# A Conference on Liquidity, Monetary Policy, and Financial Intermediation

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## Introduction

In September 1994, the Federal Reserve Bank of Cleveland and the *Journal of Money, Credit, and Banking* sponsored a conference on liquidity, monetary policy, and financial intermediation. This symposium was the fifth in a jointly sponsored series aimed at promoting research on basic issues in monetary policy, financial markets, and the payments system.

This particular conference dealt with monetary policy issues. The papers included examinations of the macroeconomic effects of price rigidity and "sluggish" savings decisions by households (that is, the assumption of limited participation in financial markets), the interaction of inflation and financial intermediation, and the "deep structural" estimation of parameters in models with money and financial intermediation. The common thread in all of these studies is the attempt to move us farther down the road to understanding the fundamental structures that ultimately determine the economic consequences of monetary policy. A complete list of the papers, their authors, and the discussants is provided in box 1.

This summary of the proceedings groups the papers (somewhat artificially) according to the type of model presented. The first group examines the general equilibrium effects of sticky prices, the second assumes that savings, rather than prices, are sluggish, and the third represents models of deep structural intermediation.

## I. Sticky Prices

In traditional static IS-LM models with sticky prices, a monetary expansion leads to a fall in both nominal interest rates (the so-called liquidity effect) and real interest rates, which in turn stimulates investment spending and hence output. These types of models have come under attack recently on both empirical and methodological grounds. The lessons of the 1970s taught us that, contrary to the implications of the simplest versions of these models, high inflation concurrent with high unemployment is possible. However, it is generally recognized that such models were poorly specified and that the dynamic general equilibrium implications of price inflexibility may be much different—and empirically more plausible—than those of earlier static sticky-price models. For these reasons, there is a great deal of interest in

BOX 1

**Papers Presented at the Conference on Liquidity, Monetary Policy, and Financial Intermediation, September 1994**

"The Effects of Real and Monetary Shocks in a Business Cycle Model with Some Sticky Prices," by Lee E. Ohanian, Alan C. Stockman, and Lutz Kilian. Comment by Christian Gilles and John V. Leahy.

"The Quantitative Analytics of the Basic Neomonetarist Model," by Miles S. Kimball. Comment by Michael Woodford.

"Financial Intermediation and Monetary Policy in a General Equilibrium Banking Model," by Pamela Labadie. Comment by Deborah J. Lucas and Stephen D. Williamson.

"Monetary and Financial Interactions in the Business Cycle," by Timothy S. Fuerst. Comment by Charles L. Evans and Mark Gertler.

"Inside Money, Outside Money, and Short-Term Interest Rates," by V.V. Chari, Lawrence J. Christiano, and Martin Eichenbaum. Comment by Wilbur John Coleman II and Julio J. Rotemberg.

"Estimating Policy-Invariant Deep Parameters in the Financial Sector When Risk and Growth Matter," by William A. Barnett, Milka Kirova, and Meenakshi Pasupathy. Comment by Stephen G. Cecchetti and David A. Marshall.

"Liquidity Effects and Transactions Technologies," by Michael Dotsey and Peter Ireland. Comment by Finn E. Kydland, Donald E. Schlagenhauf, and Jeffrey Wrase.

"Computable General Equilibrium Models and Monetary Policy Advice," by David E. Altig, Charles T. Carlstrom, and Kevin J. Lansing. Comment by Eric M. Leeper and Edward C. Prescott.

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examining price rigidities in dynamic general equilibrium frameworks.

In this vein, the papers by Miles Kimball and by Lee Ohanian, Alan Stockman, and Lutz Kilian take as their starting point this familiar position: Monetary policy has real effects because some or all goods in the economy have sticky prices. Both papers represent an attempt to construct explicitly dynamic macroeconomic models with less-than-perfect price flexibility, incorporating elements typically associated with simple Keynesian analysis into relatively standard real-business-cycle frameworks.

In "The Effects of Real and Monetary Shocks in a Business Cycle Model with Some Sticky Prices," Ohanian, Stockman, and Kilian (OSK) adopt a simple specification for price stickiness (dating back at least to Phelps and Taylor [1977]) in which firms that exhibit price rigidity preset their prices one period in advance. However, unlike the few other papers that are similarly constructed, OSK allow for both a sticky- and a flexible-price sector.[1] Their novel finding is that the cyclical behavior of aggregate variables is influenced only slightly by introducing price rigidities, even when the sticky-price sector is relatively large and despite the important distributional consequences associated with real and monetary shocks.

