (1994) of long-run growth rates for US data of 2% for 1959–91, this implies $x_2 = 0{\cdot}1025$. The second number is calibrated under the assumption that 10% of all investment goods are cash-financed to check the robustness of the results. For this number, $x_2 = 0{\cdot}0592$.

TABLE 1

ACTUAL AND SIMULATED VOLATILITY MEASURES AND SIMULATED CORRELATIONS FOR IMPORTANT ENDOGENOUS VARIABLES WITH INFLATION

Variable[a]	Standard deviations: Actual data	Standard deviations: Simulated data	Correlations with the inflation rate (simulated data)
80% credit investment goods in steady state ($\bar{\mu} = 1{\cdot}015$, $x_1 = 0{\cdot}107$, $x_2 = 0{\cdot}1025$, $\psi = 0$)			
R_{DM}	7·06	4·34	−0·41
R_C	9·05	7·91	−0·22
I	8·39	7·32	−0·25
Y	1·75	1·82	−0·41
C	0·82	0·70	−0·16
90% credit investment goods in steady state ($\bar{\mu} = 1{\cdot}015$, $x_1 = 0{\cdot}107$, $x_2 = 0{\cdot}0592$, $\psi = 0$)			
R_{DM}	7·06	3·92	−0·21
R_C	9·05	7·05	−0·15
I	8·39	7·14	−0·21
Y	1·75	1·81	−0·15
C	0·82	0·77	−0·07

[a] Actual R_{DM} denotes the weighted *ex post* asset returns for NYSE index from 1959(I)–1991(IV) suggested Donaldson and Mehra (1984, eq. (7)). The actual R_C is the *ex post* production-based investment returns using nonresidential investment from 1959(I)–1993(I) constructed using Cochrane's (1991, pp. 215–18) measure, except that marginal products innovate according to Solow residuals specified by (33), and returns are scaled by empirical measures constructed from the theoretical p and ϕ_c given realizations of S. Actual statistics are for US quarterly time series (1959(I)–1992(I)). Both actual and simulated data are seasonally adjusted, logged, and filtered using the Hodrick–Prescott Filter as in Cooley and Hansen (1989). All simulated statistics are averages over 200 periods, 1000 replications.

Table 1 presents the basic summary statistics for the endogenous variables in the model.[13] The first set of results is for investment transaction costs consistent with 80% of investment goods being financed with private financial arrangements, while the second part of the table is for the case of 90% credit investment goods. As is typical of monetary business cycle models, the consumption and investment series are too smooth. The measured volatilities in asset returns are also too smooth.[14] Some interesting features are also present. For example, the volatility of returns is sensitive to the specification of transaction costs on investment goods. For production-based returns measured by

TABLE 2

RISK PRICE DISTORTIONS FOR MODERATE INFLATIONS[a]

Inflation rates (%)[b]	Γ_0^*/Γ_0	Γ_0^*/Γ_1
80% credit investment goods ($x_1 = 0{\cdot}107$, $x_2 = 0{\cdot}1025$, $\psi = 0$)		
0	1·012	0·994
5	1·023	0·989
10	1·032	0·980
20	1·046	0·968
30	1·072	0·953
90% credit investment goods ($x_1 = 0{\cdot}107$, $x_2 = 0{\cdot}0592$, $\psi = 0$)		
0	1·003	0·999
5	1·009	0·995
10	1·015	0·988
20	1·020	0·979
30	1·027	0·968

[a] Γ^* denote the risk under Pareto-optimal monetary rules.
[b] These inflation rates are steady-state inflation rates when $\bar{\mu}$ is chosen appropriately, given the target steady-state inflation.

R_C, returns are over 10% more volatile in the higher transaction costs case. Even in the low transaction costs case, returns are far from constant as in real models without adjustment costs. In addition, the magnitude of the negative inflation–return correlation with the synthetic data appears to be more pronounced in the high transaction costs case, fixing monetary policy, than in the low transaction costs case.

