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## Program Report

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## Productivity, Innovation, and Entrepreneurship Program

Nicholas Bloom and Josh Lerner\*

The Productivity, Innovation and Entrepreneurship Program was founded as the Productivity Program, with Zvi Griliches as the inaugural program director, in 1978. It has more recently expanded to incorporate the vibrant and growing body of research in the affiliated fields of innovation and entrepreneurship. The program benefited tremendously from Griliches' inspirational leadership, continued by Ernst Berndt after Zvi's untimely death in 1999. We have had the privilege of co-directing the program since 2011.

The program has generated a remarkable volume of research activity. It currently has 90 active members, and the program's cumulative output includes more than 1,350 affiliated working papers on a wide range of topics. The activities of the program are organized into four large project areas. These are: economic research on the measurement and drivers of productivity growth; entrepreneurship, which focuses on the measurement, causes, and effects of new business creation; innovation, which examines R and D, patenting, and creative activities; and digitization, a recently-launched project area, which focuses on the creation, use, and impact of digital information. This review summarizes the research in each of these four areas.

### Economic Research on Productivity

As Paul Krugman famously quipped, "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its

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# NBER Reporter

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ability to raise its output per worker.”<sup>1</sup> Rising productivity has been the key to American growth over the last two centuries and will be the key to improving the lives of many millions in the developing world. Even in the recent recession, there has been an active and ongoing debate about the long-term potential growth rate of US output. Understanding productivity growth is a central topic in economics, and one that naturally overlaps with many other NBER programs.

The research by program affiliates displays a strong emphasis on the roles of research and development, patents, incentive systems, regulations, technological progress, and organizational form in influencing the extent and nature of productivity growth. In addition, the PRIE Program has long had a sharp focus on economic measurement, including inputs, outputs, prices, quality change, and multifactor productivity, that has been led in particular by the Conference on Research in Income and Wealth (CRIW). Activities on the broad subject of productivity center on spring and summer research meetings. These meetings allow program members to present work in progress on a variety of productivity topics. The summer meetings are split into sessions that focus on macroeconomic aspects of productivity, and on productivity issues in developing countries. Given the breadth of the program's research, we can highlight only a few examples of the research issues that program members explore.

One strand of research revolves around the productivity and performance of health care. For example, one recent study examines the traditional wisdom that market forces are weak in the health care sector, leading to a massive dispersion of performance across hospitals.<sup>2</sup> If poorly performing hospitals rarely close, there should exist a huge dispersion of performance. The paper finds that indeed while there is a large spread of performance across hospitals, surprisingly it is comparable to the extent of dispersion in other sectors like manufacturing and retail.<sup>3</sup> Moreover, much like manufacturing, the health care sector shows a strong link between market share and productivity — high performing hospitals grow faster than low performing hospitals, so that performance and size are strongly linked. The paper concludes that health care is far less of

an exceptional industry than is commonly believed, looking in fact rather similar to sectors like manufacturing on certain market dimensions.

Another strand of the program focuses on the importance of micro and macro forces in driving aggregate productivity. Researchers often highlight two ways aggregate productivity can rise: firstly there is the reallocation “batting average” effect, whereby if more productive firms expand and less productive firms contract, then average productivity rises.<sup>4</sup> The second is the macro “rising tide” effect, whereby if innovation and development increase the productivity of every firm, aggregate productivity also rises. One recent paper on this topic investigated the role of adjustment costs and volatility in explaining the dispersion and average of productivity across over 30 developing countries.<sup>5</sup> The authors found that low productivity in developing countries may be the result of extremely volatile micro-productivity of firms, making it hard for market forces to reallocate output appropriately. This highlights how removing distortions and adjustment costs, as well as reducing market turbulence and uncertainty, can aid the promotion of successful firms.

