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Comment

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The paper by Venky Venkateswaran and Randall Wright (henceforth VW) is a laudable and useful contribution that seeks to integrate two literatures that focus on financial market frictions: a literature in monetary economics that assumes that all assets cannot be used in many trades, and a literature that focuses on constraints, such as collateral constraints, that limit borrowing. Integrating these literatures is useful because it allows us to consider how monetary policy should be conducted in the face of collateral constraints.

VW's model is an extension of that in Lagos-Wright (2005). As in Lagos-Wright, in each period of an infinite-horizon model, households trade sequentially in two distinct markets. The first market, called KM (after Kiyotaki-Moore) is a market in which goods are traded for money and debt. The amount of debt is constrained to be a proportion of the traders' holdings of assets. I will refer to these constraints as collateral constraints. The second market, called AD (after Arrow-Debreu) is a conventional centralized market. The difference from the model in Lagos-Wright is that households can use debt claims in the KM market.

VW conduct a variety of comparative steady-state experiments as various parameters (including policy parameters) are varied. Here I focus on the experiments that I find particularly interesting. The main substantive and policy findings are as follows.

1. Monetary equilibria (in the sense of equilibria in which money has a positive value) exist only if the collateral constraints are sufficiently tight.
2. The Friedman rule is not optimal in an economy with capital income taxes.

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3. The model can account for part of the Equity Premium. This part is large at their preferred calibration.

4. Across steady states, monetary policies that lead to higher inflation lead to a rise in the steady-state level of output, a rise in the capital-output ratio, a fall in the consumption-output ratio, and either a rise or a fall in labor input depending on whether labor in the KM market is excluded or included. VW interpret the HP trend component of US data as corresponding to the steady states of their model and argue that US experience is roughly consistent with their findings.

5. Financial innovation, modeled as changes in the collateral constraint parameters, have nonmonotonic effects on aggregate variables.

In this discussion, I will argue that VW's main contribution is to come up with a tractable model in which one can analyze privately produced media of exchange. Such models seem essential given that most media of exchange in practice, such as bank deposits or the use of credit cards, are privately produced. In this sense, VW's contribution is very important.

In terms of the detailed findings when they put their model to work, I will argue that findings (1) and (5) are interesting and useful contributions, finding (2) is less useful, (3) arises from a calibration that I find hard to defend, and that many aspects of finding (4) depend on assumptions about technologies that seem hard to swallow.

It is convenient to make the arguments, particularly about findings (1) and (4), by recasting VW's model in Lucas and Stokey's (1986) standard and widely used cash-credit goods model. In that model, (at least with my functional forms and for a wide range of parameter values, including those used by VW) I show that monetary policies that lead to higher inflation lead to a fall in the steady-state level of output, a rise in the capital-output ratio, a fall in the consumption-output ratio, and a fall in labor input.

Consider a cash-credit goods model with a representative infinitely-lived household. The resource constraint is given by

$$c_{1t} + c_{2t} + k_{t+1} \leq F(k_t, l_t) + (1 - \delta)k_t, \tag{1}$$

where c_{1t} and c_{2t} denote consumption of "cash" and "credit" goods, k_t is the capital stock, l_t is the labor input, F is a constant returns to scale production function, and δ is the depreciation rate. The representative household's preferences are given by

$$\sum_{t=0}^{\infty} \beta^t u(c_{1t}, c_{2t}, l_t), \tag{2}$$

where β is the discount factor and u is the period utility function. The household can use money and part of its capital and government debt bond holdings to purchase cash goods. The household's cash in advance constraint is given by

$$P_t c_{1t} \leq M_t + \theta_k P_t k_t + \theta_b P_t b_t, \tag{3}$$

where P_t is the price level, M_t denotes currency holdings, b_t denotes holdings of government debt, and θ_k and θ_b are parameters that specify the portion of capital and government debt that can be used to purchase cash goods. The budget constraint of the household is given by

$$\begin{aligned} &M_{t+1} + P_t c_{1t} + P_t c_{2t} + P_t k_{t+1} + P_t b_{t+1} \\ &\qquad \leq M_t + P_t(1 + r_{kt})k_t + P_t(1 + r_{bt})b_t + P_t w_t l_t + T_t' \end{aligned} \tag{4}$$

where r_{kt} denotes the return to holding capital net of depreciation, r_{bt} denotes the return to holding government debt, w_t denotes the real wage rate, and T_t denotes lump sum transfers. The household's problem is to maximize (2) subject to (3) and (4) and the usual no Ponzi constraints. Profit maximization by firms implies that $r_{kt} = F_{kt} - \delta$ and an equilibrium can be defined in the usual manner.

