Welcome to the third annual issue of the *Richmond Fed Research Digest*. The Federal Reserve Bank of Richmond produces several publications that feature the work of economists in its Research Department, but those economists also publish extensively in other venues. The *Richmond Fed Research Digest*, a mid-year annual, brings this externally published research together in one place with brief summaries, full citations, and links to the original work. (Please note that access to articles may require registration or payment.) So bookmark this spot on the Richmond Fed website and mark your calendar for July 1, 2015, when the Bank will publish the next issue of the *Richmond Fed Research Digest*.

Deep Habits in the New Keynesian Phillips Curve

By Thomas A. Lubik and Wing Leong Teo
Journal of Money, Credit and Banking, *February 2014, vol. 46, no. 1, pp. 79–114.*

The New Keynesian Phillips Curve (NKPC) is the centerpiece of modern macroeconomic models used for monetary policy analysis. It can be derived from the optimal price-setting problem of a monopolistically competitive firm that operates in an environment where firms face downward-sloping demand curves. In contrast to the traditional Phillips Curve, the NKPC is explicitly forward looking and imposes restrictions on the comovement of its components. Specifically, theory identifies marginal cost as the main driver of inflation dynamics. However, the NKPC faced the early criticism that marginal cost is not observable and that the stochastic properties of various proxies do not line up with the properties of the inflation process they claim to explain.

Lubik and Teo show that deep habits in preferences are an essential element in understanding inflation dynamics.

Previous research showed that inflation dynamics are explained both by intrinsic factors, such as inflation indexation in price setting, and by extrinsic driving forces, such as marginal cost movements. In a *Journal of Money, Credit and Banking* paper, Thomas Lubik of the Richmond Fed and Wing Leong Teo of the University of Nottingham follow in the footsteps of more recent research that modifies the environment in which firms operate. The authors introduce "deep habits" in the preferences of the consumer and derive the corresponding NKPC. Habit formation is deep in the sense that it extends to each individual good of the consumption bundle available to consumers, not only to the consumption composite.

In Lubik and Teo's framework, deep habit formation implies a downward-sloping demand function that depends on the lagged level of the consumer's purchases. Since firms take this demand function as a constraint in their optimal price-setting problem, the time dependence carries over to the NKPC and results in the introduction of future, current, and lagged consumption in this relationship.

The authors use this insight to construct a modified driving process for the NKPC. They combine the additional explanatory variables introduced by the deep habits environment with marginal cost into a single process. They then impute this unobservable series using data on consumption and real unit labor cost. This allows them to compare the driving process implied by deep habits to the process of the standard NKPC (which is marginal cost). Lubik and Teo find that the former is considerably more volatile than real unit labor cost. Moreover, the deep habits specification is an improvement over the standard version of the NKPC in terms of empirical fit. The new estimation puts much less weight on lagged inflation, which suggests a lower degree of intrinsic inflation persistence. This stems from two influences. First, the model implies additional regressors, specifically consumption growth and a marginal value of demand term. This, in and of itself, produces a better fit, but the authors also show that a large part of the improved performance is due to the altered responsiveness of inflation to the coefficients in the NKPC. Thus, Lubik and Teo show that deep habits in preferences are an essential element in understanding inflation dynamics.

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The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy

By Lorenzo Caliendo, Fernando Parro, Esteban Rossi-Hansberg, and Pierre-Daniel Sarte
NBER Working Paper No. 20168, May 2014.

Traditionally, macroeconomic research has emphasized aggregate economic disturbances as sources of aggregate economic outcomes. More recently, economists have advanced the view that aggregate economic outcomes result from a wide variety of disaggregated productivity disturbances that are sectoral, such as process or product innovations, or regional, such as natural disasters or changes in local regulations.

In a National Bureau of Economic Research working paper, Lorenzo Caliendo of Yale University, Fernando Parro of the Federal Reserve Board, Esteban Rossi-Hansberg of Princeton University, and Pierre-Daniel Sarte of the Richmond Fed present a quantitative model of the sectoral and regional composition of the U.S. economy. The model allows for sectoral interactions in the form of an intermediate input structure that matches the U.S. input-output matrix. The model also explicitly recognizes that these interactions take place over potentially large distances by featuring costly pairwise interregional trade across all 50 states and 26 traded and nontraded industries. Of central importance is the fact that U.S. economic activity is not uniformly distributed across space and that different regions specialize in different sectors. Labor can move across regions and sectors, and while structures and land are fixed geographically, they can be used by any sector.

Employing newly released data on trade flows by industry between states, as well as other regional and industry data, the authors calibrate the model and assess how different regions and sectors of the economy adjust to disaggregated productivity changes. For a given productivity change within a particular sector and region, the model is able to deliver the effects of this change on all other sectors and regions in the economy.