A third strand of work centers around management and managers. For example, one recent paper<sup>6</sup> shows how the structure of top management in US firms has radically changed since the 1980s. CEOs have doubled the number of managers reporting to them, with a large rise in the number of “product” managers (R and D, marketing) as firms have focused their businesses, and in “functional” managers (finance, law, human resources) as firms invest more heavily in information technology. General managerial positions have shrunk as a share of the total, and the pay of such managers has fallen as more specialized product and functional managers have joined. Another study on a related topic detailed the collection of extensive data on the daily activities of Indian

CEOs.<sup>7</sup> It revealed that there is a massive variation in their activities, with CEOs who adopt a more structured routine involving internal cross-functional meetings tending to be more successful compared to those with more “free” time focused on outsiders. It also reported that CEO hours are strongly linked with performance, and that non-family CEOs tend to be much harder working and dedicated—in particular, showing they battle to work even during monsoons and Indian international cricket matches. This highlights how CEO types, hours, and management styles are important drivers of firm productivity, and the importance of starting to explore what these are and how to measure them.

The CRIW is also an important component of the program’s research activities on productivity issues. One of its goals is to support the development of the national accounts and associated statistics. It represents an ongoing collaboration between the statistical agencies, policy community, and academia to advance the field of economic measurement. As such, the membership of the CRIW is split between academic and non-academic members. The CRIW is funded by the statistical agencies and the organization has a sixteen person executive committee, chaired by Charles Hulten, that elects the membership and arranges for individual conferences.

The CRIW organizes a workshop at the NBER Summer Institute which tackles a range of data-related topics. In 2012, for example, one focus was on the emerging value of “big data,” including both administrative records from government agencies and transaction and customer data from private firms. The CRIW also sponsors an annual conference. In 2013 the topic will be “Measuring and Modeling Health Care Costs”, and in 2014, “Measuring Entrepreneurial Businesses: Current Knowledge and Challenges.” These conferences usually result in a conference volume published under the auspices of the NBER.

## Entrepreneurship

The PRIE Program’s activities in the entrepreneurship area, and the NBER’s efforts more broadly, are directed by Antoinette Schoar, an NBER Research Associate at MIT’s Sloan School of Management. Activities in this area were launched at a 2003 meeting that included many of the leading researchers from various fields of economics that touched on entrepreneurship. This meeting led to a broad consensus that by many measures, the years since 1980 had seen a dramatic increase in the importance of entrepreneurial activity in the United States. While the overall growth in the number of entrepreneurial firms and business starts was relatively modest, the role of new enterprises in fomenting innovation, stimulating employment, and creating value for investors increased dramatically. Yet surprisingly, academic research—particularly in economics—had not kept pace. The number of articles on entrepreneurship issues in the major economics journals actually declined in the 1990s from the levels seen in the 1980s. A number of factors might explain this pattern. While data on public firms are readily available in machine-readable databases such as those maintained by the Center for Research in Security Prices, and Compustat, information on young private firms is much harder to come by. Datasets on entrepreneurial firms are in many cases only available through the time-consuming cultivation of personal contacts, and even then are often of widely variable quality.

In an effort to encourage research on entrepreneurship and to build a network of researchers who could share data and other insights, and with the ongoing support of the Ewing Marion Kauffman Foundation, the NBER launched an entrepreneurship initiative, which has carried out three broad types of research activity. First, the group convenes a semi-annual meeting of researchers interested in entrepreneurship research. During the 2013 Summer Institute, for example, more

than 100 scholars participated, ranging from Ph.D. candidates to some of the most senior scholars in the field. This meeting has brought together researchers working on a wide range of topics and presentations have included papers ranging from the financing of entrepreneurs and venture capital funding,<sup>8</sup> to macro implications of entrepreneurship and self-employment,<sup>9</sup> to entrepreneurship in developing countries.<sup>10</sup>

Second, the entrepreneurship initiative has sponsored a number of meetings on specialized topics. The first was on academic entrepreneurship. The idea that academic science is an engine of growth, creating technological opportunities for industrial innovation as well as future scientific research, is well known and studied. Little is known, however, about the role of academic entrepreneurship — faculty participation in commercialization of their inventions and new firm creation — in the innovation process. The project offered a range of new insights on the nature of the entrepreneurship process that emerges from colleges and universities. The second meeting focused on the strategy and structure of entrepreneurial firms.<sup>11</sup> It provided a forum for rigorous research on the microeconomic and institutional foundations of entrepreneurship, and the strategic and market consequences of entrepreneurial activity. The third meeting focused on international differences in entrepreneurship. It was motivated by the concern that far too much of the research into entrepreneurship was focused on the United States. This project sought to encourage a range of studies by a global team of scholars. A fourth conference was motivated by the unprecedented activity in private equity, despite which most of the academic research on private equity markets was undertaken as a result of the previous leveraged buyout (LBO) wave of the 1980s.