Tables 2 and 3 discuss measures of bias in the equilibrium pricing of risk introduced by transaction costs and positive nominal interest rates. Table 2

TABLE 3

INVESTMENT RETURN ANOMALIES FOR DIFFERENT LEVELS OF MODERATE INFLATION: EXAMPLE-DIFFERENCES IN INVESTMENT RETURNS AS TRANSACTIONS COSTS VARY[a] ($\psi = 0$)

	Cases			
Net inflation rate (%)	1	2	3	4
Panel A. Percentage investment return anomalies: capital v. money ($\ln E(R_k - R_m)$)				
0	0·092	0·473	1·006	0·564
5	0·174	0·874	1·298	0·82
10	0·201	0·986	1·654	1·05
15	0·321	1·021	2·13	1·62
20	0·356	1·216	3·52	2·13
Panel B. Equilibrium risk prices-distorted v. optimal[b] *capital returns:* $b_0^*\text{-}b_0$				
0	0·003	0·21	0·37	0·25
5	0·021	0·45	0·93	0·78
10	0·029	0·78	1·12	0·96
15	0·033	1·31	1·96	1·51
20	0·039	1·43	2·21	1·67

[a] Case 1 is $x_1 = 0{\cdot}107$, $x_2 = 0$; case 2 is $x_1 = 0{\cdot}107$, $x_2 = 0{\cdot}0592$; case 3 is $x_1 = 0{\cdot}107 = x_2$; and case 4 is $x_1 = 0$, $x_2 = 0{\cdot}0592$. Panel A calculates the LHS of (24), panel B uses (23). Both are calculated numerically conditioning on steady-state values for the state variables.
[b] These returns are calculated for monetary policies such that $\bar{\mu} = \beta$.

begins to address the issue of how inflation taxes and transaction costs might alter the actual structure of returns. It examines the magnitude of the distortion in the equilibrium price of risk associated with various distortionary monetary policies. The first column summarizes the relative size of the risk-free rate distortion, while the second column examines the change (in this case, the increase) in the risk price of technological innovations in production. What is clear is that, once again, the magnitude of the transaction costs appears to be important. For the 90% credit investment good case, for historical rates of inflation (4·8% over the 1959–91 period), the securities market line is rotated upward as risk-free rates drop and the price of risky assets rises. For moderate inflations of 5%–20% for the case of 90% credit investment goods, the change in the risk price of uncertainty changes from 0.5% to 2·5%. For the 80% case, this range increases from 1·9% to 4·8%. Notice also that, in the 90% credit investment good case, the change in risk-free returns varies only from 0·9% to 2%. Comparable numbers for the 80% case range from 2% to 4%. Therefore, for the calibrated case, the securities market line gets steeper as the expected monetary growth rate increases.

Table 3 provides a different way of examining similar issues. Here, we simply compute differences in returns between (1) capital and money for distorted economies, and (2) capital for economies with moderate inflations and capital for economies where monetary agents follow Friedman's rule. As a robustness check, we also vary asset structures by configuring transaction costs in four ways. The first column summarizes the Lacker–Schreft (1992) case. This is basically the standard cash-in-advance case modified to allow for finite transaction costs. In this case, the size of the return anomaly for both capital versus money and actual capital versus optimal capital is quite small. For example, even in the case of 20% inflation, capital return dominates money by only 0·5%, while the return difference between optimal and actual capital stocks is less than 0·04%. This is substantially smaller than found in the pure currency cash-in-advance model such as Lucas (1980). Column 2 reveals that, for the calibrated parameter settings used, the return anomalies for the historical inflation rate of around 5% correspond to a 1% return dominance for investment goods.[15] Also, optimal capital returns are lower by approximately 0·5%. The largest return anomalies occur in the symmetric transaction costs case, where investment financing with private financial arrangements is twice as expensive as in case 2. In this case, at 10% inflation rates capital return dominates money by almost 1·5%, while distorted capital returns are over a percentage point higher than their returns for optimal monetary policies.

