these results it seems that this model, in which interest rates are determined entirely by Fisherian fundamentals, explains the pattern of correlations that CCE refer to as the sign switch phenomenon.

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Comment on Inside Money, Outside Money, and Short-Term Interest Rates, *by Julio J. Rotemberg*

This is a very valuable paper for two reasons. First, it provides a quantitative general equilibrium model that incorporates both exogenous monetary disturbances and an endogenous response of the money stock to other shocks. As a result, the model can rationalize the fact that reserves are only weakly related to interest rates. Second, the process of providing this rationalization has led the authors to construct a model that is substantially richer than its predecessors. I particularly like the fact that their model has households that can use a variety of assets to carry out transactions and that the authors take into account that converting reserves into loans takes resources.

One great benefit of incorporating a rich menu of assets and a serious model of the intermediation sector is that it allows one to use evidence on the evolution of actual portfolios and on the behavior of actual financial institutions to calibrate the model. While that is not done here, this paper makes me optimistic that, someday, the results of the rich empirical literatures on asset demands and on the costs of financial intermediation will find their way into calibrated models like this one. There is also a more immediate payoff from constructing a model where households

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use several assets to carry out transactions. This avoids the really severe distortions on household behavior implied by the cash-in-advance constraint that was an integral part of previous generations of models with liquidity effects. In those models, an increase in the supply of reserves that raised the price level forced households with limited cash to work longer hours if they wished to maintain a constant consumption. Here, they have the option of simply rearranging the way they pay for goods.

In my discussion, I will concentrate on three issues. First, I will talk about the two shocks that they use in combination to obtain their results concerning reserves and interest rates. Second, I will talk about the fact that small costs of adjustment prolong the effects of monetary policy. Third, I will talk about what I regard to be the central issue with regard to this class of models, namely, the output and price effects of monetary disturbances.

The authors are surely right that the Fed often responds to money demand shocks by accommodation. Instead of just letting interest rates rise when money demand goes up, it lets the money supply rise as well. If it followed an interest rate rule, there would be no effect on interest rates. But I am quite ready to believe that the Fed's accommodation is less than complete so that increases in the demand for money raise both interest rates and reserves. Coupled with the fact that exogenous increases in reserves lower interest rates one can thus rationalize a slightly positive overall correlation of interest rates and reserves.

What I am less persuaded by is that the authors are focusing on the most relevant endogeneity of reserves. The authors make two assumptions. First, even though their formal model treats all reserves the same—it assumes that all reserves result from helicopter drops—they interpret the endogenous movements in reserves as primarily movements in borrowed reserves. Second, they assume that these endogenous movements in borrowed reserves are primarily responses to technology shocks which, naturally, affect output. In their interpretation, technology shocks that raise output are supposed to raise borrowed reserves. This runs counter to what I was taught as an undergraduate. I was then taught that the Fed used the discount window mainly to help banks in trouble and one would expect there to be more trouble in recessions. Given this contradiction, I decided to look at the data on borrowed reserves.

Figure 1 displays borrowed reserves divided by the CPI and a measure of economic activity, namely, per capita hours worked in the nonagricultural sector. The correlation between these two series is $-.46$, and this negative correlation is particularly pronounced in the period that precedes my undergraduate days. One could say that, from the point of view of the overall statistical fit of the model, this lack of correspondence of the movement of borrowed reserves with the business cycle is of relatively small importance since, as I mentioned, their formal model makes no distinction between borrowed and nonborrowed reserves. However, it is important to note that the model cannot explain the negative correlation between nonborrowed reserves and interest rates without assuming that movements in nonborrowed reserves are largely exogenous. This then forces the authors to treat borrowed reserves

