Welcome to the seventh 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 midyear 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 June 28, 2019, when the Bank will publish the next issue of the *Richmond Fed Research Digest*.

Underlining indicates links to bios of Richmond Fed economists.

Bankruptcy and Delinquency in a Model of Unsecured Debt

By Kartik Athreya, Juan M. Sánchez, Xuan S. Tam, and Eric R. Young
International Economic Review, *forthcoming*

Consumer debt delinquency, unlike bankruptcy, is informal default—not paying back debt as initially promised. Delinquency occurs frequently, but many delinquent borrowers improve their credit status fairly quickly. According to recent New York Fed Consumer Credit Panel/Equifax data, 85 percent of borrowers who are sixty to ninety days delinquent make a payment in the following quarter, and 40 percent reduce their debt by making payments, receiving partial debt forgiveness, or both.

In an article forthcoming in the *International Economic Review*, Kartik Athreya of the Richmond Fed, Juan M. Sánchez of the St. Louis Fed, Xuan S. Tam of City University of Hong Kong, and Eric R. Young of the University of Virginia and Zhejiang University use data and theory to shed light on these observations. They evaluate the extent to which quantitative models of consumer default can be useful for understanding the borrower-level, short-term dynamics of delinquency. The informality of delinquency complicates this analysis. In particular, a feature of many unsecured lending contracts is a penalty rate on past-due payments. However, while most lenders might claim to impose this penalty rate, the proportion of consumers who actually pay such penalties is not clear. As a result, an open question is whether the data help the authors clearly discipline the interpretation of how borrowers are treated in delinquency.

Athreya, Sánchez, Tam, and Young establish two stylized facts from the data that describe individual-level dynamics associated with delinquency. As noted above, they show that delinquency does not mean a persistent cessation of payments, and they detail substantial dispersion in the change in the debt of delinquent borrowers. In addition, the authors assemble previously undocumented facts regarding heterogeneity in the use of delinquency (and bankruptcy), both by income group

and across the life cycle. The authors use this information to develop a model of debt delinquency and bankruptcy that is theoretically and institutionally plausible and that nests a variety of specifications for what delinquency implies for borrowers and lenders. Next, they derive the predictions of two important polar cases. In the first case, lenders impose the penalty rate on all delinquent borrowers as specified by the terms of their contracts. In the second case, lenders reset the terms of the contracts to optimize the market value of the delinquent debt.

The authors explore the extent to which the data are driven by each of these models, first in their pure form and then when they are allowed to coexist. They find that the pure penalty-rate model has reasonable implications for some of the characteristics of borrowers in delinquency, but it fails to provide reasonable implications for the facts on both short-term borrowing dynamics following delinquency and the evolution of credit terms during delinquency. They find that the optimal-resetting model—in which lenders propose new lending terms—better matches the facts on borrower dynamics following delinquency, but it fails to fully reproduce the evolution of credit terms during delinquency. The authors therefore conclude that each scenario plays a role in accounting for the facts. Their preferred "mixture" model suggests that in most cases (59.5 percent) lenders impose the predetermined penalty rate, but in the remaining cases (40.5 percent), they reset the terms for delinquent borrowers, typically granting partial debt forgiveness.

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A Simple General Equilibrium Model of Large Excess Reserves

By Huberto M. Ennis
Journal of Monetary Economics, *forthcoming*

Macroeconomic models typically generate a tight long-run relationship between the monetary base and the price level. In the years since the financial crisis, however, that link has weakened considerably in many advanced economies. In the United States, for example, the monetary base grew at an average annual rate of 16 percent during the past ten years, while prices grew only 1.8 percent per year on average. The expansion of bank reserves accounts for most of the growth in monetary assets during that period, pushing the U.S. banking system to operate with an extremely large amount of excess reserves for a number of years.

These results suggest that it is possible for the central bank to purchase securities using nominal reserves without inducing increases in the price level, but there are limits to such policy.

In an article forthcoming in the *Journal of Monetary Economics*, Huberto Ennis of the Richmond Fed constructs a relatively simple general equilibrium model of a macro economy with a banking system that can hold large excess reserves and is subject to (possibly binding) capital constraints. The model is designed to assist in the understanding of medium- to long-run relationships between macroeconomic and monetary variables and, in particular, the possibility of large changes in the monetary base that do not translate into comparable changes in the price level when the central bank is paying interest on bank reserves.

In the model, when the central bank pays low (or no) interest on reserves, banks hold no excess reserves, the demand for reserves is pinned down in equilibrium, and the price level moves one-to-one with the monetary base. When the central bank pays interest on reserves at market rates, excess reserves can be large and, as long as bank capital in the economy is not scarce, the price level may decouple from the monetary base. However, if the quantity of reserves is sufficiently large so that attracting extra bank capital requires paying abnormally high interest rates, then the bank-capital constraint becomes binding, and the price level again moves in lockstep with the monetary base. These results suggest that it is possible for the central bank to purchase securities using nominal reserves without inducing increases in the price level, but there are limits to such

policy. After some point, if excess reserves become large enough, more nominal reserves would translate into higher prices.

Three features of the model are of special importance for these results. First, the central bank can pay interest on reserves. Second, the central bank controls the monetary base (currency plus reserves) but does not control the split between currency and reserves—an endogenous variable in the model. And third, the quantity of bank capital in the economy is potentially large but limited. When the central bank is paying interest on reserves at market rates and bank capital is plentiful, banks are basically indifferent between holding more or less reserves funded with deposits because the costs and benefits of doing so are effectively equal. This indifference and the flexibility provided by the endogenous split of currency and reserves allow for adjustments to the quantity of reserves without significant changes in the price level. Eventually, though, as excess reserves become sufficiently large, the amount of bank capital in the economy turns into the limiting factor, breaking down banks' aforementioned indifference because the costs of funding reserves becomes higher than the benefits of holding them. At that point, a larger monetary base translates into a higher price level, and the tight long-run link between money and prices reemerges.

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End-of-Life Medical Spending in Last Twelve Months of Life Is Lower than Previously Reported

The high medical expenses that people incur close to death have attracted considerable interest from academics and policymakers over the past thirty years, particularly in the United States. Many believe that unnecessary end-of-life care is a major source of wasteful medical spending. Despite this interest, evidence on medical spending close to death is relatively scarce and incomplete. Most studies examine just one country, and each study uses a different measure of medical spending.

In an article in *Health Affairs*, John Bailey Jones of the Richmond Fed and twenty-seven coauthors use health care data for 2009–11 from Denmark, England, France, Germany, Japan, the Netherlands, Taiwan, the United States, and the Canadian province of Quebec to measure the composition and magnitude of medical spending in the three years before death. In each country, medical spending near the end of life was high relative to spending at other times. Spending during the last twelve months of life ranged from 8.5 percent of aggregate medical spending in the United States to 11.2 percent in Taiwan, while spending in the last three years of life ranged from 16.7 percent of aggregate spending in the United States to 24.5 percent in Taiwan. These ranges suggest that high medical spending is due not to last-ditch efforts to prolong life but to spending on people with chronic conditions that are associated with shorter lives.

To address gaps in the data, the authors estimate end-of-life spending in multiple countries using consistent methods and a comprehensive measure that includes spending on both health care and long-term care. They find that the ratio of end-of-life spending to overall spending is similar across very different health care systems. The greatest variation across countries in spending by category was in hospital spending, which ranged from 8.2 percent in Japan to 22.7 percent in Quebec during the last twelve months of life and from 13.5 percent in Japan to 34.9 percent in Taiwan during the last three years of life. The United States is toward the bottom of those ranges. The larger variation in hospital spending is consistent with health care systems using different combinations of services to provide care for people near the end of life. This finding suggests that

previous research that focused on hospital spending may have overestimated the variation in total end-of-life spending across countries.

The authors conclude that reducing wasteful spending just before death would have only a modest effect on total medical spending. They emphasize, however, that this finding is not an argument against reform. A country's medical spending in the last three years of life usually exceeds 2 percent of its gross domestic product, so the potential savings could be large. Perhaps an even stronger argument for focusing on end-of-life care is to improve the quality of care for patients who face expensive and painful treatments in their final years. The authors note that effective reform likely would require a multifaceted approach by policymakers and clinicians. The authors also urge health systems to learn from both successful and unsuccessful approaches around the world.