This surprising conclusion—which does not characterize one-sector sticky-price models—appears to arise from the assumption that the investment sector is not subject to price rigidities. The key insight into understanding this result is that modeling investment as a sticky-price good induces both an intratemporal and an intertemporal distortion, the latter of which is not present when investment is the flexible-price good. If investment were placed in the sticky-price sector, OSK's results would presumably change dramatically.

In "The Quantitative Analytics of the Basic Neomonetarist Model," Miles Kimball maintains the simpler one-sector setup of earlier papers. However, unlike OSK, who assume that all sticky prices are preset one period in advance, his introduction of less-than-perfect price flexibility is motivated by increasing returns to scale and imperfect competition. Like Calvo's (1983) model, each firm gets the opportunity to adjust its prices at intervals determined exogenously by a Poisson process.[2] One interesting implication of this setup is that the aggregate rate of price adjustment in general equilibrium differs from the rate at which prices adjust for individual firms. In fact, given Kimball's preferred parameter values, the rate of macroeconomic price adjustment is four times that of an individual firm. This surprising degree of

1 See, for example, Cooley and Hansen (1994), Cho and Cooley (1990), and King (1990).

2 The Poisson distribution specifies that the probability of an opportunity to adjust prices is the same for all time intervals of equal length, and that these probabilities are independent across any two periods.

persistence is potentially important, given that the persistence in most general equilibrium business-cycle models is very weak. (We will return to the issue of persistence below.)

The sticky prices at the heart of the OSK and Kimball papers are, of course, central to the typical textbook treatment of static Keynesian IS-LM analysis. Interestingly, it is unclear whether the liquidity effect survives the translation of price rigidity to dynamic general equilibrium contexts. In Kimball's model, a monetary injection stimulates investment spending, which, in the absence of adjustment costs, will increase the real interest rate. Because such policies also raise inflation expectations when money is positively serially correlated, the nominal interest rate rises unambiguously. This conclusion can be overturned by the introduction of adjustment costs *if* prices in the economy adjust quickly enough. However, unless the half-life for macroeconomic price adjustments is less than two quarters—which Kimball argues is unrealistically brief—real interest rates will increase with monetary injections, ruling out any hope for generating liquidity effects.

In OSK, monetary injections do temporarily lower the real rate of interest.[3] However, based on their chosen calibration, increases in anticipated inflation dominate these real effects, and the nominal rate rises following a positive monetary shock.

In light of these results, it does not appear straightforward to construct sticky-price models that generate liquidity effects. The key difficulty is that prices must adjust slowly to mitigate the expected inflation component. However, we know from Kimball's paper that slower price adjustment is precisely the condition that magnifies demand effects, thus increasing investment demand and the real rate of interest.[4]

## II. Limited-Participation Models

The difficulty in generating a liquidity effect with sticky-price models leads Kimball to conclude that "it may be necessary to model any real-world tendency for the real (and hence the nominal) interest rate to fall in response to a monetary stimulus as a result of output being temporarily off the IS curve." In some sense, this is essentially the strategy of the so-called limited-participation framework pioneered by Lucas (1990) and Fuerst (1992). The key insight of these papers is embedded in the assumption that agents must adjust their portfolios slowly. Although investment equals saving ex post, limitations on financial market transactions break the household's ex post intertemporal linkage, at least temporarily. Such a break would appear to be a necessary condition for any model to simultaneously generate a liquidity effect and a hump-shaped response of consumption following a decline in the federal funds rate, both of which seem to characterize post–World War II data.[5]

In fact, a central motivation for the limited-participation framework is to provide a model in which monetary injections can generate both a liquidity effect and a temporary expansion of output. Four of the papers in this volume—Chari, Christiano, and Eichenbaum; Altig, Carlstrom, and Lansing; Dotsey and Ireland; and Fuerst—can be considered studies that flesh out the properties of models incorporating the limited-participation device.

"Inside Money, Outside Money, and Short-Term Interest Rates," by V.V. Chari, Lawrence Christiano, and Martin Eichenbaum (CCE), attempts to impose a theoretical structure on key monetary business-cycle regularities identified in Christiano and Eichenbaum (1992) and Christiano, Eichenbaum, and Evans (1995). Of particular concern is what the authors refer to as the "sign-switch" phenomenon: Nonborrowed reserves co-vary negatively with the federal funds rate, while broader measures of money co-vary positively.