Finally, in Table 4 we examine the time-series properties for distorted investment returns and compare them with the investment returns generated by real production-based asset pricing models. Panel A indicates that distorted investment returns appear to explain actual investment returns quite well. The results for our zero adjustment costs model seem encouraging. By introducing equilibrium distortions, we can also generate relationships between inflation, investment returns and stock returns. These relationships are obviously absent in models without nominal magnitudes. In this sense, the model helps provide a production counterpart to Marshall (1992). Notice that optimal investment returns explain nothing here. This is because, without adjustment costs, optimal investment returns are excessively smooth.[16] Volatility in optimal investment returns is essentially generated by only the production shocks, and

TABLE 4

PRODUCTION-BASED ASSET PRICING REGRESSIONS QUARTERLY DATA

Explanatory variables	β	p-value ($\beta=0$)
Panel A. Dependent variable: actual stock returns		
Model 1: Distorted investment returns[a]	0·67	0·041
Model 2:		
Distorted investment returns	0·749	0·023
Inflation[b]	−1·2	0·087
Model 3: Optimal investment returns	0·14	0·43
Panel B. Dependent variable: distorted investment returns		
Model 1 Optimal investment returns	−0·53	0·39
Model 2: Inflation	−0·92	0·046

[a] See Table 1 for discussion of measurement issues. Actual investment returns computed according to (26) with $(1-r_t)^{-1}$ proxying for the inflation tax where r_t is measured as the three-month Treasury bill rate. (For example, in simulations, the correlation between $\phi_c(S)$ and $r(S)$ was 0·81 for Lacker and Schreft's parameterization of x_c.) Actual *ex post* inflation is constructed by taking the *theoretical* equilibrium mapping of S_t to P_t, with $\delta=0{\cdot}1$ and the capital stock K generated from the investment series, and shocks θ specified in (33). Simulated inflation rates are calculated from calibrated model.

[b] Actual inflation is also significantly inversely related to actual investment returns.

therefore these returns are not highly correlated with distorted investment returns. Panel B indicates that distorted investment returns look very different from optimal investment returns. The findings support the importance of stochastic inflation taxes associated with financing the purchase of investment goods in generating volatility in asset returns. The volatility in distorted investment returns is arising from the technology shocks and the volatility of the stochastic inflation tax.

III. CONCLUSION

This paper has generalized the discussion of asset return anomalies in monetary economies introduced by Townsend (1987), and has discussed the asset pricing implications of these types of friction. The frictions are essentially transaction costs. In numerical work, I have shown that for production-based models these frictions can be very important. In particular, the equilibrium price of risk is distorted. I identified how these asset return anomalies alter the structure of risk prices in a capital asset pricing model. It is shown that the vector of stochastic inflation taxes directly alters both the stochastic discount factor and the specifications of investment returns used to price real assets in an equilibrium model. The distortion in the stochastic discount factor impacts on the structure of equilibrium risk prices when monetary policies are non-optimal. Risk-free rates appear to decline, while the equilibrium price of risk increases. Therefore, the slope of the securities market line becomes steeper.

As for production-based asset pricing, we find that models of equilibrium distortions can help induce volatilities in investment returns that are not present in frictionless production-based models. Therefore distortion in the specification of investment returns can have implications for production-based asset pricing. Although investment return volatilities associated with equilibrium distortions are *not* as large as in production-based models with adjustment costs, they do help reproduce the relationship in investment returns between nominal magnitudes such as inflation and stock returns. In this sense they are not substitutes for adjustment costs in this class of asset pricing models, but they appear to be very helpful in providing a mechanism in production-based models for generating a relationship between actual stock returns and inflation as an alternative to the transactions technology mechanism for consumption-based models discussed in recent work by Marshall (1992).

