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## Analyzing Indeterminacies in a Real Business Cycle Model with Money

*A Reply by Roger E.A. Farmer*

My purpose in writing the paper "Money in a Real Business Cycle Model" was to explore the idea that the monetary transmission mechanism may be explained in an *equilibrium* model in which preferences, endowments, and technology are, on their own, insufficient to pin down a unique equilibrium. By the "monetary transmission mechanism" I mean the time series properties of money, interest rates, prices, and output in data from Europe and the United States. According to a common interpretation of these data, a change in the money supply has real effects on output in the short run but it is neutral in the long run. I had also hoped that an explanation of the monetary transmission mechanism that relies on indeterminacy might rest *solely* on the idea that money is useful as a medium of exchange. I am indebted to Kirill Sossounov for pointing out a sign error in the computations in my 1997 article and for rescuing the message of the paper with minimal alterations to the basic framework.

We have several examples of calibrated models of real economies in which the theoretical structure permits the existence of multiple stationary equilibria and I have argued elsewhere (Farmer 1993) that models of this class can be completed by specifying a rule by which agents form beliefs. These models suggest the possibility that "animal spirits" or "self-fulfilling prophecies" may have an independent role in propagating business cycles and that this possibility is fully consistent with the hypothesis of rational expectations and market clearing. We also have examples of monetary models in which multiple equilibria may play a role in the transmission of monetary shocks.<sup>1</sup> But to date, none of these models has been calibrated with the same degree of attention to the explanation of data as has become typical in the real business cycle literature. My 1997 paper, with Sossounov's amendments, goes some way toward filling this gap.

From an argument originally advanced by Negishi in 1960, it is known, if one imposes standard assumptions of convexity of preferences and technology, that infinite horizon economies with a finite number of agents typically contain a finite odd number of equilibria. From this fact, it follows that steady-state equilibria are locally determinate and that multiplicities that are exploited in models of self-fulfilling prophecies cannot occur.

1. For a survey of recent research in this area, see Benhabib and Farmer (1999).

ROGER E.A. FARMER is professor of economics at the European University Institute and University of California at Los Angeles. E-mail: rfarmer@econ.ucla.edu

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There are at least two paths around the Negishi theorem that have been followed in the literature. The first, explored in a variety of real models, drops the assumption that the technology set is convex and assumes instead that the economy is subject to increasing returns to scale. Early applied work that followed this path to indeterminacy required a degree of increasing returns to scale greater than 1.6, a figure that has been criticized as unrealistically large. Subsequent literature has reduced this figure considerably and there are currently a number of researchers working to demonstrate that market imperfections can be realistically small in multisector models yet still these economies may display business cycles driven by self-fulfilling beliefs.

A second path around the Negishi theorem is one that I had hoped to rely on in my 1997 paper. It recognizes that monetary economies in which real balances enter the utility function violate one of the basic assumptions of general equilibrium theory since these economies include the price level (the denominator of real balances) as an argument of the utility function. The inclusion of prices in utility functions is, in itself, sufficient to invalidate the Negishi theorem but, as Sossounov has shown, the effect of real balances on utility is not strong enough in a calibrated model to generate indeterminacy of equilibrium; some other mechanism is needed. By combining money in the utility function, with a relatively mild degree of increasing returns to scale,<sup>2</sup> Kirill Sossounov has demonstrated that equilibrium models have a reasonable shot at explaining why money seems to have real short-run effects.

#### LITERATURE CITED

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2. 1.2 as used by Sossounov is within the confidence bounds of recent estimates of returns to scale from U.S. data.