In this model, in addition to the usual motives for holding capital, households have an additional return from holding capital since it can be used to economize on non-interest bearing currency holdings. The incentives to economize on currency holdings are stronger when the inflation rate is higher. It is straightforward to show that when the inflation rate is sufficiently high, or when θ_k is sufficiently large, households will finance their cash goods consumption entirely with capital and the economy has no monetary equilibrium.

This model has an attractive interpretation. Under this interpretation, think of households depositing some of their assets in banks. The banks issue demand deposits that can be used for purchasing cash goods. The banks face a reserve requirement that dictates the fraction of deposits that must be backed by currency and the fraction by claims to capital and to government debt. Under this interpretation, the parameters θ_k and θ_b can be interpreted as regulatory restrictions on bank portfolios. The comparative statics exercises on these parameters can then be interpreted as determining the response to regulatory policy.

The Friedman rule is optimal in a large class of monetary models. In this cash-credit goods model any policy that relaxes the cash in advance constraint is desirable. Raising the return to holding currency relaxes the constraint. VW argue that in the presence of capital taxation, it may be optimal to deviate from the Friedman rule. This finding is somewhat interesting because in standard cash-credit good models (i.e., with $\theta_k = \theta_b = 0$), the Friedman rule is optimal even with capital taxation. The presence of capital in the cash in advance constraint makes it desirable to deviate from the Friedman rule. Other cash in advance models, such as Stockman (1981), allow cash in advance constraints to apply to investment goods as well and generate a similar effect.

To conduct other comparative statics, assume that the production function is Cobb Douglas and is given by $F(k, l) = k^{\alpha} l^{-\alpha}$. Solving the household's problem, we can easily show that in a steady state, the following conditions must be satisfied

$$F_k = \frac{\alpha y}{k} = \frac{1}{\beta} - 1 + \delta - \theta_k \left[\frac{u_1}{u_2} - 1\right] \tag{5}$$

$$r_b = \frac{1}{\beta} - 1 - \theta_b \left[\frac{u_1}{u_2} - 1\right] \tag{6}$$

$$\frac{u_1}{u_2} = \frac{\pi}{\beta} \tag{7}$$

$$-\frac{u_l}{u_2} = F_l \tag{8}$$

$$c_1 + c_2 = y - \delta k, \tag{9}$$

where π denotes the steady-state inflation rate. From (5) and (7), we see that a rise in the inflation rate raises the capital-output ratio. The economics behind this effect are that a rise in the inflation rate leads households to economize on currency holdings, partly by reducing cash goods consumption and partly by increasing the amount of capital. If we assume that the utility function has the form

$$u(c_1, c_2, l) = \log c_1 + \psi \log c_2 + b \log(1 - l),$$

we obtain closed-form solutions for consumption, labor, and the capital stock. Straightforward calculations show that for a wide range of parameters, including those used in the quantitative literature using cash-credit goods models and in VW's preferred calibration, output and the labor input fall in response to a rise in the inflation rate. (Calculations available upon request.)

So why do VW obtain a rise in the level of output? The answer is that they assume that production functions for producing cash goods (KM goods in their model) are different from the production functions for producing credit goods (AD goods in their model). In particular, cash goods are either endowments or produced using labor. They also point to the possibility that cash goods production may not be measured in the National Income Accounts. Absent a systematic attempt to catalog goods into various types, I do not see how much we could learn from purely aggregative models.

What do we know about the long-run effects of inflation on real variables? Cross-country evidence suggests that high inflation tends to reduce output. The time series evidence is mixed. VW do present some fascinating new evidence on this question. They interpret Hodrick-Prescott trend levels of output and other aggregates in the data as corresponding to steady states. They find interesting evidence that the relationship between these aggregates and HP trend inflation in US data are similar to the relationships in their model.

The most interesting aspect of their data analysis concerns the construction of the capital-output ratio. They use nominal private nonresidential fixed assets from the Bureau of Economic Analysis as their measure of the capital stock and nominal GDP as their measure of output to obtain the capital-output ratios. The BEA describes their methodology in http://www.bea.gov/national/pdf/Fixed_Assets_1925_97.pdf. Specifically, they begin with historical data on nominal investment by subcategories of assets, such as types of equipment. Using data on prices of investment goods within each subcategory, assumptions on depreciation rates, and the perpetual inventory method, they then construct constant cost estimates of the value of assets within each subcategory. That is, they construct estimates of real capital stocks at subcategory levels. They then use current investment prices to construct estimates of nominal asset values to compute their nominal assets. This procedure implies that if the price of investment goods rises, the value of the capital stock rises as well. Whether this is true in practice is an open question. In any event, there are good reasons to be concerned about high frequency estimates of the nominal value of the capital stock.