The third major activity of the entrepreneurship initiative is outreach to young scholars interested in entrepreneurship. At many universities,

graduate students interested in entrepreneurship have few knowledgeable scholars with whom to discuss their research. The consequences in many cases are either the abandonment of the research agenda or the production of inferior research. Since the summer of 2008, the NBER has brought together graduate students in doctoral programs in the United States and Europe for a four-day “boot camp” on entrepreneurship research. The Entrepreneurship Research Boot Camp (ERBC), which is organized by Thomas Hellmann, is typically held immediately following the NBER Entrepreneurship summer meeting. ERBC participants are Ph.D. students who have completed at least one year (and ideally two or three) of their Ph.D. program, and are committed to doing research on entrepreneurship.

### Innovation Policy

The PRIE program’s activities on innovation policy, and those of the NBER more generally, are directed by Scott Stern, an NBER Research Associate at the MIT Sloan School of Management. This effort, including the Innovation Policy and the Economy (IPE) meeting which is held in Washington each year, was launched in 1999 to provide first-class researchers with frequent and repeated interaction with other researchers interested in innovation, and with those who deal with specific policy questions. Early support was provided by the Alfred P. Sloan Foundation. More recently, the Kauffman Foundation provided partial support for the IPE program as well, focusing specifically on the relationship between entrepreneurship and public policy.

This effort examines a wide range of issues, including any policy that affects the ability of an economy to produce scientific and technological progress or that mediates the impact that science and technology has on the process of economic growth. Thus the area of attention is broader than “sci-

ence and technology policy,” which typically connotes a focus on issues such as federal R and D policy and fiscal incentives for private R and D. Recent research discussed at meetings of the innovation group has touched on the role of intellectual property rights in affecting innovation,<sup>12</sup> the impact of incentives for innovation on the production of new ideas,<sup>13</sup> and the role of innovation in the health care sector.<sup>14</sup>

The NBER’s innovation policy initiative has four primary activities, the first of which is the IPE meeting. For more than ten years, the NBER has hosted this meeting in Washington geared to an audience of congressional and administration staff and other policymakers and policy analysts. The organizers solicit the papers for this meeting, identifying particular individuals who have been active researchers in areas of policy interest, and who have the skills and inclination to interact with a broader audience. These meetings are not organized around a single theme, but rather include about six papers on topics of current policy interest. The meeting concludes with a luncheon address by an academic economist currently involved in public service such as the Chairman of the Council of Economic Advisers. In recent years, these meetings have traditionally attracted between 125 and 150 people from the executive and legislative branches, as well as from other Washington organizations, as well as members of the press. Each of these meetings results in an annual edited volume.

The second activity is a meeting at the NBER Summer Institute featuring the presentation of early-stage research. One day of this meeting has typically focused on the economics of intellectual property. Collectively, these meetings have highlighted research on a wide range of issues in innovation policy, such as the Orphan Drug Act, the drivers of regional entrepreneurship, R and D manpower policy, a range of issues related to the patent system, and the evaluation of various innovation



policy programs. These sessions have been organized in recent years by Pierre Azoulay, Jeff Furman, Ben Jones, and Scott Stern.