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Health, Health Insurance, and Retirement: A Survey

By Eric French and John Bailey Jones

During the past century, the developed world has enjoyed an increase in healthy life spans accompanied by a move toward earlier retirement. These trends, coupled with reduced fertility and increasing medical costs, have led to persistent fiscal imbalances. Many countries have responded with public pension reforms intended to keep older people in the workforce longer (French and Jones 2012). Such reforms are unlikely to be successful, however, if older individuals are not healthy enough to significantly extend their careers. On the other hand, if individuals are retiring in good health, they may be receptive to greater incentives to continue working. The academic literature on health and retirement sheds light on both of these scenarios.

The authors note that both reduced-form and structural comparisons suggest that much of the cross-country variation in retirement comes from differences in public pensions and disability insurance.

In an article in the *Annual Review of Economics*, Eric French of University College London and John Bailey Jones of the Richmond Fed review the evidence from developed countries on the health-retirement link and its implications for public policy. The literature contains a variety of methodologies, ranging from broad historical reviews to fully articulated dynamic models, that allow the authors to document empirical relationships and assess the economic mechanisms through which health affects labor supply.

Over the past century, there has been a pronounced decline of older men in the workforce. Given that life expectancy (even at older ages) has increased over the same period, the decline in labor supply is not due to health considerations. Much of the decline is due instead to increases in retirement income from higher compensation, significant increases in public pension benefits, and growing participation in disability programs. Even in the past two decades, when the decline of older men in the workforce has stopped or reversed in many countries, employment appears to have, in general, grown more slowly than the capacity for people to continue working beyond traditional retirement age. See Coile, Milligan, and Wise (2017).

French and Jones find that the effects of health on retirement are more apparent in cross-sectional relationships. All else being equal, people in worse health clearly are less likely to work. It is much less clear, however, whether bad health is generally a compelling force, a tipping factor in an environment already conducive to early retirement, or a gateway to disability benefits. Several mechanisms are possible. Illness can make work extremely unpleasant. Bad health also can reduce worker productivity. People in sufficiently poor health may receive disability benefits, and people receiving disabil-

ity benefits are usually prohibited from working. Finally, with shorter expected life spans, individuals in bad health may not need to work as long to accumulate financial and pension wealth for their retirements.

The authors also note that health may affect labor supply through concerns about health care costs. Such concerns may encourage people in the United States to continue working to maintain employer-provided health insurance. Alternatively, uninsured workers may leave their jobs in order to qualify for health care provided through disability or means-tested social insurance programs, such as Medicaid. There are numerous factors to analyze, but the authors note that both reduced-form and structural comparisons suggest that much of the cross-country variation in retirement comes from differences in public pensions and disability insurance. The increases in labor supply that have followed recent pension reforms suggest the same thing.

The Accuracy of Economic Measurement in the Health and Retirement Study

The University of Michigan Health and Retirement Study (HRS) captures an unparalleled variety of survey-based measures of well-being for elderly people living in the United States. In an article in the *Forum for Health Economics and Policy*, Eric French and Jeremy McCauley, both of University College London, and John Bailey Jones of the Richmond Fed assess the quality of HRS measures of out-of-pocket medical spending and health insurance premia—both in core-interview and exit-interview data. They pay particular attention to issues of data imputation.

The authors credit the RAND Corporation with doing "a fantastic job" of making HRS data highly accessible to researchers by creating recoded HRS variables that are both well-imputed and consistent over time. They note, however, that RAND recodes a relatively small share of the variables in the HRS—leaving an abundance of useful data beyond the reach of many researchers. Overall, the quality of these hard-to-access variables is still high. This fact interests the authors because many of the variables not coded by RAND employ more complex survey methodologies, such as those used for the exit interviews.

French, Jones, and McCauley find that the HRS medical spending data line up well with data from the Medicare Current Beneficiary Survey (MCBS). But the HRS insurance premia data do not match data from the MCBS and the Medical Expenditure Panel Survey (MEPS) quite as well. "It is not obvious," the authors say, "whether the problem lies with the HRS, MEPS, or with the MCBS."

In the HRS, the authors find that nonresponse rates are fairly high for many variables, including insurance premia. Issues of either partial or complete nonresponses (coded as "don't know" or "refused") are especially serious among the exit interviews. The HRS has addressed these issues by using "unfolding brackets" and imputations. Overall, the HRS follows good procedures that balance the need for accuracy with the need for robustness, but the authors find what they believe to be errors, some of them serious. In particular, they document apparent mistakes in the 2002 and 2004 insurance premia imputations. "These problems are sufficiently serious that it would be better to remove some of the imputed variables than to leave them on the HRS website as currently constructed," the authors conclude.

Perhaps a bigger problem is that the HRS no longer imputes data, and RAND only imputes a small portion of the data. French, Jones, and McCauley recommend that a trusted source, such as RAND, continue to clean, impute, and recode as much HRS data as possible—especially all variables with

unfolding brackets. These imputations should satisfy basic accounting identities. For example, the to-tal value of an estate bequeathed to all children should equal the sum of the bequests to each child.

The authors also reiterate two recommendations from Venti (2011). First, the HRS should be linked to administrative Medicaid data. The authors document modest underreporting of Medicaid recipiency in the HRS, and using administrative data should circumvent this problem. Adding the administrative data also would introduce new variables, such as the dollar value of Medicaid benefits, that should stimulate new research. Second, the authors recommend that imputation procedures exploit the HRS's panel dimension.

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The Effects of Collecting Income Taxes on Social Security Benefits

By John Bailey Jones and Yue Li
Journal of Public Economics*, March 2018, vol. 159, pp. 128–145*

In 2014, about half of Social Security recipients owed income taxes on their Social Security ben-efits. An important feature of these taxes is that the amount of Social Security benefits subject to taxation is an increasing function of beneficiaries' "combined" income. At certain income levels, each additional dollar of earnings, in addition to being taxable itself, adds fifty to eighty-five cents of Social Security benefits to taxable income, increasing the effective marginal income tax rate on these earnings by 50 percent to 85 percent.

In an article in the *Journal of Public Economics*, John Bailey Jones of the Richmond Fed and Yue Li of the University at Albany (SUNY) assess the effects of taxing Social Security benefits on asset accumulation, employment, Social Security claiming, and welfare. They study these effects using a heterogeneous-agent, life-cycle framework that includes a detailed model of Social Security and the taxation of benefits.

> **Jones and Li's principal finding is that the way in which income taxes on Social Security benefits are calculated significantly lowers the returns to work at older ages, a time in the life cycle when labor supply is especially elastic.**

In the model, individuals face uncertain wages, health, health spend-ing, and survival. They choose how much to work and save and when to claim Social Security benefits. Consistent with empirical evidence, as older workers transition into part-time jobs, their wages fall. The government collects income, payroll, and consumption taxes and provides Social Security, Medicare, and means-tested social insurance. The authors calibrate their model to match the 2006 U.S. economy and use it to examine the effect of replacing income taxes on Social Secu-rity benefits with offsetting increases to payroll taxes. Their framework allows them to consider effects across the entire income distribution and life cycle.

Jones and Li's principal finding is that the way in which income taxes on Social Security benefits are calculated significantly lowers the returns to work at older ages, a time in the life cycle when labor supply is especially elastic. Severing this link would be quite beneficial, they conclude. Jones and Li consider two distinct approaches to accomplishing this. The first would be to replace the taxation of Social Security benefits with a revenue-equivalent change in the payroll tax. While payroll taxes also discourage work, their disincentives apply evenly across all ages, unlike the work disincentives of the benefit tax, which are concentrated at older ages, when labor supply is elastic. The second approach Jones and Li consider would be to make the portion of Social Security ben-efits that is taxed independent of other income. Under current rules, higher earnings can lead to much higher benefit taxes. Making the taxation of benefits unconditional would end this process, thus encouraging work. This reform would have the additional benefit of allowing the government

to lower the payroll tax rate. Replacing regressive payroll taxes with progressive income taxes would increase aggregate welfare. A drawback of the reform is that its welfare effects would vary greatly by age. While the young would benefit, the increase in benefit-related income taxes would harm older individuals.