In figure C1 I display the time series of the capital-output ratio from the data that VW use and kindly provided to me. Note that the capital-

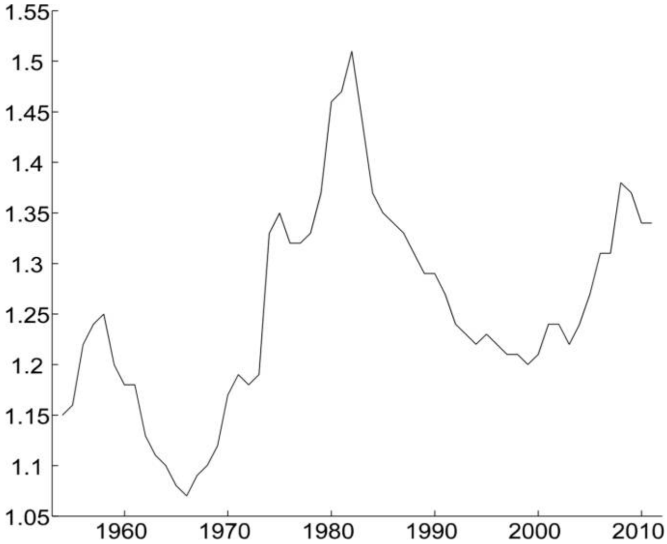

Fig. C1. Capital-output ratios from Venkateswaran and Wright's data

output ratio rises sharply in the 1970s and is generally high throughout the 1970s when inflation rates were also high. The figure also shows that capital-output ratio rose from 1.19 in 1973 to 1.33 in 1974, a rise of about 12 percent. Given that private nonresidential investment rose by about 10 percent, that it accounts for only about 10 percent of the stock, and nominal GDP rose by about 8 percent between those years, it seems likely that a large jump in the price of investment goods accounts for the rise in the ratio reported by VW. An alternative procedure uses the HP trend of the ratio of constant cost estimates of the capital stock to real GDP. Figure C2 reports a scatter plot of capital-output ratios against inflation using this approach as well as VW's approach. Clearly the results are very different. Understanding these differences is essential if we are to accept VW's analysis in this regard.

VW argue that their model generates large differences between the returns on equities and bonds. To understand this difference, consider the cash-credit goods model described earlier. Straightforward manipulation of the household problem's first-order conditions yields that in a steady state the following relationship must hold

$$r_k - r_b = (\theta_b - \theta_k)\left[\frac{\pi}{\beta} - 1\right] \tag{10}$$

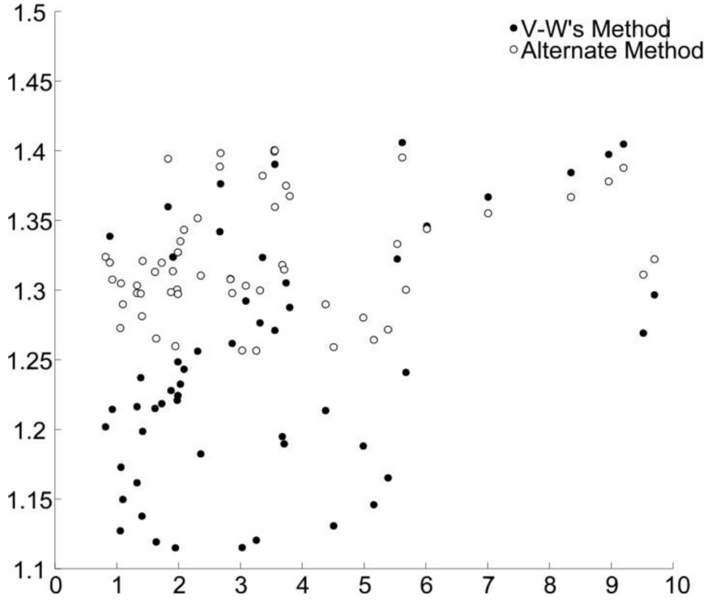

Fig. C2. Capital-output ratios (HP-Trends) versus inflation, both methods

This version of the model makes clear that capital returns will be higher than debt returns if and only if $\theta_b > \theta_k$, or if bonds can be pledged more easily than capital. The idea that government debt may be easier to pledge than, say, privately held business capital is surely borne out by the data. But recall that the equity premium refers to differences in rates of return between assets that are traded in public markets. Surely it is just as easy for me to sell my holdings in Vanguard's Total Stock Market Index Fund as it is for me to sell my assets in Vanguard's Total Bond Market Index Fund. I am not convinced that the liquidity premium in VW's model is helpful in understanding the equity premium puzzle.

Endnote

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