Third, the innovation policy initiative convenes occasional research conferences. One particularly notable meeting, held in 2010, was organized to mark the 50<sup>th</sup> anniversary of *The Rate and Direction of Inventive Activity*, a volume published by the NBER in 1962. This historical volume contains several landmark papers in the economics of technological change, including Kenneth Arrow's essay on "Economic Welfare and the Allocation of Resources for Invention." The 2010 conference and subsequent volume, *The Rate and Direction of Inventive Activity Revisited*, sought to commemorate the achievements of the original volume, and to sponsor new theoretical and empirical contributions on fundamental questions in the economics of innovation and technological change. In 2013, the group convened for another meeting titled "The Changing Frontier: Rethinking Science and Innovation Policy." The proceedings of this meeting, which focused on the impact of the changing nature of scientific research and innovation, for example, the rise of scientific teams, increased internationalization, and rising specialization, will be published as an NBER volume.

Finally, the innovation policy initiative administers an annual series of modest research grants, and appoints an Innovation Policy and the Economy Fellow. The IPE Fellow is a junior scholar who has the opportunity to spend a year in residence at the NBER and to participate in the activities of the IPE group and those of the NBER more generally.

## The Economics of Digitization

The fourth distinct project within the PRIE program focuses on the economics of digitization. This project is led by NBER researchers Shane Greenstein, of Northwestern

University, and Scott Stern. The starting point for this project is the recognition that the creation, support, use, and consumption of digital representation of information has touched a wide breadth of economic activities. In less than a generation the costs of storage, computation, and transmission of information have declined by several orders of magnitude, lowering the costs of many final products and enabling the creation of an enormous range of new applications. Digitization has transformed social interactions, facilitated entirely new industries and undermined others, and reshaped the ability of people — consumers, job seekers, managers, government officials, and citizens — to access and leverage information. This project is supported by the Alfred P. Sloan Foundation.

The digitization project examines the causes and consequences of digitization for market actors — for their choices over strategic organization, market conduct, and public policies. This project seeks to identify and stress unaddressed research areas, and to tackle questions about business strategy and economics touched by legal forms for governing property rights in information, in particular copyright and open source. Of the various technology drivers enabling the rise of digital technology, growth in digital communication — particularly the internet — has played a central role. Not surprisingly, therefore, this project emphasizes research on internet technology and its economics.

The digitization project has focused on several core themes. One concerns the analysis of supply and demand in internet-mediated markets. These studies help to explain how internet technology came to be widespread, and they explore how the benefits and costs of moving information to a digital format determined internet diffusion. A second theme explores how internet technology changes market behavior and outcomes. These studies explore, in particular, how digitization altered economic frictions such

as search costs and distribution costs over a wide range of economic activity. Research on this theme also emphasizes the constraints on the ability of digital technology to overcome such frictions. A third theme explores the impact of the changes associated with digitization on policy and vice versa. If search and distribution costs are lower and information sharing is easy, how does that affect local sales taxes, local restrictions on information, and the demand for privacy? What issues can government policy address, and what consequences — anticipated and unanticipated — result from different types of intervention? The economics of digitization project has hosted two meetings, each of which has included not only economists but also lawyers and business leaders.

This project has convened two meetings as part of the NBER Summer Institute. These have been organized by Susan Athey, Erik Brynjolfsson, Shane Greenstein, and Hal Varian. The papers presented at these meetings have touched on a range of issues, including the role of copyright protection in the music industry,<sup>15</sup> the microeconomics of digitization (online content, market structures, impacts on the economy and society), and the macroeconomics of digitization (the role of IT in driving US growth, inequality, and innovation). The project also sponsored a recent conference that included sixteen papers, organized by Shane Greenstein, Catherine Tucker, and Avi Goldfarb: the published proceedings will represent an important reference on this emerging topic area.<sup>16</sup> This project also offers fellowship support for a Ph.D. student who is completing a dissertation on some topic related to the economics of digitization, and it offers small grants to more senior researchers who are working on this topic.

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<sup>1</sup> P. R. Krugman, *The Age of Diminished Expectations* (Cambridge: MIT Press, 1994).

<sup>2</sup> A. Chandra, A. Finkelstein,

A. Sacarny, and C. Syverson, "Healthcare Exceptionalism? Productivity and Allocation in the US Healthcare Sector," NBER Working Paper No. 19200, July 2013.