An essential element of CCE's model is a careful disentangling of exogenous monetary shocks from endogenous responses of both the monetary authority and private intermediaries. The key identifying assumptions with respect to the monetary authority's behavior are that innovations in nonborrowed reserves are associated with exogenous policy shocks, and innovations in borrowed reserves are endogenous policy reactions to output, or technology, shocks. Because nonborrowed-reserve innovations represent unanticipated policy changes,

**3** Because the OSK model presets prices for one period, this result is consistent with Kimball's conclusion that real rates decline when prices adjust relatively quickly.

**4** Sticky wages do not resolve this quandary. Wages that take sufficiently long to adjust also lead to the prediction that the real interest rate is positively related to monetary surprises. Ohanian and Stockman (1995) provide an example of a two-sector model with price rigidity in which liquidity effects arise. However, this variant of their model does not include capital. Again, it appears that the treatment of investment is critical in sticky-price models.

**5** See, for example, Christiano, Eichenbaum, and Evans (1995).

**TABLE 1**

**Correlation Properties of Money and Output, 1954:IQ–1988:IIQ**

| | $x_{t+2}$ | $x_{t+1}$ | $x_t$ | $x_{t-1}$ | $x_{t-2}$ |
|---|---|---|---|---|---|
| M1 | 0.33 | 0.34 | 0.29 | 0.18 | 0.10 |
| Monetary base | 0.37 | 0.39 | 0.34 | 0.26 | 0.20 |
| Nonborrowed reserves | 0.10 | –0.06 | –0.22 | –0.32 | –0.34 |

NOTE: Entries represent the correlation of $x_t$ with output$_{t-k}$. All variables are logged and Hodrick–Prescott filtered.
SOURCE: V.V. Chari, Lawrence J. Christiano, and Martin Eichenbaum, "Inside Money, Outside Money, and Short-Term Interest Rates" (see box 1).

they interact with the limited-participation assumption to generate liquidity effects.[6] Broader aggregates, however, are dominated by both the positive response of the discount window and loan creation by financial intermediaries, thus accounting for the sign switch that the authors wish to capture.[7]

The model also broadly captures some of the simple dynamics of relationships between the federal funds rate and various monetary aggregates found in U.S. data (see table 1). Specifically, consistent with the data, the CCE model generates a positive correlation between the short-term interest rate and lagged values of the model's analogue to M1 and the monetary base, as well as a negative correlation with future values. In addition, the model exhibits the observed symmetric negative correlation between the interest rate and nonborrowed reserves. However, the leading relationship of the funds rate with the monetary variables is much stronger in the data than in the model. The authors attribute this to the offsetting influences of real and monetary shocks, and suggest that fully capturing these dynamics would require either strengthening the dynamic effect of monetary shocks or reducing that of real shocks.

Contrasted with CCE, the paper by David Altig, Charles Carlstrom, and Kevin Lansing (ACL) maintains the less-rich intermediary structure of earlier limited-participation models. In "Computable General Equilibrium Models and Monetary Policy Advice," ACL's innovation involves examining the model's short-run forecasting performance—an approach for "taking the model to the data" that has been largely unexplored in the context of quantitative general equilibrium analysis.[8] In addition, the setup in ACL incorporates a central-bank reaction function that involves operating on a nominal interest-rate target, as opposed to the standard strategy of expressing the reaction function in terms of a monetary aggregate.

ACL's goal is to investigate whether computable general equilibrium models have reached the stage where they can be directly useful to policymakers. The specific question posed is whether variations and extensions of fairly standard quantitative-theoretic models can provide accurate real-time forecasts of both inflation and real GDP growth. The results of this exercise are mixed. ACL argue that quantitative-theoretic models do appear to be capable of delivering a reasonable degree of forecasting accuracy: When mean-squared-error and mean-absolute-deviation metrics are used, the model's forecast errors with respect to inflation and output growth are comparable to those of the internal Federal Reserve Board forecasts constructed for Federal Open Market Committee briefings. However, to obtain inflation forecasts that are at least as good as Board staff projections, ACL make an ad hoc, "judgmental" adjustment to their model.[9]

As in the CCE paper, the failures in ACL provide some clues about the direction that limited-participation models must take to deliver a fully satisfactory empirical performance. For example, the problem with the nonjudgmental ACL model shows up clearly in its inflation forecasts for 1993. Over the course of that year, the federal funds rate and inflation both

**6** Some additional persistence is built into the model by assuming that interperiod portfolio adjustment is costly, in contrast to the solely one-period sluggishness built into the Fuerst (1992) model.

