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Comment

John B. Taylor

An important methodological innovation of Guillermo Calvo's paper is his continuous time formulation of the staggered contracts model. I found the analysis fascinating. The approach should have many applications, not only in the open economy setting emphasized by Calvo, but also in closed economy models. In this respect the general, staggered contracts approach—focusing not so much on contracts per se but on unsynchronized wage or price setting—has a number of advantages as a technique

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for modeling slow adjustment of prices, and these come out in Calvo's continuous time treatment. Among these I would emphasize that (1) there is no long-run trade-off between inflation and unemployment; (2) there is a short-run trade-off even if policy is fully anticipated, so that an announced monetary deceleration can have real effects; and (3) anticipations of the future matter for wage behavior since firms and workers look ahead when setting prices and wages. Calvo's continuous time treatment permits a convenient analytic development of these properties of wage and price dynamics. In discussing the paper, I will concentrate on the specifications of the price and contract equations as well as the nonuniqueness property—a result emphasized in Calvo's discussion.

Some of the analytic convenience that Calvo obtains comes from the exponential distribution assumption used in the price equation: the number of periods a set price will last before termination is random and exponentially distributed. While allowing for random contract length is in principle an improvement over the existing literature, I have several reservations about the stochastic assumptions in this model.

Casual observation suggests that many contracts in the real world are not of uniform length; for example, recent wage concessions in the United States have lead to termination of union contracts before the customary three-year contract period is completed. Clearly it would be an improvement over many existing contract models to allow for variable contract length so that such behavior can be studied. But to model phenomena like union concessions, it is necessary to capture the economic rationale for the early termination by making the contract period endogenous, or depending on endogenous variables. By making contract length random, it might appear that Calvo's approach can capture such phenomena. However, because the randomness is exogenous in the Calvo model, contract length is no more responsive to endogenous events than in the fixed-length contract models. Early termination of contracts arising for endogenous reasons is ruled out by the assumption that the randomness is exogenous.

When we consider the microeconomic problem of a firm or a worker setting wages or prices, this exogenous randomness raises further questions. One of the rationales that has been given for implicit contracts is the ongoing relationship between a worker and a firm, or a firm and its customers. For example, it is a convenience for a customer to know with near certainty the price charged by a firm for its product. Similarly, risk-averse workers prefer a stable wage. Part of the implicit contract is a (limited) guarantee that the price or wage will be relatively stable. In this sense, adding pure randomness to the length of the contract seems counter to the rationale for the implicit contract. If there were to be early termination of a contract, one would expect this to be the result of the occurrence of an endogenous contingency rather than to some purely random factor.

Fortunately, I feel that there is another way to interpret the equations arising from this randomness in Calvo's equations. Rather than each individual contract having a random length, there could be a distribution of contracts by length across firms due to heterogeneity of markets or products. Some contracts could be short while others could be long, even though no contract would necessarily be random. If over the economy as a whole there is a stable distribution of firms by contract length, then the Calvo methods would give the same results but with a different interpretation.

However, if this interpretation is made, then Calvo's exponential assumption might not be realistic. In some empirical work I have done to estimate distributions of contracts by length, I found that the distribution is humped-shaped rather than exponential. For example, there are more one-year wage contracts than one-quarter contracts. Hence, from an empirical perspective it would be interesting to consider an extension of the Calvo model to allow for more general distribution. Unfortunately, this would likely be at the cost of some of the analytic simplicity which makes Calvo's approach so attractive.

From an open economy perspective, another potential difficulty with the Calvo price-setting formulation is that the aggregate price index in the economy is based solely on domestic firm's pricing decisions. This is seen most clearly in Calvo's equation (7). In an open economy, the aggregate price index would be influenced by foreign price decisions and exchange rate movements either through the channel of imported intermediate inputs to production, or through escalation clauses. The omission of such influences from the aggregate price equation could be misleading if one were interested in how alternative exchange rate policies influence domestic inflation and unemployment trade-offs.[1] Another interesting extension of Calvo's model would be to consider such influences on price by making the aggregate price in equation (7) a weighted average of domestic firms' prices and a foreign price index converted into domestic currency units using the exchange rate.

As currently formulated, Calvo's model potentially has a continuum of solutions arising from the self-fulfilling properties of rational expectations. Calvo shows that this nonuniqueness can arise if the parameters of the model are such that a devaluation causes a *decline* in aggregate demand. It should be pointed out, however, that this nonuniqueness does not arise because of the existence of contracts in the model. The replacement of Calvo's contract equations with perfectly flexible prices would

1. This is illustrated in a small, open economy setting by R. Dornbusch, "PPP Exchange Rate Rules and Macroeconomic Stability," *Journal of Political Economy* (1982) 90, no. 1, pp. 158–65, and in a multicountry setting by J. B. Taylor, "Macroeconomic Tradeoffs in an International Economy with Rational Expectations," in *Advances in Quantitative Economics*, ed. W. Hildenbrand (Cambridge: Cambridge University Press, 1982).

still result in nonuniqueness for similar parameter values. In fact, the reason for the nonuniqueness is best understood in a flexible price version of the model. Substituting the real interest rate ($r = i - \dot{P}$) and the "interest rate parity" condition ($i = \dot{E}$) into the aggregate excess demand for goods, $f(P - E, r)$, results in the aggregate demand equation, $f(p, -\dot{p})$, where $p = P - E$. If a devaluation causes a decline in aggregate demand, then $f_p > 0$. Solving the implicit function f for $\dot{p}$ results in $\dot{p} = g(p)$, where $g' < 0$ iff $f_p > 0$. As is now well known in rational expectations modeling, nonuniqueness occurs in a simple first-order differential equation system if *any* initial "price" p leads to convergence. Clearly this is the situation if $g' < 0$, and it arises whether or not contracts are in the system. Whether $f_p > 0$ is an econometric issue related to the relative importance of income and substitution effects. As in other examples of nonuniqueness in rational expectations models,[2] the conditions for nonuniqueness arise when the demand or supply curves slope the "wrong way." In Calvo's open economy model, the aggregate demand curve must be upward sloping in the relevant price because substitution effects are dominated by wealth or income effects.

Comment Michael Mussa

Guillermo Calvo has presented us with a paper that is both ingenious in its formal analysis and interesting in its substantive economic content. I am especially impressed by Calvo's modeling of the mechanism of price adjustment in a situation where the prices of individual commodities are fixed by long-term contracts. The differential equation system (equations [9] and [10]) that describes the dynamic behavior of the general price level and the individual commodity price for a newly negotiated contract is simple and intuitively appealing. As Calvo demonstrates, this model of price adjustment is easily applied to interesting issues in open-economy macroeconomics. I believe it will find many other interesting applications.

My concerns with Calvo's paper arise primarily in connection with his discussion of, and his emphasis upon, situations in which a devalutaion of a country's currency is contractionary with respect to aggregate demand. In Calvo's model of macroeconomic behavior (as distinct from his model

2. In J. B. Taylor, "Conditions for Unique Solutions in Stochastic Macroeconomic Models with Rational Expectations," *Econometrica* 45 (September 1977):1377–85; for example, it is shown that the IS—LM curves must cross in an unusual way to get nonuniqueness.

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