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NOTES

1. The present work is also related to this literature. These calculations can be used to compute the distortion in the Hansen–Jagannathan bound directly, as opposed to using inequality restrictions such as discussed in the literature, e.g. Luttmer (1993). Also, I discuss how monetary distortions alter the study of production-based asset pricing by providing alternative discount factors and specifications for investment returns which allow us to identify additional sources of investment return volatility. Thus, I formalize some of the issues mentioned in Cochrane and Hansen (1992).
2. The model is also a generalization of work presented in Prescott (1987), Ireland (1994a, b) and Gillman (1993).
3. As is standard for general equilibrium models with distortions, I distinguish between the behaviour of aggregate *per capita* measures and individual decision rules; see e.g. Stokey *et al.* (1989). I utilize capital letters for aggregate *per capita* measures and lower-case letters for individual decisions. In a competitive equilibrium, these magnitudes will be the same.
4. The formalities are as follows. Let $(\Theta, \mathbb{O}, \chi)$ be a probability space, $\mathbb{O}$ the Borel sets of Θ, χ being a $\mathbb{O}$-measurable function on subsets $A \quad \mathbb{O}$. Assume $\Theta \quad \mathbb{R}^m_{++}$ is compact, χ is monotone; i.e. if $\mathbb{D}$ is the set of nondecreasing $\mathbb{O}$-measurable functions $d: \Theta \rightarrow \mathbb{R}$, then the operator $Td = \int_\Theta d(\theta')\chi(\theta, \mathrm{d}\theta')$ is nondecreasing also. For any $\varepsilon > 0$, $\exists$ a function $\delta(\varepsilon) > 0$ such that $\forall \theta, \hat{\theta} \in \Theta$,

$$\theta - \hat{\theta} \quad < \delta(\varepsilon) \Rightarrow \int_{A \quad \Theta} |\chi(\theta, A) - \chi(\hat{\theta}, A)| < \varepsilon.$$

5. Notice that since labour is fixed, the capital aggregation here is exact by arguments in Fisher (1969).
6. Specifically, we assume that technologies satisfy the assumptions in Greenwood and Huffman (1992).
7. One possible explanation for these positive intermediation costs is discussed in the literature on the agency costs associated monitoring financial contracts with firms producing investment goods (e.g. Williamson 1987). Other types of cost associated with the creation of private intermediated structures are discussed in Townsend (1983).
8. This setup can be directly mapped into a framework within the class of models with equilibrium distortions (e.g. a tax) described by Greenwood and Huffman (1992). Existence then follows from the main theorem of Greenwood and Huffman (Section 3, Theorem 1). With some curvature restrictions on u and f, unique, strictly positive equilibria exist. The details are available upon request from the author.
9. I follow Townsend (1987) and state the asset return anomalies in terms of liquidity premia, not inflation taxes. To reformulate the problem as a tax problem, define the stochastic inflation tax for consumption purchases as a rescaled measure of the liquidity premia; i.e. $\tau(S) = \phi(S)/\mu'[C(S)]$ as in Coleman (1994). A similar definition could be used for investment goods.
10. When restricting our attention to monetary economies with endogenous cash–credit decisions, we need some restrictions on monetary growth rates. As in the case of Lucas and Stokey (1987), monetary policy is optimal when $J(S)$ satisfies $\beta \int_\Theta [1/J(S')]\chi(\theta, \mathrm{d}\theta') = 1$. For such economies, $r(S) = 0$ and $\mathbf{D}^*(S) = 0$. Therefore, private financial arrangements are never used,

and a pure currency equilibrium can be constructed. Likewise, if the expected costs of intermediating private claims is too large, the economy can become a pure currency setup. For a cash–credit economy, we restrict $J(S)$ to satisfy the following condition:

$$\beta\int_{\Theta}[1/1+\min\{x_1(\theta)/2, x_2(\theta)/2\}]\,\chi(\theta, \mathrm{d}') < \beta\int_{\Theta}[1/J(S')]\chi(\theta, \mathrm{d}\theta') \leq 1.$$