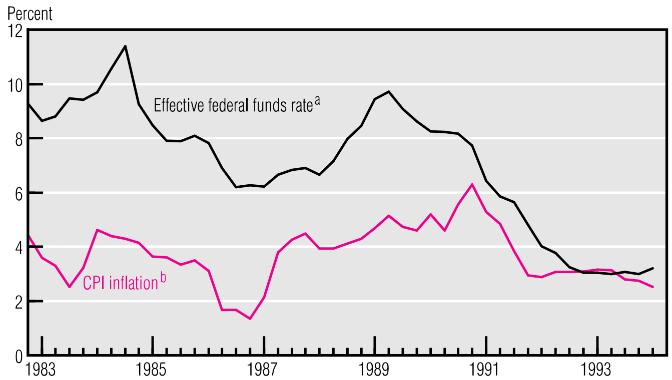
**7** The identifying assumptions in CCE are somewhat stronger than those imposed in either Christiano and Eichenbaum (1992) or Christiano, Eichenbaum, and Evans (1995), in that these papers do not assume that nonborrowed-reserve innovations are entirely exogenous to current technology shocks. This difference is likely to be important: The CCE model counterfactually predicts a positive contemporaneous correlation between nonborrowed reserves and output. As the authors point out, the observed negative correlation could presumably be generated by incorporating a reaction function in which the monetary authority "leans against the wind." Whether such a model would continue to exhibit the sign-switch property is an open question.

**8** See, however, Rotemberg (1994), which measures model performance in terms of the correlations among long-run forecastable movements of prices, output, and the monetary aggregates.

**9** The ACL model treats deviations of the federal funds rate as exogenous inputs in simulating the path of inflation and output. Their judgmental adjustment amounts to replacing the deviation of the nominal federal funds rate from a constant mean (or the long-run value) with the deviation from a "moving" mean, measured as a moving average of past federal fund rates.

FIGURE 1

**Federal Funds Rate and Inflation, 1982:IVQ–1994:IQ**




a. Average daily rate on overnight fed funds as reported by the Federal Reserve Bank of New York.
b. Four-quarter percent change in the Consumer Price Index.
SOURCES: U.S. Department of Labor, Bureau of Labor Statistics; and Board of Governors of the Federal Reserve System.

stabilized near 3 percent, implying inflation-adjusted real rates near zero (see figure 1). Given the calibration of the model, the ACL framework delivers a long-run real interest rate of 3 percent. In the absence of persistence in real interest rates, or perhaps more extensive monetary non-neutralities than those delivered by a one-quarter limited-participation assumption, the only way to support a sustained 3 percent nominal funds rate is for monetary policy to engineer an expected inflation of approximately zero. But such an outcome is clearly inconsistent with the data, since it is unreasonable to believe that agents would have rationally expected zero inflation during that period.

ACL argue that the failure of their model is actually a failure present in most general equilibrium models; that is, most existing frameworks do not deliver the type of persistence in real variables that is found in the data.[10] In “Monetary and Financial Interactions in the Business Cycle,” Timothy Fuerst examines this issue by investigating whether adding more extensive non-neutralities arising from financial markets can generate more serial correlation in real variables than does a standard model. In particular, he looks at whether persistence can be introduced by adding a financial structure that gives rise to countercyclical endogenous agency costs.

The basic idea of the Fuerst framework is to build in frictions similar to those discussed by Bernanke and Gertler (1989). Entrepreneurs live for one period and work to receive a wage income. They then use this income, along with additional funds borrowed from households, to produce capital. Individual entrepreneurs can costlessly observe how much capital they produce, but other agents must expend a resource cost to monitor the project’s outcome. This agency problem leads to a standard debt contract and reduces the amount of investment (and thus capital accumulation) in equilibrium. The idea is that a positive technology shock today will increase an entrepreneur’s net worth or wage income, which will mitigate agency costs and boost capital accumulation. The hope is that this extra capital will lead to greater persistence.

Fuerst finds that the amount of persistence generated by his experiments is nearly identical to that of standard quantitative business-cycle models. The reason is that his method of introducing agency costs leaves capital as the only method of propagating shocks across time. The failure is thus another illustration that capital adds little to the serial correlation properties of the standard quantitative business-cycle model.