The authors also find that along many dimensions the effects of reforming or eliminating the benefit tax would be much larger than the effects of eliminating the Social Security earnings test, a mechanism that triggers a reduction in current Social Security benefits and an increase in future benefits when a beneficiary's earnings exceed a threshold. It may be the case that misunderstandings of the tax code lead older workers to overreact to the earnings test and underreact to the taxation of benefits. The magnitudes of the authors' results suggest, however, that reforms to the benefit taxation provisions deserve serious consideration.

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The Lifetime Medical Spending of Retirees

By John Bailey Jones, Mariacristina De Nardi, Eric French, Rory McGee, and Justin Kirschner
National Bureau of Economic Research Working Paper No. 24599, May 2018

Despite nearly universal enrollment in the Medicare program, most elderly Americans still face the risk of catastrophic health care expenses. There are many gaps in Medicare coverage: for example, Medicare does not pay for long stays in hospitals or nursing homes, and it requires copayments for many medical goods and services. Medical spending is thus a major financial concern among elderly households. So it is not surprising that a large literature documents annual medical spending at older ages, but there is relatively little research on the distribution of cumulative lifetime spending. Yet, in many ways, lifetime spending totals are just as important—perhaps more important—to households' saving decisions and financial well-being.

In a National Bureau of Economic Research working paper, John Bailey Jones and Justin Kirschner, both of the Richmond Fed, Mariacristina De Nardi of the Chicago Fed, and Eric French and Rory McGee, both of University College London, estimate the distribution of lifetime medical spending for retired households whose heads are seventy or older. The authors focus on out-of-pocket spending, the payments made by households themselves. High out-of-pocket expenses, however, can leave households financially indigent and reliant on Medicaid. The authors' spending estimates, therefore, include payments made by Medicaid in order to fully capture all of the medical spending risk that households potentially face. Their estimates thus measure the medical spending risk that wealthier households face and the medical spending risk that less-wealthy households would face if Medicaid were not available (absent other changes in their insurance).

The authors' main dataset is the Health and Retirement Study (HRS), which contains high-quality information on out-of-pocket medical spending from 1995–2014. Because the HRS does not include Medicaid payment data, the authors impute Medicaid payments using the Medicare Current Beneficiary Survey. In De Nardi et al. (2018), these data were used to estimate dynamic models of health, mortality, and out-of-pocket medical spending. Medical spending depends on age, household composition, health, and idiosyncratic shocks. Simulating the models allows the authors to construct household histories, calculate discounted sums, and ultimately compute the distribution of lifetime medical spending.

The authors find that lifetime medical spending during retirement is high and uncertain. After turning seventy, households will on average incur $122,000 (in 2014 dollars) in medical spending, including Medicaid payments, over their remaining lives. (The models are designed to measure the health expenses of households whose heads were ages sixty-eight through seventy-two in 1992.) On the high end of the distribution, 5 percent of households will incur more than $300,000

in medical spending, and 1 percent of households will incur more than $600,000 in medical spending. The level and dispersion of remaining lifetime spending diminishes only slowly with age. Although older people have fewer remaining years to live, they are also more likely to reach extreme old age when medical expenses are very high. Even though permanent income, initial health, and initial marital status have large effects on this spending, much of the dispersion in lifetime spending is due to events realized in later years.

The authors find that Medicaid lowers average lifetime expenditures by 20 percent. It covers the majority of medical costs for the poorest households, and to a lesser extent, it reduces the level and volatility of medical spending for high-income households.

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Labor Market Uncertainty and Portfolio Choice Puzzles

Despite a longer investment horizon, the average young household in the United States maintains a conservative financial portfolio. Most young households do not aggressively take advantage of high rates of return from risky investments, such as stocks, corporate bonds, and real estate funds. According to the Survey of Consumer Finances (SCF), conducted by the Board of Governors of the Federal Reserve System for years 1998 through 2007, the fraction of households that participate in risky financial investments is just 30 percent at ages twenty-one through twenty-five compared with 65 percent at ages fifty-six through sixty. The conditional risky share—risky assets as a percentage of total financial assets among households that participate in risky investment—is 40 percent at ages twenty-one through twenty-five and mildly increases to 50 percent at ages sixty-one through sixty-five. Standard life-cycle models of household portfolio choice have difficulty generating a realistic age profile of risky share. Not only do these models imply a high risky share on average (the so-called equity premium puzzle), they also imply a steeply decreasing age profile.

The authors conclude that great uncertainty in the labor market prevents many young workers from taking more risk in financial markets. As labor market uncertainty is resolved in their minds over time, workers start taking more risk in their financial portfolios.

In an article in the *American Economic Journal: Macroeconomics*, Yongsung Chang of the University of Rochester and Yonsei University, Jay H. Hong of Seoul National University, and Marios Karabarbounis of the Richmond Fed introduce three types of age-dependent labor market uncertainty—unemployment risk, the probability of switching occupations, and gradual learning about earnings ability—into an otherwise standard life-cycle model of household portfolio choice as in Cocco, Gomes, and Maenhout (2005).

Chang, Hong, and Karabarbounis calibrate their model to match four life-cycle patterns in the data: income volatility, unemployment risk, occupational changes, and consumption dispersion. They show that age-dependent labor market uncertainty can partially reconcile the gap between the risky share in the standard model and the risky share observed in the SCF data. In their model, the average risky share is 56 percent, slightly higher than the risky share observed in the SCF data (47 percent) but much lower than the value (83 percent) implied by the standard model without age-dependent labor market uncertainty. This more reasonable value of risky share in their model is achieved under a relative risk aversion of five, much lower than the typical value required in standard models. More importantly, the age profile of risky share in their model exhibits a mildly increasing pattern: workers at ages twenty-one through twenty-five have an average risky share of 48 percent, while the average risky share for workers at ages forty-one through forty-five is 59 percent.

Chang, Hong, and Karabarbounis conclude that great uncertainty in the labor market prevents many young workers from taking more risk in financial markets. As labor market uncertainty is resolved in their minds over time, workers start taking more risk in their financial portfolios.

According to the proposed theory, workers in an industry (or occupation) with highly volatile earnings should take less risk with their financial investments. Based on industry-level labor-income volatility measures, Chang, Hong, and Karabarbounis also verify empirically that a household whose head is working in an industry with high income volatility does exhibit a lower risky share.

Global Dynamics in a Search and Matching Model of the Labor Market

The search and matching model of the labor market has proved to be a convenient framework for studying the joint behavior of unemployment and job vacancies. Much of the qualitative and quantitative analysis within this framework relies on linear approximations and local solutions of fundamentally nonlinear environments, as does most of the dynamic literature in macroeconomics. Yet, researchers increasingly have come to realize that the global dynamics of such frameworks can have quite different implications than the local dynamics. In particular, nonlinear dynamics can be periodic or chaotic, which a linear approach cannot capture. Moreover, a purely linear approach may rule out steady-state equilibria as unstable with explosive dynamics and therefore miss on cyclical equilibria or stable dynamics elsewhere in the economic domain. Without a full characterization of the nature of the processes that generate economic data, any conclusions drawn based on a local approach can therefore be misleading.

In an article forthcoming in *Economic Theory*, Nika Lazaryan and Thomas Lubik, both of the Richmond Fed, study the global and local dynamics of the simple search and matching model in light of these concerns. They show analytically that the model exhibits periodic and chaotic dynamics for a wide range of plausible parameterizations that have been used in the quantitative literature.

In contrast to earlier work, they employ analytic proofs that are derived without placing numerical restrictions on the parameters. They are aided in this effort by the structure of the search and matching framework, which can be reduced to a recursive two-variable system. The model is thereby amenable to analytical characterization of its local and global properties. The key dynamics arise from the model's job-creation condition, whereby the authors show that this holds both in backward and forward time. For the backward dynamics, they derive a mapping that can be easily analyzed after introducing a variable change. This mapping ensures that the evolution of labor market dynamics is both economically meaningful—in the sense that trajectories of the model's variables are well-defined—and that it is consistent with the model's job-creation condition in terms of uniqueness of the steady state. This differentiates the authors' work from prior analysis of this model, which uses a representation that can have more than one steady state for certain parameter values and may not always be defined on its domain.