The authors find that disaggregated productivity disturbances can have dramatically different effects depending on the regions and sectors where they occur. The differences arise in part from endogenous changes in the pattern of regional trade through a selection effect that determines what types of goods are produced in which regions. The differences also arise from labor migration

to regions that become more productive. This inflow of workers strains local fixed factors, mitigating the direct effects of productivity increases. Thus, the effects of disaggregated productivity changes depend on the characteristics of the sectors and regions involved, and how these sectors and regions are linked through input-output and trade relationships to other sectors and regions.

The authors conclude that regional characteristics significantly influence the extent to which disaggregated productivity disturbances affect economic outcomes. They estimate that in the absence of regional transportation costs, gross domestic product would more than double, and productivity and welfare would increase 50 percent. These estimates may be interpreted as upper bounds on how much advances in transportation technologies eventually could contribute to productivity and output. More importantly, they represent a foundation for the role of economic geography in the study of the macroeconomic implications of disaggregated productivity disturbances.

http://www.nber.org/papers/w20168

Large and Small Sellers: A Theory of Equilibrium Price Dispersion with Sequential Search

By Guido Menzio and Nicholas Trachter
NBER Working Paper No. 19990, March 2014.

In a famous 1971 paper, Peter Diamond analyzes a product market where buyers search sequentially for sellers. In the absence of search frictions, he finds that the market reaches equilibrium only when all sellers charge the monopoly price—leaving buyers with none of the gains from trade. This scenario is known as the Diamond Paradox. Empirically, it contradicts evidence of significant price dispersion for identical goods. Theoretically, it implies the following incongruous outcomes. Without search frictions, all sellers would post the competitive price and buyers would capture all of the gains from trade. But every seller wants to post each buyer's reservation price (the price where a buyer becomes indifferent between purchasing the good and searching for another seller). But if every seller charged the same price, the value of searching for a better deal would be zero, and each buyer's reservation price would equal the monopoly price.

In contrast to Diamond's theory, however, buyers do not meet all sellers with the same probability.

A number of researchers have attempted to resolve the Diamond Paradox by modeling a market where some buyers contact multiple sellers simultaneously while other buyers contact one seller at a time. At equilibrium, such a market accounts for price dispersion, and buyers capture some of the gains from trade, but the assumption that some buyers contact multiple sellers simultaneously seems unlikely.

In a National Bureau of Economic Research working paper, Guido Menzio of the University of Pennsylvania and Nicholas Trachter of the Richmond Fed suggest that the assumption of simultaneous contact "really means that there are some buyers who come into contact with multiple sellers before being able to decide whether to stop searching." This interpretation motivates their research, which advances a theory of equilibrium price dispersion in markets where search is sequential in the sense that buyers have the option to stop searching after meeting any individual seller.

In contrast to Diamond's theory, however, buyers do not meet all sellers with the same probability. Some buyers meet one large seller, while the remaining meetings are with small sellers. In this environment, the small sellers would like to reach each buyer's reservation price, while the large seller would like to price the small sellers out of the market. "These incentives give rise to a game of cat and mouse, whose only equilibrium involves mixed strategies for both the large and the

small sellers," Menzio and Trachter conclude. "The fact that the small sellers play mixed strategies implies that there is price dispersion. The fact that the large seller plays mixed strategies implies that prices and allocations vary over time."

As long as the large seller has some market power but not complete market power, the fraction of gains from trade accruing to the buyers depends on the extent of search frictions. In the absence of search frictions, buyers capture all of the gains, and when search frictions become infinitely large, they capture none of the gains. The authors conclude: "It is only when the large seller has no market power at all (the case considered in Diamond 1971) or when he has complete market power that buyers do not capture any of the gains from trade independently of how small search frictions might be. Therefore, the Diamond Paradox is a nongeneric outcome in markets with sequential search."

http://www.nber.org/papers/w19990

Does Greater Inequality Lead to More Household Borrowing? New Evidence from Household Data

By Olivier Coibion, Yuriy Gorodnichenko, Marianna Kudlyak, and John Mondragon
NBER Working Paper No. 19850, January 2014.