<sup>3</sup> Examples include A. Collard-Wexler and J. De Loecker, "Reallocation and Technology: Evidence from the US Steel Industry," NBER Working Paper No. 18739, January 2013; E. Basker, "Raising the Barcode Scanner: Technology and Productivity in the Retail Sector," NBER Working Paper No. 17825, February 2012; and L. Foster, J. Haltiwanger, and C. Syverson, "The Slow Growth of New Plants: Learning About Demand?" NBER Working Paper No. 17853, February 2012.

<sup>4</sup> Examples include D. Acemoglu, U. Akcigit, N. Bloom, and W. Kerr, "Innovation, Reallocation, and Growth," NBER Working Paper No. 18993, April 2013, and M. Nishida, A. Petrin, and S. Polanec, "Exploring Reallocation's Apparent Weak Contribution to Growth," NBER Working Paper No. 19012, May 2013.

<sup>5</sup> A. Collard-Wexler, J. Asker, and J. De Loecker, "Productivity Volatility and Misallocation of Resources in Developing Economies," NBER Working

Paper No. 17175, June 2011.

<sup>6</sup> M. Guadalupe, H. Li, and J. Wulf, "Who Lives in the C-Suite? Organizational Structure and the Division of Labor in Top Management," NBER Working Paper No. 17846, February 2012.

<sup>7</sup> O. Bandiera, A. Prat, and R. Sadun, "Managing Firms in an Emerging Economy: Evidence from the Time Use of Indian CEOs," Harvard Business School working paper, April 2013.

<sup>8</sup> R. Nanda and M. Rhodes-Kropf, "Investment Cycles and Start-up Innovation," Harvard Business School Entrepreneurial Management Working Paper No. 12-032, December 2012.

<sup>9</sup> T. Fort, J. Haltiwanger, R. Jarmin, and J. Miranda, "How Firms Respond to Business Cycles: The Role of Firm Age and Firm Size," NBER Working Paper No. 19134, August 2013.

<sup>10</sup> A. Adhvaryu, N. Kala, and A. Nyshadham, "Booms, Busts, and Household Enterprise: Evidence from Coffee Farmers in Tanzania," Yale School of Public Health working paper, March 2013.

<sup>11</sup> The proceedings were published in the Fall 2009 issue of the *Journal of Economics and Management Strategy*.

<sup>12</sup> H. Williams, "Intellectual Property Rights and Innovation: Evidence from the Human Genome," NBER Working Paper No. 16213, July 2010.

<sup>13</sup> P. Azoulay, J. Graff Zivin, and G. Manso, "Incentives and Creativity: Evidence from the Academic Life Sciences," *RAND Journal of Economics* 42 (2011), pp. 527-54 (also NBER Working Paper No. 15466, October 2009.)

<sup>14</sup> D. Cutler, "Where are the Health Care Entrepreneurs? The Failure of Organizational Innovation in Health Care," in *Innovation Policy and the Economy*, Volume 11, J. Lerner and S. Stern, eds. Chicago: University of Chicago Press, 2010 (also NBER Working Paper No. 16030, May 2010.)

<sup>15</sup> J. Waldfogel, "Copyright Protection, Technological Change, and the Quality of New Products: Evidence from Recorded Music since Napster," *Journal of Law and Economics* 55 (2012), pp. 715-40 (also NBER Working Paper No. 17503, October 2011.)

<sup>16</sup> S. Greenstein, C. Tucker, and A. Goldfarb, *The Economics of Digitization* (in process).

# Banking Crises and the Federal Reserve as a Lender of Last Resort during the Great Depression

Gary Richardson\*

My research focuses on banking crises in the Great Depression, the structural flaws in the financial system that propagated the crises, the Federal Reserve's efforts to act as a lender of last resort, and the factors that shaped how policymakers responded to the crisis. Research on these issues involves gathering documents from the archives of the Federal Reserve System as well as collecting information from state regulators and private firms.

My emphasis on institutions and data stems from a desire to identify the causes of the crises and the effects of a lender of last resort. These events and policies were, obviously, endogenous, making it difficult and at times impossible to clearly identify cause and effect. Identification is complicated because the factors that facilitate identification in financial theory consist of information—like the beliefs and expectations of economic agents and policymakers—that is difficult (and often impossible) to observe in practice and that exists in few of the records remaining from the 1930s.