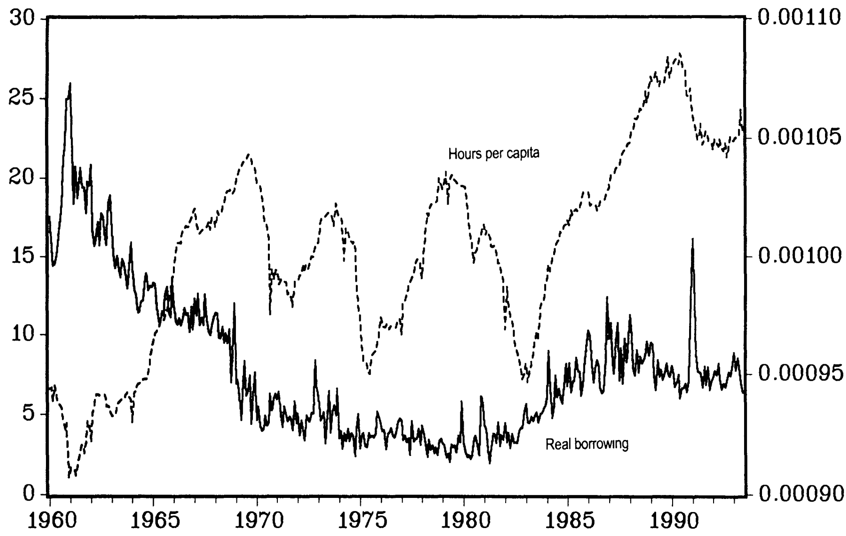

FIG. 1. Real Borrowing from the Federal Reserve over the Business Cycle

as endogenous. Moreover, to explain the positive correlation of the base with interest rates in a model where the only other shock is a shock to technology, they need to assume that borrowed reserves are positively correlated with favorable technology shocks.

The lack of positive correlation between borrowed reserves and aggregate activity suggests this is not a very important component of the endogeneity of money. Indeed, my recent work (Rotemberg 1994) has led me to believe that the important endogenous component of money is not one that leads the money supply to increase in response to shocks that raise economic activity. If this were important in determining the money supply one would expect forecastable increases in output to be associated with forecastable increases in the money supply. My work shows that, in contrast, forecastable increases in money are negatively correlated with forecastable movements in output. A more likely source of endogenous movements in the money supply consists of responses of the Federal Reserve to changes in money demand for given output and interest rates. To accommodate such shocks, the model would have to be changed, but these changes are likely to be relatively straightforward.

Let me turn to the slow adjustment of the stock of money held by households. Here again I completely agree with the authors in believing that households adjust their portfolios very slowly. The big question, and it is a question that baffles me, is why. Perhaps it is due to the fact that different people carry out their transactions at different times. The author's answer is instead that each household incurs adjustment costs if its level of currency at the beginning of period t is very different from its level of currency at the beginning of period $t - 1$. In their defense, the authors point out that the costs of adjusting currency holdings by 1 percent is trivial in their model and this seems relevant since the standard deviation of changes in currency from one month to the next is below 1 percent. The problem is that it makes little sense to posit adjustment costs that depend on the level of currency that one had a long time ago. In most models, as in reality, people run down their currency holdings before they get more. So why should the level of currency that a household had *before it ran down its currency holdings* be of any relevance whatsoever. In other words, the motivation for positing convex adjustment costs for prices, or for capital, does not hold here because the stock of currency held at the beginning of the previous period is not needed to describe the current state of the physical system.[1]

Finally, let me turn to a discussion of the output and price effects of monetary policy that are presented in this paper. Unfortunately, the output effects of exogenous monetary policy in this model amount to little and have several counterfactual features. That they amount to little can be seen from the fact that the calibration apparently produces almost the same output changes with and without monetary disturbances. This is partly attributable to the fact that they assume a relatively small variance for monetary shocks that appears not to be, itself, estimated with data on changes in monetary assets. But, in addition, the output effects are very short (six weeks) and small enough that a 1 percent increase in reserves leads immediately to a price increase in excess of 1 percent.

These disappointing results may well stem in part from the fact that the effect stressed by Fuerst of interest rates on output gets smaller (and shorter) as the delay between the moment wages are paid and the moment output is sold gets smaller. In this paper, that delay equals the length of one "period," namely, six weeks. Choosing a short period such as this one makes sense if one wants the period length to equal the time during which people do not carry out asset market transactions. Indeed, from this perspective, a period of six weeks may well be too long. On the other hand, does it make sense that the period between the moment wages are paid and the moment output is sold equals six weeks?

To understand the issues involved, it is worth thinking about them a bit more formally. Suppose time is continuous and that production which can be sold at $t + T$ must be started at t. For simplicity one can imagine that all the effort is exerted at t so that one needs h units of labor at t to get one unit of output at $t + T$. Thus the present value at t from making and selling one more unit is

$$Pe^{-iT} - hW \tag{1}$$

where P is the output price, W is the wage, and i is the instantaneous interest rate. The derivative of this expression with respect to i is

$$-TPe^{-iT}$$

which, for a given present value Pe^{-iT}, has an absolute value that is obviously increasing in the delay T.

1. It may be one of the things that are on people's minds, insofar as people remember how much currency they took out at the beginning of the previous period but this seems a tenuous basis on which to make it a state variable.