Although Fuerst’s model does exhibit a small propagation effect on net worth through the capital channel, his setup is fundamentally unable to generate persistent movements in net worth because entrepreneurs are assumed to live for only one period. However, allowing entrepreneurs to live for many periods opens up the possibility of a repeated game between households and entrepreneurs as well as an immense amount of potential heterogeneity, implying that straightforward extensions of Fuerst’s model are nontrivial.[11]

A skeptical view of the limited-participation framework is provided by Michael Dotsey and Peter Ireland. In “Liquidity Effects and Transactions Technologies,” they note the ad hoc one-period adjustment cost formulation in both ACL and Fuerst, and similarly criticize CCE’s use of a more general adjustment cost formulation without proper calibration of the magnitude of these costs. Like CCE’s model, Dotsey and Ireland’s considers a financial intermediation structure that implies a spread between the

**10** This idea is not new. For example, Cogley and Nason (1995) argue that persistence in most quantitative business cycle models is completely inherited from the exogenous shock process, which is assumed to be serially correlated. See Boldrin, Christiano, and Fisher (1995) for a recent attempt to build a framework that directly tackles this issue in the context of resolving asset-pricing puzzles that arise in standard business cycle models.

**11** See Carlstrom and Fuerst (1996) for an extension of Fuerst’s model that includes entrepreneurs who live for multiple periods.

deposit rate paid to households and the loan rate charged by intermediaries. Although less rich in detail than the CCE model, the Dotsey/Ireland framework expands the basic limited-participation setup by introducing explicit representations of the costs of adjusting both household and intermediary portfolios. The central question they address is whether the liquidity effects generated by existing limited-participation models survive the introduction of plausible specifications for such costs.[12]

The challenging aspect of this exercise is to calibrate the relevant adjustment cost functions. Dotsey and Ireland do so by capitalizing on the fact that their model delivers a wedge between loan and deposit rates that is dependent on the parameters of the representative intermediary's adjustment cost function.[13] The model is explicitly connected to the data by associating loan rates with commercial paper rates, and deposit rates with the return on small time deposits.

Unfortunately, it is not possible to calibrate directly to the spread itself, since generating the observed average differential would require introducing fixed marginal costs to loan production, which are themselves unobservable. The authors' provocative solution is to calibrate to the standard deviation of the difference between commercial-paper and time-deposit rates. This does not, however, pin down the key parameter in the household's cost function. Dotsey and Ireland proceed by assuming that household costs are a simple multiple of the costs to a financial intermediary.

The bottom line of the Dotsey/Ireland experiments is that the liquidity effects which motivate the limited-participation framework are not easily preserved when the assumption of infinite transaction costs is relaxed. Given their parameterization, they find that liquidity effects of the magnitude reported by, say, Christiano and Eichenbaum (1992), require household transaction costs that are roughly seven times as large as intermediaries' costs. This corresponds to about 123 minutes of forgone leisure per quarter.

## III. Deep Structural Intermediation

Dotsey and Ireland conclude that their results militate for research efforts that return to "... the more careful methodology of building financial structure from microfoundations ...." Such efforts are represented in the papers by Pamela Labadie and by William Barnett, Milka Kirova, and Meenakshi Pasupathy.

The Labadie study, "Financial Intermediation and Monetary Policy in a General Equilibrium Banking Model," contains a detailed model with many salient features of the U.S. financial sector. Banks, for example, are subject to reserve requirements, hold assets that consist of loans (to both the private and public sectors) and equity capital, and have access to deposit insurance. Furthermore, the model contains a government sector that operates much like the Federal Reserve in that it sets reserve requirements, supplies deposit insurance, and conducts open-market operations that alter the aggregate ratio of bonds to money.

The Labadie framework incorporates several features typically associated with monetary non-neutrality. These include informational asymmetries that make intermediation costly, and household assets (deposits) with fixed nominal returns. Despite these elements, Labadie reports the surprising result that monetary policy actions which alter the size and composition of nominal assets are entirely neutral. Although she finds that non-neutralities appear in cases where monitoring costs are fixed in nominal terms, it is unclear how such a device should be interpreted.