## Structural Weakness in the Commercial Banking System before the Great Depression

The NBER dates the onset of the Great Depression to August 1929. In the fall of 1930, 15 months after the onset of the contraction, the economy appeared

poised for recovery. The previous three contractions, in 1920, 1923, and 1926, had lasted an average of 15 months. In November 1930, however, a series of crises among commercial banks turned what up to that time had been a typical recession into the longest and deepest contraction of the twentieth century.

When the crises began, over 8,000 commercial banks belonged to the Federal Reserve System, but nearly 16,000 did not. Those non-member banks operated in an environment similar to that which existed before the Federal Reserve was established in 1914. That environment harbored the causes of the banking crises.

One cause was the practice of counting checks in the process of collection as part of banks' cash reserves. These "floating" checks were counted in the reserves of two banks, the one in which the check was deposited and the one on which the check was drawn, and in many cases additional banks through which the check flowed while clearing. In reality, however, the cash resided in only one bank. Bankers at the time referred to the reserves comprised of float as fictitious reserves. The quantity of fictitious reserves rose throughout the 1920s and peaked just before the financial crisis in 1930. Estimates vary, but in the fall of 1930, fictitious reserves probably accounted for more than half and possibly up to four-fifths of all reserves in non-member banks. This meant that the banking system as a whole had a limited amount of cash reserves available for emergencies.<sup>1</sup>

Another challenge was the inability to mobilize bank reserves in times of crisis. Non-member banks kept a portion of their reserves as cash in their

vaults and the bulk of their reserves as deposits in correspondent banks in designated cities. Many, but not all, of the ultimate correspondents belonged to the Federal Reserve System. This reserve pyramid limited country banks' access to reserves during times of crisis. When a bank needed cash, because its customers were panicking and withdrawing funds *en masse*, the bank had to turn to its correspondent, which might be faced with requests from many banks simultaneously, or might be beset by depositor runs itself. The correspondent bank also might not have the funds on hand because its reserves consisted of checks in the mail, rather than cash in its vault. If so, the correspondent would, in turn, have to request reserves from another correspondent bank. That bank, in turn, might not have reserves available or might not respond to the request.<sup>2</sup>

It should be noted that these flaws had been apparent to the founders of the Federal Reserve. Paul Warburg wrote about them even before the financial crisis in 1907. The National Monetary Commission described them in its series of reports. The initial leaders of the Federal Reserve System discussed them in their writings and explained how the structure of the Federal Reserve and the actions of its leaders solved these problems for member banks. But—here is a key part of the story—the Federal Reserve solved these problems only for member banks. For this reason, Warburg urged all commercial banks to join the Federal Reserve System. At the start of the depression, what the Federal Reserve could and should do for non-member banks remained an open question.

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## The Initial Banking Crisis and a Policy Experiment

These flaws in the financial system engendered the initial banking crisis of the Great Depression. This crisis began with the collapse of Caldwell and Company. Caldwell was a rapidly expanding conglomerate and the largest financial holding company in the South. It provided its clients with an array of services—including banking, brokerage, and insurance—through an expanding chain and a series of overlapping directorates controlled by its parent corporation headquartered in Nashville, Tennessee. The parent got into trouble when its leaders invested too heavily in securities markets and lost substantial sums when stock prices declined. In order to cover their own losses, the leaders drained cash from the corporations that they controlled.

On November 7, one of Caldwell's principal subsidiaries, the Bank of Tennessee (Nashville) closed its doors. On November 12 and 17, Caldwell affiliates in Knoxville, Tennessee, and Louisville, Kentucky, also failed. The failures of these institutions triggered a correspondent cascade that forced scores of commercial banks to suspend operations. In communities where these banks closed, depositors panicked and withdrew funds from other banks. Panic spread from town to town. Within a few weeks, hundreds of banks suspended operations. About a third of these banks reopened within a few months, but the majority liquidated.