Lazaryan and Lubik contribute to the literature along two dimensions. First, the phenomenon of chaotic dynamics in economic models is interesting on its own. However, most research on this phenomenon has focused on the real business cycle model or variants of the New Keynesian model. There has been recent interest in global dynamics in the literature, best exemplified by the monetary search model developed in Gu et al. (2013). While this model is also based on search theory, the general framework of Lazaryan and Lubik's model is sufficiently different to make an

independent contribution in this area because the study of the global dynamics of the labor market search and matching model is new. Second, Lazaryan and Lubik emphasize the importance of considering global dynamics more broadly, especially since there is a growing awareness that reliance on local dynamics can be misleading.

Measurement Errors and Monetary Policy: Then and Now

When monetary policymakers evaluate the effects of their most recent policy decisions (perhaps to prepare for their next round of policy decisions) they only have access to preliminary (real-time) estimates of macroeconomic data that have been collected following the policy decisions they want to evaluate. However, these real-time estimates often are revised substantially during subsequent months and years, so there can be large differences between real-time data and final data. Are such differences important enough to be considered when conducting and analyzing monetary policy? In an article in the *Journal of Economic Dynamics and Control*, Pooyan Amir-Ahmadi of the University of Illinois at Urbana-Champaign, Christian Matthes of the Richmond Fed, and Mu-Chun Wang of the University of Hamburg attempt to answer this question by using a Bayesian vector autoregression (VAR) with time-varying parameters and stochastic volatility.

The authors find that real-time responses can be significantly biased and that responses of various measures of real economic activity are consistently larger in magnitude among final data. They conclude that these differences have persisted over the past forty years and should be taken into account when conducting or studying monetary policy.

The question was first addressed by Croushore and Evans (2006) in the context of a fixed-coefficient VAR using either recursive or long-run restrictions. Their model of measurement error is less general than the one employed by Amir-Ahmadi, Matthes, and Wang. For example, in addition to using a fixed-coefficient VAR, Croushore and Evans's model does not allow for nonzero intercepts in the relationship between different vintages of data. Amir-Ahmadi, Matthes, and Wang find that these model differences matter quite a bit. They use a VAR with time-varying parameters and stochastic volatility because time variation in the dynamics and volatility of final data have been identified as important for final U.S. data by Cogley and Sargent (2005), Primiceri (2005), and Canova and Gambetti (2009), among other researchers. Borrowing a model from these papers, the authors show that these features are important for real-time U.S. data as well. They estimate their VAR using both real-time and "final" macroeconomic data. They obtain their real-time data from the Philadelphia Fed's real-time database, developed by Croushore and Stark (2001). And as a proxy for final data, they employ the most recently revised data.

The authors show that measurement errors are pervasive in real-time macroeconomic data. By extending the insights of Aruoba (2008) to incorporate time-varying dynamics, they find that the measurement errors are significantly correlated for some variables, feature substantial changes in volatility, and can be different from zero for long periods of time with magnitudes that are economically meaningful. Therefore, modeling real-time data as the sum of the final data and a simple independent noise process can miss important features of the data.

Amir-Ahmadi, Matthes, and Wang also show that differences between real-time data and final data manifest themselves in the substantially different ways that real-time and final data respond to monetary policy shocks. They find that real-time responses can be significantly biased and that responses of various measures of real economic activity are consistently larger in magnitude among

final data. They conclude that these differences have persisted over the past forty years and should be taken into account when conducting or studying monetary policy. With this insight and with the assumption that other shocks do not play a significant role during the time period of interest, policymakers could use recent real-time data to estimate the response of final data to monetary policy decisions before final data become available.

Choosing Prior Hyperparameters: With Applications to Time-Varying Parameter Models

By Pooyan Amir-Ahmadi, Christian Matthes, and Mu-Chun Wang
Journal of Business and Economic Statistics, *forthcoming*

Multivariate time series models form the backbone of empirical macroeconomics. A common feature of all popular multivariate time series models is that, as researchers include more variables, the number of parameters quickly grows large. This problem is perhaps most evident in vector autoregressions (VARs) that feature time-varying parameters and stochastic volatility.

Bayesian inference, via its use of prior distributions, allows researchers to avoid overfitting an observed sample. Therefore, Bayesian inference has become the standard approach to estimating multivariate time series models with many parameters. But choosing prior distributions in such high-dimensional models is a daunting task. A common practice is to focus on priors that depend on relatively few prior "hyperparameters." The choice of hyperparameters is crucial because their influence is often large for standard sample sizes. Even so, the choice of hyperparameters is often ad hoc, with researchers merely employing values that have been used before in the literature.

In an article forthcoming in the *Journal of Business and Economic Statistics*, Pooyan Amir-Ahmadi of the University of Illinois at Urbana-Champaign, Christian Matthes of the Richmond Fed, and Mu-Chun Wang of the University of Hamburg argue that researchers should consider estimating prior hyperparameters instead of borrowing them from previous studies that use vastly different datasets. To facilitate estimation, the authors have developed a fast, tractable, and simple Metropolis step that can be added easily to standard posterior samplers, such as the Metropolis-Hastings algorithm or the Gibbs sampler. See Gelman et al. (2013). Researchers can use this approach with minimal changes to their code and negligible increases in computational time because the densities that need to be considered in the additional estimation step are prior distributions that are usually fast to evaluate.

The estimation algorithm that the authors propose exploits the hierarchical structure that is always present whenever prior hyperparameters are used and thus can be used generally in any model with prior hyperparameters. Their approach interprets the structure implied by the interaction of parameters of the model and the associated prior hyperparameters as a hierarchical model, which is a standard model in Bayesian inference. The Gibbs sampler is already a standard approach to estimating multivariate time series models, and thus the authors' approach fits naturally into the estimation method used for such models.

The importance of prior hyperparameters for VARs with time-varying parameters and stochastic volatility was established by Primiceri (2005), who also estimated hyperparameters in a Bayesian context. Unfortunately, Primiceri's approach is computationally complex and requires focusing on only a small number of possible values for the hyperparameters. Other researchers have addressed related issues in a frequentist framework, but Amir-Ahmadi, Matthes, and Wang's approach is more related to the literature on choosing prior hyperparameters in a Bayesian inference. Giannone, Lenza, and Primiceri (2015) estimated prior hyperparameters for time-invariant

VARs with conjugate Normal-Inverse Wishart priors by exploiting the fact that in such cases the density of the data conditional on the hyperparameters (the marginal likelihood) is known in closed form. But in models with time-varying parameters and stochastic volatility, there is no closed form for the marginal data density. In this class of models, Amir-Ahmadi, Matthes, and Wang demonstrate, via Monte Carlo simulations, that their approach can drastically improve on using the fixed hyperparameters previously proposed in the literature.

Functional Approximation of Impulse Responses

By Regis Barnichon and Christian Matthes
Journal of Monetary Economics, *forthcoming*

The impulse response function (IRF) is a popular tool for describing the dynamic effects of shocks on macroeconomic time series. In an article forthcoming in the *Journal of Monetary Economics*, Regis Barnichon of the San Francisco Fed and Christian Matthes of the Richmond Fed propose a new method—functional approximation of impulse responses (FAIR)—for estimating IRFs.

The FAIR methodology has two distinct features. First, instead of assuming the existence of a vector-autoregressive (VAR) representation, FAIR directly estimates the vector-moving-average (VMA) representation of the data. In other words, FAIR directly estimates IRFs. This approach confers a number of advantages, notably the ability to impose prior information and structural-identifying restrictions in a flexible and transparent fashion, as well as the possibility of allowing for a large class of nonlinear effects. FAIR also approximates the IRFs with a few basis functions.