11. A linear arbitrage pricing model for our production economy will impose a simple linear form for the stochastic discount factor $M(S)$, writing $M(S)$ exactly in terms of market risk 'factors' that are used to explain investment returns. For capital asset pricing, the number of market factors typically is reduced to one. Further, in the numerical work below we will study the conditional version of Hansen and Richard as opposed to the unconditional version used in for example Hansen and Jagannathan (1991).
12. I use the Lacker–Schreft parameter settings based on consumption credit costs. I also use their procedure for constructing transaction costs for firms based on the semi-elasticities of long-run money demand for business money measures. The semi-interest elasticities for firms' money data were estimated for business M2 for 1952–91 using CCR with prewhitening (see Park 1992), and Park and Ogaki 1991 for a discussion of the techniques used), which are roughly consistent with 80% of all investment goods being credit goods. We thank Valarie Ramey for graciously supplying this data, and Masao Ogaki for providing some of his CCR programs for these runs.
13. To obtain decision rules, I used a version of the linear quadratic approximation method discussed in Christiano (1991). See an earlier draft of the paper for the details (Reffett 1994).
14. It is important to note that, without inflation taxes and production shocks, the investment returns in the real version of this model show very little variability. That is, they are far too smooth. It is well-known that in real models adjustment costs provide a fruitful avenue to make investment dynamics as volatile as observed in aggregate data. In simulations with a simple adjustment cost parameterized exactly as in Cochrane (1991), the investment volatilities for both real and monetary economies can be increased to much more realistic levels (actually larger than in Cochrane 1991). Since I was seeking to isolate distortions as an additional source of volatility, I excluded adjustment costs for my reported results.
15. In Campbell and Cochrane (1994), it is argued that security return volatility can have important implications for welfare. This is especially true when frictions are present. Here, using the Cooley–Hansen (1989) welfare loss measure and my parameter setting, the welfare cost of risk price distortion is 0·9% of GNP for historical inflation rates (4·8%), which is three times as large as reported in Cooley and Hansen (1989).
16. This finding, of course, is not inconsistent with the findings in Cochrane (1991, 1996) and Braun (1993). These papers consider optimal investment returns in models with adjustment costs. As mentioned in n. 15, the present model abstracts from these costs.

REFERENCES

ABEL, A. (1985). Dynamic behavior of capital accumulation in a cash-in-advance model. *Journal of Monetary Economics*, **16,** 55–72.

BRAUN, P. (1993). Asset pricing and capital investment. Unpublished paper, Northwestern University.

BROCK, W. (1982). Asset prices in a production economy. In J. J. McCall (ed.), *The Economics of Information and Uncertainty*. Chicago: University of Chicago Press, pp. 1–42.

CAMPBELL, J. and COCHRANE, J. (1994). By force of habit: a consumption-based explanation of aggregate stock market behavior. Unpublished paper.

CHRISTIANO, L. (1991). Modeling the liquidity effect of a money shock. *Federal Reserve Bank of Minneapolis Quarterly Review*, **15,** 3–34.

COCHRANE, J. (1991). Production-based asset pricing and the link between stock returns and economic fluctuations. *Journal of Finance*, **66,** 209–37.

—— and HANSEN, L. P. (1992). Asset pricing explorations for macroeconomics. NBER Working Paper 4088; also in *1992 NBER Macroeconomics Annual.*

—— (1996). A cross-sectional test of a production-based asset pricing model; Journal of Political Economy, forthcoming.

COLEMAN, W. J. II (1994). Money, interest and capital in a cash-in-advance economy. Unpublished paper, Duke University.

COOLEY, T. and HANSEN, G. (1989). The inflation tax in a real business cycle model. *American Economic Review*, **79,** 733–48.

DONALDSON, J. B. and MEHRA, R. (1984). Comparative dynamics of an equilibrium asset pricing model. *Review of Economic Studies*, **51,** 481–508.

FISHER, F. (1969). The existence of aggregate production functions. *Econometrica*, **37,** 553–77.

GILLMAN, M. (1993). The welfare cost of inflation in a cash-in-advance economy with costly credit. *Journal of Monetary Economics*, **31,** 97–115.