The years preceding the financial crisis of 2007–08 saw an exceptional rise in U.S. household borrowing, specifically mortgage debt. Indeed, securitized mortgage debt would ultimately play a major role in the crisis. Understandably, the root cause of this increase in borrowing has been the subject of much research and debate, and economists generally point to either an increase in the demand for credit or factors related to credit supply. Data linking rising borrowing levels to rising levels of income inequality over the past several decades provides some support for the "demand-side" hypothesis, as greater income inequality may have caused lower income households to take on more debt than they otherwise would have. One conventional rationale for this behavior is that lower-income households attempt to keep pace with the consumption of their higher-income neighbors—in other words, "keeping up with the Joneses." In a National Bureau of Economic Research working paper, Olivier Coibion of the University of Texas at Austin; Yuriy Gorodnichenko and John Mondragon of the University of California, Berkeley; and Marianna Kudlyak of the Richmond Fed investigate this claim and attempt to discern a relationship between income inequality and borrowing levels.

The major empirical finding of the paper is that income inequality is in fact negatively correlated with the debt-to-income ratio of low-income households. To find this, the authors study changes in the debt-to-income ratio of households over the course of the 2000s and their relationship to both the household's absolute income level and their income level relative to their region defined by zip code, county, and state. They measure differences in the debt-to-income ratio between higher- and lower-income households and then identify differences in differences between regions of high- and low-income inequality.

Low-income households in regions with a large degree of income inequality hold less debt than low-income households in areas with low income inequality, suggesting that the "keeping up with the Joneses" explanation is incorrect. The authors' findings hold for all major types of household debt. Furthermore, while higher credit limits were extended to low-income borrowers in low-inequality regions more than in high-inequality regions, there was no significant difference in credit demand as represented by credit balances between high- and low-inequality regions.

To illustrate the role of supply-side factors, the authors use a model in which two types of borrowers—higher-income, lower-risk and lower-income, higher-risk—attempt to borrow from banks that can only infer their risk type. They show that higher levels of income inequality allow the banks to more precisely differentiate between types, as higher inequality implies that applicant incomes are stronger signals of creditworthiness. Consistent with this view, the authors document both that lower-income borrowers in high-inequality regions faced higher interest rates or higher rates of rejection than their counterparts in low-inequality regions, and that high-income households in high-inequality regions faced lower interest rates and lower rates of rejection than similar households in low-inequality regions. The paper provides support for the conclusion that the growth in household borrowing during the mid-2000s was driven in large part by credit-supply expansion targeted toward lower-income households, instead of credit-demand forces, such as "keeping up with the Joneses."

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The Time-Varying Beveridge Curve

By Luca Benati and Thomas A. Lubik
In Advances in Non-Linear Economic Modeling: Theory and Applications,
edited by Frauke Schleer-van Gellecom, Berlin: Springer-Verlag, 2014, pp. 167–204.

The Beveridge curve represents the relationship between the unemployment rate and vacancies (open positions offered by firms) in the labor market. In a scatter diagram, it is captured by a downward-sloping relationship, where the individual data points cluster around a concave curve reflecting a highly negative correlation between the two data series. Empirical work on the Beveridge curve tends to assume that this relationship is time-invariant. However, the behavior of the curve during the Great Recession—with unemployment remaining high even as vacancies increased—raised doubts about the time-invariance assumption.

Luca Benati of the University of Bern and Thomas Lubik of the Richmond Fed use a Bayesian time-varying parameter structural vector autoregression (VAR) with stochastic volatility to trace the sources of movements, shifts, and tilts in the Beveridge curve in the United States after World War II. They build on the research of Blanchard and Diamond (1989), who reintroduced the Beveridge curve as one of the key relationships in macroeconomic data.

The authors' time-varying approach is based on the idea that a linear framework does not explain some patterns in the Beveridge curve data.

The theoretical underpinning for Benati and Lubik's work is the simple search-and-matching model, which they use to identify structural shocks. The Beveridge curve encapsulates the logic of this model. During economic expansions, unemployment is low and vacancies are high. As the economy slows, firms post fewer vacancies and unemployment rises in a downward move along the curve. At the bottom of the business cycle, firms start posting more vacancies in anticipation of recovery. As the economy improves, unemployment falls and vacancies rise in an upward move along the curve. Using insights from the theoretical model, Benati and Lubik identify both permanent and transitory structural shocks in a time-varying VAR context.

The authors' time-varying approach is based on the idea that a linear framework does not explain some patterns in the Beveridge curve data. Specifically, the data suggest that the slope of the curve is different during each business cycle, that the curve shifts over time, and that the pattern of driving forces changes in a nonlinear fashion as well. The authors use a time-varying parameter framework because it is a reasonably straightforward extension of linear VARs and, more impor-

tantly, because it can capture and approximate a wide range of nonlinear behavior. They introduce time variation in a nonlinear theoretical model to relate it to the results of the VAR.