What the paper does not discuss is how one should think empirically about the delay T. This delay is the minimal time in which firms can be expected to produce one additional unit of the output for sale. This is easy to think of in the case of farm products. An additional bushel of wheat cannot be obtained without planting more seed and waiting until harvest time and, similarly, an extra liter of fine wine requires a long maturation.

In the case of industrial goods, matters are more complex. These goods also involve long delays in the sense that the spectral analysis of a car sold at t would probably reveal that some of its ingredients were mined much earlier. And yet, the time between the moment the first ingredient is mined and the time the car is delivered to a customer is not the minimum time needed to deliver an additional car to a customer. The reason is that industrial goods are produced in several distinct stages with firms carrying inventories of each intermediate stage. Car assembly requires steel, glass, textile upholstery, transmissions, and so on and firms typically keep positive inventories of each of these intermediate goods. The existence of these intermediate inventories allows firms to produce an additional car for sale to final customers in a relatively short time (and indeed firms often claim that they hold these inventories to make their production more flexible).

Suppose that there are L intermediate inputs[2] indexed by ℓ. The production of one unit of intermediate input ℓ requires labor and, possibly, the use of one unit of some input from an earlier stage. Moreover, each final good requires directly or indirectly one unit of each of the L intermediate inputs. Of course, the production of good ℓ requires time as well. For concreteness, I'll assume that the firm needs one unit of materials at t as well as one unit of labor at t to produce one unit of good ℓ at $t + \tau_\ell$. Thus, τ_ℓ is the length of time between two stages at which goods are inventoried. One advantage of this formulation is that τ_ℓ is amenable to measurement. For most industrial processes, this period appears to be fairly short. The assembly of cars, for instance, takes less than a day.

Obviously one cannot simply equate τ_ℓ with T. Rather, one must recognize that the profitability of producing intermediary ℓ (assuming it requires one unit of intermediary $\ell - 1$ is

$$P^{\ell}_{t+\tau_\ell} e^{-i\tau_\ell} - (W + P^{\ell-1}_t) \,. \tag{2}$$

This makes it clear that one cannot determine the effect of changes in interest rates without determining their effect on the prices of the intermediaries.[3] The simplest model of inventory holding would posit that positive inventories of good ℓ are held only if the inventoried object's price obeys the asset equation

2. These intermediate inputs can differ either by their physical characteristic or by their location in space.

3. Here these are treated as being sold from one firm to another but the analysis would be the same if I considered an integrated firm; the prices would then be the shadow prices attached with the immediate consumption of the intermediate goods on hand.

$$iP_t^\ell = E\,\frac{dP_t^\ell}{dt} \qquad (3)$$

where E is the expectations operator and I am considering the right derivative of the price P. It thus follows that increases in interest rates are likely to reduce the price of the intermediate goods. If the expectation of the price of intermediary ℓ in the far future is not changed, the current price must fall to raise the rate of return earned on holding a positive stock of the intermediate good.

Equation (2) then implies that a reduction in the price of intermediaries has rather different effects on the profitability of producing goods at different stages in the overall production process. Consider first the last stage, namely, the production of the final good. For a given price of the final good, an increase in interest rates has two counteracting effects. The effect stressed in this paper reduces the profitability of producing the final good, although this effect is enfeebled once one recognizes that τ_L, the delay at the last stage, is small. On the other hand, the reduction in the price of the intermediate inputs raises the profitability of producing the final good. This latter effect could easily dominate so that firms produce more of the final good. Doing so has the beneficial effect of flushing inventories out of the system.

Now consider intermediaries that are produced so early in the production process that they require only labor. For these goods, the reduction in their price reduces their profitability over and above the direct effect due to the rise in rates. This difference in the effects of interest rate increases on the profitability at various stages has two consequences. The first is that the instantaneous effect of a rise in interest rates on the total demand for labor, holding fixed the wage and the price of the final good, is ambiguous. If the profitability of producing the final good rises sufficiently and this production uses significantly more labor than the production of earlier intermediaries, total labor demand may rise. On the other hand, it may well turn out that a setup such as this one leads to a larger instantaneous reduction than the one in this paper. The second consequence of this setup is that an increase in interest rates reduces the inventories of intermediate goods. This may, in turn, lead to reductions in final output in subsequent periods and, as a result, to longer periods of low output. Thus it is at least possible that this setup would yield deeper and longer reductions in labor demand than those of this paper. In any event, it doesn't seem possible to know how large an effect of interest rates on labor demand one ought to expect from the existence of delays in production without considering explicitly a model with storable intermediaries.

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