It is apparent that some other special features of Labadie's model contribute to this result. Banks, for instance, write optimal state-contingent loan contracts that are expressed in real terms. Also, household saving consists solely of bank deposits and bank equity. Thus, it appears that any redistribution of wealth caused by the effects of unanticipated price changes on real deposit returns are rechanneled to the affected agents via changes in the market value of equity claims. Disentangling this and the many other elements of her very rich model could provide considerable insight into how the regulatory environment and financial market structure interact and what the consequences are for the macroeconomy.

**12** The standard model in this class assumes (at least implicitly) that intraperiod adjustment costs are infinite.

**13** The model's cost functions — which depend on the ratio of deposits to money — are quadratic, so that the spread is proportional to the function's sole parameter. Although both the CCE and Dotsey/Ireland models generate deposit-to-loan-rate spreads, they arise from very different sources. The spread in CCE results from a combination of reserve requirements and the contribution of excess reserves in the representative intermediary's production function.

As in almost all of the papers presented at the conference, the Labadie model takes the measurement of money as a given. In studies where models are taken to the actual data, money is assumed to correspond to some standard monetary aggregate. An exception is the article by Barnett, Kirova, and Pasupathy (BKP), who explore a methodology to construct money from the fundamental problems solved by economic actors in a well-defined, explicit economic environment.

In "Estimating Policy-Invariant Deep Parameters in the Financial Sector When Risk and Growth Matter," BKP start from the perspective of the well-known Lucas critique; that is, sensible experiments involving policy simulations require knowledge of the functions describing private decision rules that are invariant to the class of policy interventions being considered. However, the authors, appealing to insights from Barnett's earlier work, take the argument one step further: Experiments involving policy simulations also require knowledge of the policy-invariant aggregator functions describing the theoretical monetary aggregates.[14]

The strategy in BKP is to jointly estimate the deep parameters of preferences and technologies—including the parameters of the relevant aggregator functions—from Euler-equation representations of the optimization problems of financial intermediaries, manufacturing firms, and households. Upon obtaining these estimates, the authors compare the implied theoretical aggregates from the separate sectors with the corresponding Divisia indexes and simple-sum aggregates. They argue that the Divisia indexes do a relatively good job of tracking their theoretical money measures, and that simple-sum aggregates—the class of which contains all the typical monetary aggregates used in the other papers—do substantially worse.

BKP's critique of the standard approach to measuring monetary assets is a serious challenge to anyone interested in the empirical relationship between money and the macroeconomy. In describing their methodology, BKP write:

> The purpose of all scientific research is to reveal the truth, not to alter the data in a manner that may tend to justify some preconceived policy view. The purpose of data is to measure something that exists, i.e., an aggregator function that is separable within the structure of the economy. (p. 1405)

14 See Barnett (1987), Barnett, Fisher, and Serletis (1992), and Barnett and Hahm (1994).

Contrast this view with the position taken by Friedman and Schwartz (1970):

> ... the definition of money is to be sought for not on the grounds of principle but on grounds of usefulness in organizing our knowledge of economic relationships. "Money" is that to which we choose to assign a number by specified operations; it is not something in existence to be discovered, like the American continent .... (p. 137)

Determining which of these views is correct has fundamental implications for the organization and development of monetary facts and, ultimately, for the conduct of monetary policy.

## IV. Summary

Each paper presented at the conference investigates at least one piece of the puzzle that must be solved if policymakers are to use dynamic general equilibrium models for giving policy advice. OSK and Kimball both provide a cautionary note by showing that the implications of sticky prices may not be as apparent as many economists think. For instance, it is inherently very difficult for this assumption to deliver a liquidity effect—something that most policymakers take for granted. Although the limited-participation (or sluggish-portfolio) assumption was invented to specifically generate inverse movements in money shocks and nominal interest rates, Dotsey and Ireland question whether portfolio costs, when properly calibrated, are large enough to deliver the desired effect.

Similarly, when a fairly standard computable general equilibrium model is actually taken to the data and used for forecasting purposes, ACL conclude that existing models need either more extensive monetary non-neutralities or some other added friction in order to generate the persistence in real variables that characterizes the data. Yet the message of Labadie's paper is that adding frictions is not always sufficient to generate monetary non-neutralities, let alone ones that have lasting effects on the real economy.

These unanswered questions clearly leave researchers with much work to do before dynamic general equilibrium models supplant static IS-LM models for policymakers, as they have for most academic economists.

*NOTE: To order a copy of these conference proceedings, see page 32.*

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