The authors find evidence of both similarities and differences in Beveridge curve behavior during the Great Recession and the Volcker disinflation. They also discover widespread time variation along two key dimensions. First, the slope of the curve is strongly negatively correlated with the Congressional Budget Office's estimate of the output gap. The evolution of the slope of the Beveridge curve during the Great Recession is very similar to its evolution during the Volcker recession in terms of its magnitude and its time profile. This suggests that the seemingly anomalous behavior of the curve during the Great Recession, which has attracted much attention in the literature, may not have been that unusual. Second, both the Great Inflation episode and the subsequent Volcker disinflation are characterized by a significantly larger (in absolute value) negative correlation between the reduced-form innovations to vacancies and the unemployment rate than the rest of the sample period. Those years also show a greater comovement between the two data series at business-cycle frequencies. This suggests that they are driven, to a larger extent than the rest of the sample, by common shocks.

http://www.dx.doi.org/10.1007/978-3-642-42039-9_5

Big Ideas in Macroeconomics: A Nontechnical View

By Kartik B. Athreya
Cambridge, Mass.: MIT Press, 2013, 464 pages.

In the midst of the financial crisis of 2007–08, macroeconomists frequently were confronted with this question: how did you not see this coming? As Kartik Athreya of the Richmond Fed argues in his book, "Disasters preventable by human agency will always hit us as surprises." He suggests that a more fruitful discussion can be had by asking different questions. How do macroeconomists think about the economy, and what are the advantages and disadvantages of their approach? To this end, Athreya provides a nontechnical overview of the models and assumptions employed by modern macroeconomists.

Unlike, say, chemists, macroeconomists do not have the luxury of running controlled experiments with world economies. Instead, they must rely on simulations using models of economic behavior. Athreya explains that the foundation for macro models is the Arrow-Debreu-McKenzie (ADM) model, in which firms and households interact in interrelated markets to trade goods and services. In the ADM framework, households and firms take prices as given and choose what and how much to consume and produce, respectively. Macroeconomists call these given prices and the resulting outcomes "Walrasian." A surprising fact is that Walrasian outcomes are those where no two participants in trade can improve their situation by further trade. Economists call such outcomes "Pareto-efficient." It is surprising that Walrasian outcomes are Pareto-efficient because in the ADM setting, no one is presumed to know anything about anyone, and no one is trying to directly improve the well-being of anyone else.

But do such models have any bearing on the real world? Evidence suggests they do. As markets get larger (have more participants), they tend to reflect the pricing structure predicted by ADM models. Even economic experiments with a small number of self-interested participants tend to generate outcomes as predicted by the ADM model. But, as Athreya notes, not all markets in the real world function this way. For example, markets for labor, public goods, and insurance often do not have the tidy price-taking structure assumed in the ADM framework.

There is also a catch with respect to Pareto efficiency: market outcomes can be efficient while still being grossly unequal. The ADM model suggests that inequality of outcomes generally will reflect inequality in the starting resources possessed by households. While policy (such as taxation) can improve the equality of such endowments, Athreya cautions that this approach can decrease the efficiency of production. For example, taxes on firms' use of inputs may lead them to produce in roundabout ways, while taxes on the labor income earned by households may lead them to simply work less. Societies may approve of this trade-off in certain circumstances (as evidenced by the widespread use of measures such as progressive tax codes), but macroeconomists are often hesitant to support such policies because it is difficult to determine whether they will improve the welfare of some people more than they harm the welfare of others.

Athreya also explains and defends several methodological "shortcuts" that macroeconomists commonly employ. For example, critics contend that aggregation—using assumptions that deliberately gloss over differences among an economy's participants—in macroeconomic models is used too often. Here the author compares macro models to maps: zoom in too close and it is difficult to glean any useful information, but pull back too far and important details begin to fade from view. Ultimately, aggregation offers a trade-off that allows for richer details in some parts of the model in exchange for less realistic assumptions elsewhere. Additionally, under some conditions, simplified models produce outcomes identical to models with more realistic assumptions. Even so, Athreya provides an extensive overview of many of the more detailed models used in modern analysis.

Lastly, Athreya explores what macroeconomics has to say about the financial crisis of 2007–08. While economists can provide some explanation for the sustained collapse of housing prices and the protracted recovery, the larger question of how to spot future asset bubbles is likely to remain unanswered. As Athreya explains, there can be any number of rational explanations for observed price increases, which makes economists "so loathe to second-guess prices that we don't recognize a bubble until it blows up in our faces." More generally, he argues that economists have a lot of work ahead of them in accounting for the use of specific financial products, such as debt (by both households and firms) and the role of these financing choices on macroeconomic outcomes.

http://mitpress.mit.edu/books/big-ideas-macroeconomics

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