In addition to being helpful in evaluating the effects of monetary shocks, FAIR may be useful in many other contexts, notably when the sample size is small and/or the data are particularly noisy.

This approximation serves as a dimension-reduction tool, which makes the estimation of the VMA feasible. While different families of basis functions are possible, Gaussian basis functions can be of particular interest for macro applications. A one Gaussian function approximation can summarize a monotonic or hump-shaped IRF with only three parameters, each capturing a separate and interpretable feature of the IRF: the magnitude of the peak effect of a shock, the time to that peak effect, and the persistence of that peak effect. This ability to summarize a high-dimensional IRF with a few key parameters amenable to statistical inference can make FAIR helpful for evaluating and developing models.

After establishing the good finite sample properties of FAIR with Monte Carlo simulations, Barnichon and Matthes illustrate the benefits of FAIR by using it to study the effects of monetary shocks. FAIR can incorporate the different identification schemes found in the structural VAR literature, and the authors present results from three popular identification schemes: a recursive identification scheme, a set identification scheme based on sign restrictions, and a narrative identification scheme where a series of shocks has been previously identified (possibly with measurement error) from narrative accounts.

First, the authors focus on linear models. They illustrate how influential stylized facts about the magnitude and dynamics of the effects of monetary shocks can be recast into statements about individual FAIR parameters. Second, they use FAIR to explore whether monetary shocks have asymmetric effects. In other words, they consider whether a contractionary monetary shock has a stronger effect than an expansionary shock. While this question is central to monetary policy, the evidence for asymmetric effects is relatively thin and inconclusive, partly because estimating the asymmetric effect of a monetary shock is difficult within a VAR framework. Using FAIR, however, the authors find evidence of strong asymmetries in the effects of monetary shocks. Regardless of

the identification scheme, a contractionary shock has a strong adverse effect on unemployment, while an expansionary shock has little effect on unemployment. They find that the response of inflation is also asymmetric but in the opposite direction of unemployment: prices react less when unemployment reacts more and vice versa.

In addition to being helpful in evaluating the effects of monetary shocks, FAIR may be useful in many other contexts, notably when the sample size is small and/or the data are particularly noisy. FAIR also could be used to explore the nonlinear effects of other important shocks, notably where the existence of nonlinearities remains an important and unresolved question, as it is in fiscal policy shocks.

Two-Sided Learning and Short-Run Dynamics in a New Keynesian Model of the Economy

By Christian Matthes and Francesca Rondina
Economics Letters, *October 2017, vol. 159, pp. 53–56*

In an article in *Economics Letters*, Christian Matthes of the Richmond Fed and Francesca Rondina of the University of Ottawa study asymmetric information and two-sided learning in a New Keynesian framework in which private agents and central bankers have imperfect knowledge of the economy but behave optimally given what knowledge they do possess. On one side, private agents do not know the monetary policy rule that the central bankers follow to set the nominal interest rate, and private agents do not observe monetary policy shocks. On the other side, central bankers do not observe shocks to the marginal cost of production and the natural rate of interest, and central bankers do not know how private agents form expectations and make decisions about production and pricing.

The authors employ a standard New Keynesian framework with specifications similar to Dennis and Ravenna (2008). They assume that private agents and central bankers use all the information that they have available to estimate the structural equations that they do not know within the model. Agents also use a statistical learning algorithm to update their beliefs as new data become available to them. In each period, these evolving beliefs will be the basis for policy decisions (on the side of central bankers) and for production and pricing decisions (on the side of private agents).

The literature on monetary policy in environments characterized by imperfect knowledge and learning is extensive. Two-sided learning was first studied in the seminal work of Marcet and Sargent (1989), upon which most of the ensuing research (including this paper) has been built. Matthes and Rondina, however, employ a framework that departs from the previous literature in two directions. First, they assume that agents are only forming beliefs on the equilibrium relationships that they do not know rather than estimating reduced-form regressions on all equilibrium variables—as, for instance, in Dennis and Ravenna (2008). Second, Matthes and Rondina assume that both private agents and central bankers are implementing optimal choices. As a consequence, their analysis does not focus on the ability of the central bank to enforce a particular policy rule or to achieve convergence to a rational expectations equilibrium—as, for instance, in Evans and Honkapohja (2003). Instead, Matthes and Rondina study the short-run dynamics that the interactions of beliefs and actions can generate.

To what extent can asymmetric information and two-sided learning affect the relationships between key macroeconomic variables? The authors address this question by examining the results of simulations they perform using a New Keynesian model with parameters calibrated to standard values. Given these parameters, they find that their model converges to a symmetric and learn-

able, but indeterminate, self-confirming equilibrium. As a point of departure and comparison for the dynamics of their model, they also use the rational expectations equilibrium that emerges when central bankers maintain a fixed policy rule while private agents continue to learn and compute expectations. Their comparative results indicate that asymmetric information and two-sided learning can significantly alter the dynamics of the model compared with the situation in which the economy is operating at a rational expectations equilibrium. The authors also find that the impact is larger when central bankers are still adjusting their beliefs toward their long-run, self-conforming equilibrium values.

A Model of Sovereign Debt with Private Information

Aclassic question in international macroeconomics is why sovereign governments repay debt to foreign creditors, given that governments are not subject to bankruptcy procedures or seizure of assets. Empirical observations indicate that there is a correlation between default and foreign investment: default episodes (periods between the onset of default and eventual settlement) are characterized by sharp declines in foreign investment in the private sector of debtor countries. These declines consist of reductions in foreign direct investment inflows, reductions in foreign credit to private sectors, and capital flight.

In an article in the *Journal of Economic Dynamics and Control*, Toan Phan of the Richmond Fed develops a simple sovereign debt model of an emerging economy, where sovereign default is endogenously costly and the government has an incentive to repay debt and settle default (even in the face of adverse shocks). The model features a small open economy model with production. The country's government is benevolent and issues debt to foreign creditors. The country's private sector receives capital from foreign direct investors. Production in the private sector is subject to a productivity shock that has two components—one that only the domestic government observes and one that everyone observes. The privately observed component represents, for instance, a change in the quality of domestic institutions (economic and/or political) that support foreign investment, about which the government may have some private information. Phan calls this component "the private shock." The public information component represents shocks such as technological changes that are common knowledge. Phan calls this component "the public shock."

> **As long as the shocks are serially correlated, Phan shows that the model predicts countercyclical sovereign spreads and trade balances. The model also predicts a correlation between default cycles and foreign investment cycles.**

First, the author shows that the model generates an endogenous cost of default because non-repayment sends a negative signal about the private shock to productivity and triggers a contraction of investment and output. The equilibrium strategy specifies that when the private shock is good, the government repays debt and settles default to attract foreign investment, as debt service is a credible signal about the good state of the country's private shock. However, when the private shock is bad, it is optimal for the government to default because the cost of repaying to mimic the behavior in the good state is too high. Therefore, in equilibrium, a default leads to a downgrade of investors' expectations over the country's productivity, leading to an endogenous drop in investment and output. In other words, due to the signaling mechanism, there is an endogenous cost to default.

Second, the combination of the public and private shocks allows the model to have several predictions that are consistent with empirical observations. As long as the public shocks and private shocks are not perfectly correlated, equilibrium repayment and settlement can occur in bad times

while default can occur in good times. This is simply because the private shock can be good when the public shock is bad, and vice versa. The model thus helps explain the weak correlation of default cycles and business cycles, as empirically documented by Tomz and Wright (2007). Furthermore, as long as the shocks are serially correlated, Phan shows that the model predicts countercyclical sovereign spreads and trade balances. The model also predicts a correlation between default cycles and foreign investment cycles. These predictions are consistent with documented stylized features of emerging economies.

Nominal Sovereign Debt

By *Toan Phan*
International Economic Review, November 2017, vol. 58, no. 4, pp. 1303–1316

What sustains sovereign debt is a classic question in the theory of international macroeconomics. Unlike private debt, sovereign debt is not secured by collateral, and the debtor government is not subject to bankruptcy procedures or seizure of assets. An influential theory, formalized by Eaton and Gersovitz (1981), is that governments want to keep a reputation for repayment to maintain access to future credit and to avoid economic sanctions. However, in an important critique, Bulow and Rogoff (1989) show that in the absence of sanctions, the threat of credit exclusion cannot sustain sovereign debt as long as defaulting governments can still save with a sufficiently rich set of instruments.