GREENWOOD, J. and HUFFMAN, G. (1992). On the existence and uniqueness of nonoptimal equilibria in dynamic stochastic economies. *Journal of Economic Theory*, forthcoming.

HANSEN, L. P. and JAGANNATHAN, R. (1991). Implications of security market data for models of dynamic economies. *Journal of Political Economy*, **00,** 225–62.

—— and RICHARD, S. (1987). The role of conditioning information in deducing testable restrictions implied by dynamic asset pricing models. *Econometrica*, **55,** 587–613.

—— HEATON, J., and LUTTMER, E. (1993). Econometric evaluation of asset pricing models. NBER Technical Working Paper 145. Unpublished.

IRELAND, P. N. (1994a). Economic growth, financial innovation, and the long-run behavior of velocity. *Journal of Economic Dynamics and Control*, forthcoming.

—— (1994b). Money and growth: an alternative approach. *American Economic Review*, forthcoming.

KING, R. and REBELO, S. (1990). Public policy and economic growth in the neoclassical model. *Journal of Political Economy*, **98,** pt2, S126–S150.

LACKER, J. M. and SCHREFT, S. L. (1992). Money and credit as a means of payment. Unpublished paper, Federal Reserve Bank of Richmond.

LANCASTER, K. (1966). A new approach to consumer theory. *Journal of Political Economy*, **74,** 132–57,

LUCAS, R. E. Jr (1980). Equilibrium in a pure currency economy. In J. Karekin and N. Wallace (eds), *Models of Monetary Economics*. Minneapolis: Federal Reserve Bank of Minneapolis, pp. 131–45.

—— (1988). Money demand in the United States: a quantitative review. *Carnegie-Rochester Conference Series on Public Policy*, **29,** 137–68.

LUTTMER, E. (1993). Asset pricing with frictions. Unpublished paper, Northwestern University.

MARQUIS, M. and REFFETT, K. (1994). The inflation tax in a convex model of equilibrium growth with transactions costs. Unpublished paper, Florida State University.

MARSHALL, D. (1992). Inflation and asset returns in a monetary economy: empirical results. *Journal of Finance*, **47,** 1315–42.

PARK, J. (1992). Canonical cointegration regression. *Econometrica*, **60,** 119–44.

—— and OGAKI, M. (1991). Inference in cointegrated models using VAR prewhitening to estimate short-run dynamics. Unpublished paper, University of Rochester.

PRESCOTT, E. (1987). A multiple means of payment model. In William Barnett and Kenneth Singleton (eds), *New Approaches to Monetary Economics*. Cambridge University Press.

—— and MEHRA, R. (1980). Recursive competitive equilibrium: the case of homogeneous households. *Econometrica*, **48,** 1365–79.

REFFETT, K. (1994). Production-based asset pricing in monetary economics with transaction costs. Unpublished paper, Florida State University.

SCHREFT, S. L. (1992). Welfare improving credit controls. *Journal of Monetary Economics*, **32,** 57–72.

SNOW, K. (1991). Diagnosing asset pricing models using the distribution of returns. *Journal of Finance*, **46,** 955–84.

STOCKMAN, A. (1981). Anticipated inflation and the capital stock in a cash-in-advance economy. *Journal of Monetary Economics*, **8,** 387–93.

STOCKEY, N., LUCAS, R. E., Jr and PRESCOTT, E. (1989). *Recursive Methods in Economic Dynamics*. Cambridge, Mass.: Harvard University Press.

TOWNSEND, R. (1983). Theories of intermediated structures. In *Carnegie–Rochester Conference Series on Public Policy*, **18,** 221–72.

—— (1987). Asset-return anomalies in a monetary economy. *Journal of Economic Theory*, **41,** 219–47.

WILLIAMSON, S. (1987). Costly monitoring, optimal contracts, and equilibrium credit rationing. *Quarterly Journal of Economics*, **102,** 135–45.