The second layer to this question is: What sustains nominal sovereign debt—that is, sovereign debt denominated in the debtor country's currency? Nominal sovereign debt is subject not only to the risk of default, but also to the risk of opportunistic currency devaluations. In the absence of sanctions, if it is already difficult for the loss of reputation to be a credible threat against default, then what could deter a government from using surprise devaluations to reduce the real value of its nominal debt? In advanced countries with well-established central bank independence, there are strong institutional constraints that deter governments from doing this. However, in developing countries with weaker institutions, the question remains.

In an article in the *International Economic Review*, Toan Phan of the Richmond Fed develops a simple model of a small open endowment economy that explains the sustainability of nominal sovereign debt. As in Bulow and Rogoff, Phan assumes there are no sanctions or exogenous economic costs of default except for the reputational cost of exclusion from future credit. But defaulters still can save. A key assumption is that markets are incomplete: the government can borrow by issuing noncontingent real and nominal bonds, and at the same time, it can save by purchasing noncontingent real risk-free foreign bonds.

Phan's model shows that, unlike Bulow and Rogoff, the reputational cost of credit exclusion is a credible threat against both default and surprise devaluations. The government has an incentive not to default because under credit exclusion, the set of real savings instruments could not replicate the hedging against economic fluctuations provided by nominal debt combined with devaluations in bad times. The government has an incentive not to use surprise devaluations because the loss of monetary reputation would prevent it from issuing nominal bonds in the future.

Once the monetary reputation is lost, debt becomes unsustainable because the reduced set of debt instruments (real government bonds) is only as rich as the set of savings instruments (real foreign reserves) that the defaulting government can use to hedge against future shocks. Therefore, the loss of repayment reputation or monetary reputation would significantly reduce the government's ability to smooth consumption. Phan's model further predicts that in equilibrium, the government would simultaneously borrow in nominal bonds and save in real foreign reserves

to optimally smooth consumption. This prediction is consistent with the stylized fact that governments, including those in emerging markets, tend to borrow and save simultaneously.

Phan concludes that reputation alone can sustain nominal sovereign debt because in the presence of default risk, the loss of monetary reputation seriously affects the ability of the government to borrow. The model accurately predicts that countries with nominal domestic debt tend to have a countercyclical exchange rate policy of devaluations in bad times.

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The Costs of (sub)Sovereign Default Risk: Evidence from Puerto Rico

By Anusha Chari, Ryan Leary, and Toan Phan
National Bureau of Economic Research Working Paper No. 24108, December 2017

The global financial crisis and subsequent debt crises highlight the heightened levels of sovereign default risk across the developed world. In a National Bureau of Economic Research working paper, Anusha Chari and Ryan Leary, both of the University of North Carolina at Chapel Hill, and Toan Phan of the Richmond Fed use Puerto Rico's debt crisis to develop a novel identification strategy for measuring the real costs of (sub)sovereign default risk. For most countries, it is difficult to isolate changes in sovereign default risk from the risks of a currency crisis or a banking crisis or government interference in private contracts. But Puerto Rico's unique characteristics as a U.S. territory effectively eliminate these difficulties, allowing the authors to more easily examine the channels through which heightened (sub)sovereign default risk can have real effects on the macroeconomy. Another important advantage is the availability of Puerto Rican data on macro-indicators, such as employment at higher frequencies and disaggregated at the industry level.

The authors' evidence is consistent with their hypothesis that default risk was an important driver of the decline in Puerto Rican employment over the sample period.

First, Chari, Leary, and Phan find that the deterioration in Puerto Rico's credit rating and credit spreads that occurred after 2012 coincided with a negative and significant aggregate divergence of Puerto Rico's real economic activity from that of the mainland United States.

Second, they use an approach similar to Rajan and Zingales (1998) to establish that Puerto Rico's heightened default risk reduced employment growth in industries that were more exposed to default risk via the government-demand channel relative to those industries that were less reliant on government demand. Specifically, they find that average monthly employment growth for manufacturing industries above the median dependence on government demand was negative 0.58 percent, while average monthly employment growth was positive 0.30 percent for industries below the median dependence on government demand during the sample period. (They use Rajan and Zingales's methodology to address the concern that declines in economic activity may have driven increased default risk, potentially confounding identification of the effect of default risk on employment.)

The authors find that the magnitude of the negative effect of default risk on employment growth in government-demand-dependent industries increased when the government undertook austerity measures. One potential rationale for this result is that agents learned about future government policy when they observed austerity measures in response to increased default risk. The authors find that increased default risk Granger caused Puerto Rico's austerity measures, indicating the government may have undertaken austerity in response to borrowing constraints or to reassure investors.

Chari, Leary, and Phan also find that employment growth decreased in industries that were ex ante more exposed or sensitive to a default event due to greater dependence on external financing. Again, using an approach similar to Rajan and Zingales (1998), they specifically find that aver-

age monthly employment growth for manufacturing industries above the median dependence on external finance was negative 0.42 percent, while average monthly employment growth was negative 0.28 percent for industries below the median dependence on external finance during the sample period.

Overall, the authors' evidence is consistent with their hypothesis that default risk was an important driver of the decline in Puerto Rican employment over the sample period.

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Review of *Zoning Rules! The Economics of Land Use Regulation* by Fischel

By Santiago Pinto

Land-use regulations are a demand-driven, bottom-up institution promoted mostly by home-owners (but also by land developers in some cases). These regulations are not bad per se, but they become a problem when they are excessive. And evidence indicates that excessive land-use regulations, commonly labeled "growth controls," have been proliferating across U.S. metropolitan areas, particularly since the 1970s.

In *Zoning Rules! The Economics of Land Use Regulation*, Dartmouth College economist William A. Fischel provides a comprehensive discussion of these ideas. He reviews the history of land-use regulations in the United States, describes the most salient factors underlying historical and recent trends, and offers explanations—founded on basic economic principles—for the emergence and evolution of zoning regulations.

The first factor Fischel highlights is the incentive of homeowners to protect the value of their homes against undesirable new development in the surrounding area. As homeownership increased, and as home values became a significant portion of households' wealth, homeowners generally demanded and received stricter land-use regulations. Fischel also contends that regional and national events may have increased the political influence of groups that tend to oppose land development. Environmentalism, mostly a national phenomenon, provided the unifying ideological justification for more restrictive top-down land-use measures. Environmental legislation of the 1970s empowered private citizens to sue their local governments. Courts became more proenvironment as well. At the same time, there was an increase in the number of state and national agencies that became more involved with local land-use issues. Their decisions sometimes overlapped and even contradicted rulings made by local authorities. Finally, Fischel suggests that the civil rights movement had a subtle impact on suburban land regulation. Since federal courts had clearly ruled against any form of selective discrimination, suburban homeowners shifted toward exclusionary regulations that essentially restricted all types of development.

Fischel proposes a number of remedies aimed at moderating the incentives to implement excessive land-use regulations. He suggests that one of the determinants of excessive regulation is excessive homeownership. So some of Fischel's proposals, such as taxing imputed rents or limiting tax deductions for home mortgage interest, are aimed at reducing homeownership. Fischel says this is necessary because homeowners are essentially overrepresented in local politics, so decisions concerning land-use regulations tend to be biased in their favor at the expense of nonhomeowners.

In a 2017 review of *Zoning Rules!* in the *Review of Regional Studies*, Santiago Pinto of the Richmond Fed notes that the book revises and updates the material presented in Fischel's previous book, *The Economics of Zoning Laws*, published in 1985. Even though the author subtly departs from some

of his previous views (most importantly his view about the role of the judicial system in assuring rational land use), his core idea that zoning regulations are an endogenous, demand-driven phenomenon remains intact. Pinto concludes that the book is an excellent resource for students who are interested in urban economics and urban planning at both the undergraduate and graduate levels. For undergraduate students, the book reviews and provides examples and applications of the economic principles behind the basic urban equilibrium model. For graduate students, the book offers a wide range of ideas that could be studied and developed further.

http://journal.srsa.org/ojs/index.php/RRS/article/view/991/705

An Anatomy of U.S. Personal Bankruptcy under Chapter 13

By Hülya Eraslan, Gizem Koşar, Wenli Li, and Pierre-Daniel Sarte

The Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 imposed many changes, including stricter rules on repayment plans under Chapter 13 personal bankruptcy. The key presumption underlying these stricter rules was that a large number of households were not repaying as much as their incomes would allow.

In an article in the *International Economic Review*, Hülya Eraslan of Rice University, Gizem Koşar of the New York Fed, Wenli Li of the Philadelphia Fed, and Pierre-Daniel Sarte of the Richmond Fed assess the effect of new restrictions on the length of repayment plans for debtors with incomes above the medians in their states. The authors begin by building and estimating a structural model that captures the salient features of personal bankruptcy under Chapter 13. A debtor decides whether or not to file under Chapter 13 and, if so, what repayment plan to propose. Since the law requires that all of a debtor's excess income be applied to his repayment plan, the debtor's choice of repayment plan boils down to its length. Overall, the model highlights the basic trade-off a debtor faces in proposing a long repayment plan versus a short one. A long repayment plan places restraints on the debtor for longer periods, but a longer plan may be more likely to be accepted by the court and, ultimately, to result in a fresh start for the debtor. In addition, the model highlights the importance of shocks to a debtor's excess income during the bankruptcy process. Even though a plan may be fair and feasible when a debtor files for bankruptcy, changes to the debtor's circumstances while in bankruptcy, such as an unexpected health expense, could make it challenging to complete the plan in practice.

In the model, it appears that new restrictions on the length of repayment plans under Chapter 13 bankruptcy can make it more difficult for debtors to obtain a fresh start while not necessarily helping creditors recover more money.

The authors estimate their model using newly collected data from all Chapter 13 personal bankruptcy filings recorded by the U.S. Bankruptcy Court for the District of Delaware between August 2001 and August 2002. They extract information concerning filers' financial and demographic characteristics at the time of filings and the final outcomes of their cases. Specifically, the authors collect data on the outcomes predicted by their model: the choice of plan length, whether the plan is confirmed or not, whether the case is successfully completed or not, and the recovery rate of the creditors. In addition to these endogenous outcomes, the decision to file for Chapter 13 in the first place is also endogenous in the model. Although all the debtors in their sample have chosen to file for Chapter 13, the authors identify the parameters associated with this decision through the variation in the decision to continue or voluntarily default on the plan following shocks to excess income.

The authors use their model to conduct policy experiments to assess the effect of the new restrictions on the length of repayment plans. They find that this new policy would not materially affect

creditor recovery rates and would not necessarily make discharge more likely for debtors with incomes above the state median. These findings are robust to alternative policy experiments that require bankruptcy plans to meet stricter standards in other ways, such as proposing a higher re-covery rate. In fact, in these alternative experiments, some Chapter 13 filers no longer choose to file, resulting in lower recovery rates and discharge rates. It appears, therefore, that the new restrictions can make it more difficult for debtors to obtain a fresh start while not necessarily helping creditors recover more money.

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Estimation and Inference of Threshold Regression Models with Measurement Errors

By Terence Tai-Leung Chong, Haiqiang Chen, Tsz-Nga Wong, and Isabel Kit-Ming Yan
Studies in Nonlinear Dynamics and Econometrics*, April 2018, vol. 22, no. 2*

Measurement error is a common problem in economic data. In particular, macroeconomic data—such as GDP, consumption, unemployment, and inflation—are often subject to mea-surement errors and frequently revised because of data aggregation or for other reasons. Over the years, economists have proposed ways of dealing with measurement errors in explanatory variables, but no study in the literature has attempted to explore the problem of measurement errors in the context of standard threshold regression models. An important assumption underlying these models and their variants in the extant literature is that the threshold variable is perfectly measured. Such an assumption is crucial for consistent estimation of model parameters. If there are measurement errors in the threshold variable, the observations cannot be correctly ranked ac-cording to their true values, a problem that can render the estimator inconsistent in such models.

In an article in *Studies in Nonlinear Dynamics and Econometrics*, Terence Tai-Leung Chong of the Chinese University of Hong Kong, Haiqiang Chen of Xiamen University, Tsz-Nga Wong of the Richmond Fed, and Isabel Kit-Ming Yan of City University of Hong Kong provide the first theoreti-cal framework for the estimation and inference of threshold regression models with measurement errors. Empirically, there is an important distinction between measurement errors in explanatory variables and measurement errors in the threshold variable. In the former case, where the mea-surement error is often assumed i.i.d. additive to the regressors, all observations of the regressors are confounded by the measurement error. As a result, the true model parameters cannot be retrieved from any subsets of the observations. In the latter case, however, the existence of mea-surement errors may not lead to misclassification of observations. Therefore, researchers can improve the parameter estimates of a threshold regression model by estimating a subsample where misclassification is unlikely to occur.

Chong, Chen, Wong, and Yan propose a new method that reduces the bias of the parameter estimates in the presence of measurement errors. Then they develop a Hausman-type test—Hausman (1978, 2001) and Jeong and Maddala (1991)—for measurement errors in threshold variables. The authors' test is based on the estimation difference between two estimators; the first estimator assigns equal weight to each observation, and the second estimator assigns zero weight to highly contaminated observations. Under the null hypothesis of no measurement error, both estimators are consistent, but the second estimator is less efficient. Under the alternative hypothesis, both estimators are inconsistent, but the second estimator is less biased. The authors' test statistic is shown to have an asymptotic Chi-square distribution, and their Monte Carlo simula-tions provide evidence that this new test performs well in terms of size and power.

Chong, Chen, Wong, and Yan use their test to reestimate the growth convergence model of Han-sen (2000), using per capita output and the adult literacy rate as threshold variables. Since the data

are taken from earlier years, these two variables might suffer from measurement error. Their test results suggest the existence of measurement errors in both threshold variables. They reestimate the model and find that the convergence hypothesis only holds for countries with lower initial per capita output, which differs from the Hansen (2000) results. They also find that the convergence hypothesis only holds for countries with higher adult literacy rates, which corroborates the Hansen (2000) results.

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A Tractable Model of Monetary Exchange with Ex-Post Heterogeneity

By Guillaume Rocheteau, Pierre-Olivier Weill, and Tsz-Nga Wong
Theoretical Economics*, forthcoming*

In an article forthcoming in *Theoretical Economics*, Guillaume Rocheteau of the University of California, Irvine, Pierre-Olivier Weill of UCLA, and Tsz-Nga Wong of the Richmond Fed construct a continuous-time pure currency economy based on the competitive version of the Lagos and Wright (2005) model developed by Rocheteau and Wright (2005)—LRW. As in LRW, agents make endogenous labor-supply decisions and use liquid assets (usually supplied by the central bank, e.g., currency and reserves) to finance unexpected expenditures. The novelty is that the authors do not restrict preferences as in LRW to shut down wealth effects and, hence, allow for a distributional channel of monetary policy that can promote risk-sharing. In contrast, policies redistributing wealth in LRW have no real consequence. The model is tractable enough to give closed-form solutions and informative policy analysis, for example, in the midst of a liquidity trap.

The authors first focus on a pure currency economy because it is the most transparent benchmark for studying the fundamental monetary policy trade-off between enhancing the rate of return of currency and providing risk-sharing. In the model, ex-ante identical households with consumption and leisure flows can trade continuously in competitive spot markets. At random times, households encounter large spending shocks that cannot be financed by income alone. The model generates heterogeneous individual histories and hence a nondegenerate distribution of money holdings.

Rocheteau, Weill, and Wong characterize households' consumption and saving decisions under smooth preferences that allow for wealth effects. They show that households have targets for their real money balances that depend on their rate of time preference, the inflation rate, and the frequency of consumption opportunities. Households approach their targets gradually by saving a decreasing fraction of their labor income. When they encounter a large shock, they tap their savings. Given households' optimal consumption-saving behavior, the authors characterize the stationary distribution of real money holdings in the population and solve for the value of money, thereby establishing a unique equilibrium. Next, they study the case where households have linear preferences over consumption and labor flows. In this case, households save their full labor incomes until they reach their targets for real balances in finite time. This version showcases the tractability of the model as the equilibrium can be characterized in closed form.

The authors study monetary policy in the form of stationary transfer schemes financed by money creation. They find that lump-sum transfers financed by money creation are welfare-enhancing when labor productivity is low and preferences are linear with a satiation point, whereas regressive transfers approach first best when labor productivity is high and agents are not too impatient.

When the authors extend their pure currency economy by adding illiquid nominal government bonds, they find that liquidity traps can occur when labor productivity is low and idiosyncratic risk is high. In such equilibria, open market operations alone would be ineffective, but a combination of open market operations and "helicopter drops" would be welfare-enhancing.

To illustrate other tractable cases, the authors provide an example with quadratic preferences. This example shows the transitional dynamics of a one-time, unanticipated money injection that leads to a welfare-enhancing decrease in the spread of the distribution of real balances. Another example shows the effects of inflation on the velocity of money under heterogeneous preference shocks. In this scenario, households spend all their real balances when their marginal utility of lumpy consumption is above an endogenous threshold. As inflation increases, households reduce this threshold, exhibiting the so-called "hot potato" effect of inflation.

https://econtheory.org/ojs/index.php/te/article/viewForthcomingFile/2821/19352/1

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
Review of Economic Studies, *forthcoming*

Editor's Note: A working paper version of this article (released by the National Bureau of Economic Research) was featured in the *2014 Richmond Fed Research Digest*. The newly published version summarized below includes three additional applications.

Fluctuations in aggregate economic activity result from a wide variety of aggregate and disaggregated phenomena. These phenomena can reflect underlying changes that are sectoral. In other cases, productivity changes are specific to a sector and location. The heterogeneity of these changes in productivity implies that the sectoral and regional composition of an economy is essential to determining their aggregate impact. That is, regional trade, the presence of land and structures, regional migration, as well as input-output relationships between sectors determine the impact of a disaggregated sectoral or regional productivity change on aggregate outcomes.

In an article forthcoming in the *Review of Economic Studies*, Lorenzo Caliendo of Yale University, Fernando Parro of Johns Hopkins University, Esteban Rossi-Hansberg of Princeton University, and Pierre-Daniel Sarte of the Richmond Fed develop a quantitative model of the U.S. economy broken down by regions and sectors to study how these different aspects of economic geography influence the effects of disaggregated productivity disturbances.

The effects of disaggregated productivity changes depend in complex ways on which sectors and regions are affected and how they are linked to other sectors and regions.

Their framework builds on Eaton and Kortum (2002) and the growing international trade literature that extends their model to multiple sectors. However, labor mobility, local fixed factors, and heterogeneous productivities introduce a different set of mechanisms. The authors' model includes two factors of production in each region: labor and land/structures. Labor can move across both regions and sectors. Land and structures can be used by any sector but are fixed locally. Sectors are interconnected by input-output linkages, and the cost of shipping materials to other regions varies with distance. The authors use data on pairwise trade flows across states by industry, as well as other regional and industry data, to quantify their model. Hence, for a given change in productivity within a particular sector and region, the model delivers the effects of this change on all sectors and regions.

The authors find that disaggregated productivity changes can have different aggregate implications depending on the regions and sectors affected. These effects arise in part by way of endogenous changes in regional trade through a selection effect that determines what types of goods are produced in which regions. They also arise by way of labor migration toward more-productive regions. This inflow of workers strains local fixed factors, therefore mitigating the direct effects of productivity increases. Thus, the effects of disaggregated productivity changes depend in complex ways on which sectors and regions are affected and how they are linked to other sectors and regions.

These spatial effects significantly impact the magnitude of the aggregate elasticity of sectoral shocks. For example, failure to account for regional trade understates the aggregate GDP elasticity of an increase in productivity in the petroleum and coal industry, the most spatially concentrated industry in the United States, by about 10 percent but overstates it by 19 percent in the transportation equipment industry, which is far less concentrated. Ultimately, regional trade linkages and the fact that materials produced in one region are potentially used as inputs far away are essential in propagating productivity changes spatially and across sectors. The authors use their model to study the aggregate and disaggregated effects of shocks to productivity and infrastructure, including the boom in California's computer industry, the shale oil boom in North Dakota, disruptions to New York's finance and real estate industry, and the destruction of Louisiana infrastructure following Hurricane Katrina.

http://www.restud.com/wp-content/uploads/2017/12/MS21211manuscript.pdf

Competitors, Complementors, Parents and Places: Explaining Regional Agglomeration in the U.S. Auto Industry

By Luís Cabral, Zhu Wang, and Daniel Yi Xu
Review of Economic Dynamics, *forthcoming*

Editor's Note: A working paper version of this article (released by the National Bureau of Economic Research) was featured in the *2013 Richmond Fed Research Digest*. The newly published version summarized below sheds new light on the relative importance of each contributing factor that accounted for the U.S. auto industry agglomeration in the authors' analysis.

Over the years, economists have offered different explanations for the phenomenon of agglomeration, the geographic clustering of firms within an industry. Alfred Marshall provided one of the earliest hypotheses for agglomeration in his 1890 text, *Principles of Economics*. He posited that firms cluster together to benefit from positive spillovers from neighboring firms in the same industry (intraindustry externalities). An alternative hypothesis is that industries benefit from positive spillovers from nearby related industries (interindustry externalities). Still others have suggested that industry clustering is primarily the result of spinouts (new firms formed by former employees of existing firms) that operate in the same area. Finally, some economists have argued that the locations themselves are important, offering unique advantages for particular industries.

In an article forthcoming in the *Review of Economic Dynamics*, Luís Cabral of New York University, Zhu Wang of the Richmond Fed, and Daniel Yi Xu of Duke University evaluate the extent to which these four hypotheses explain agglomeration in the U.S. auto industry. They analyze data on the auto industry ranging from 1895–1969, including data on the precursor carriage and wagon industry. The authors identify six historically important auto-production centers: Detroit, New York, Indianapolis, Chicago, Rochester, and St. Louis. They find that, contrary to the narrow definition of Marshall's hypothesis, intraindustry spillover had a negligible or even negative effect on auto-industry clustering. They interpret this result as implying that negative competition externalities offset or outweighed the positive spillovers. In contrast, the authors find that interindustry externalities were very important. The size of the carriage and wagon industry, in particular, significantly affected the number and quality of auto firms in several clusters. This suggests that Marshall's hypothesis may be valid if interpreted in a broader context. Spinouts were also very important, especially in Detroit's rise to preeminence. However, the authors find that the performance of spinouts is heavily affected by local "family members" but not by distant ones, which suggests that spinouts may actually benefit from intrafamily local spillovers rather than a heredity effect. This finding suggests that the spinout hypothesis also may relate to Marshall's intraindustry hypothesis.

Finally, the authors find significant location-specific effects, particularly in the long run. The search for locally available inputs led auto-company founders to Detroit. Moreover, many of them were previously associated with local carriage and wagon companies, the location of which was in turn largely determined by the availability of local inputs. In the short run (taking carriage and wagon industry locations as given), they estimate that interindustry spillovers contribute 46 percent toward explaining total agglomeration; local input resources, 23 percent; and spinouts, 60 percent. These three factors total more than 100 percent to compensate for the dispersion effect of local competitors. In the long run (taking explicit account of carriage and wagon industry location decisions), the authors estimate that interindustry spillovers contribute 10 percent; local input resources, 53 percent; and spinouts, 80 percent. In other words, much of the effect of related industry spillovers is transferred to local input resources once the authors consider carriage and wagon industry location decisions as endogenous.

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Equilibrium Price Dispersion across and within Stores

By Guido Menzio and Nicholas Trachter

Editor's Note: This article is substantially the same as the National Bureau of Economic Research working paper of the same title that was summarized in the _2016 Richmond Fed Research Digest_.

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