Panic began to subside in early December. But on December 11, the fourth largest bank in New York City, Bank of United States, ceased operations. The bank had been negotiating to merge with another institution. The New York Fed had helped with the search for a merger partner. When negotiations broke down, depositors rushed to withdraw funds, and New York's Superintendent of Banking closed the institution. This event, like the collapse of Caldwell, generated newspaper headlines throughout the United States, stoking fears of financial Armageddon and inducing jittery depositors to withdraw funds from other banks.

The Federal Reserve's reaction to this crisis varied across districts. The crisis began in the Sixth District, headquartered in Atlanta. The leaders of the Federal Reserve Bank of Atlanta believed that their responsibility as a lender of last resort extended to the broader banking system. The Atlanta Fed expedited discount lending to member banks, encouraged member banks to extend loans to their non-member correspondents, and rushed funds to cities and towns beset by banking panics.

The crisis also hit the Eighth District, headquartered in St. Louis. The leaders of the Federal Reserve Bank of St. Louis had a narrower view of their responsibilities and refused to rediscount loans for the purpose of accommodating non-member banks. During the crisis, the St. Louis Fed limited discount lending and refused to assist non-member institutions.

Outcomes differed between the districts. After the crisis, in the Sixth District, the economic contraction slowed and recovery began. In the Eighth District, the banking system lay in shambles. Lending declined. Business faltered and unemployment rose.

I examine these events in a paper that estimates the effect of the intervention by the Federal Reserve Bank of Atlanta relative to the inaction of the Federal Reserve Bank of St. Louis.<sup>3</sup> To control for the factors that typically impede inference in such situations, we restrict our analysis to the state of Mississippi. The southern half of Mississippi belonged to the Atlanta District. The northern half belonged to the St. Louis District. None of the banks in Mississippi had connections to the Caldwell conglomerate, so the banking crisis in the state stemmed almost entirely from the panic and runs that spread throughout the region in the wake of Caldwell's collapse. An array of statistical tests (including non-parametric survival analysis and more common parametric regressions) demonstrate that during the panic in the Atlanta District, banks failed at much lower rates, and after the crisis, banks loaned larger amounts of funds, and output and employment were higher than in the St. Louis District. A

variety of robustness checks corroborate this claim.

To further examine the impact of Atlanta's lender-of-last resort policies, two co-authors and I exploit exogenous variation in banking conditions across Florida in 1929 to assess the effect of the Atlanta Fed's policies during the last banking crisis before the onset of the contraction. This crisis involved an infestation of Mediterranean fruit flies in the spring and summer of 1929. In the summer of 1929, the state and federal government began eradicating infested groves and embargoing shipments of crops from infested regions. Congress recessed without determining whether to compensate farmers for their losses. Within two weeks, runs began on the correspondent banks in Tampa which served as a hub of the financial network in central Florida. The Atlanta Fed intervened by rushing large quantities of cash to the afflicted institutions, stopping the panic in its tracks, and resuscitating the financial system.<sup>4</sup>

## Banking Crises in 1931 through 1933

Much of my research focuses on the initial banking crises of the Great Depression, because the structure of institutions and events enables plausible identification of cause and effect at that time. The banking crises continued, however, for two and a half years, and my research examines that period as well.

From 1931 to 1933, the US banking system experienced a series of regional crises as well as two national crises. The first national crisis coincided with the financial crisis in Europe and peaked after Britain's departure from the gold standard in the fall of 1931. The second national crisis began in the winter of 1933 and ended when Roosevelt declared a national banking holiday.

In one paper, I reassess a perennial debate concerning the causes of the banking crises during the Great Depression. One school argues that illiquidity forced most banks out of business, and therefore, an aggressive lender of last resort may have mitigated the crisis. Another



school argues that insolvency forced most banks out of business. These failures occurred, in other words, because the banks invested funds in assets that failed to pay back. Returns to investments fell because the industrial economy contracted. “Fundamental” investment losses drove banks out of business. In this case, a lender of last resort could not have ameliorated the crisis. Government assistance of financial institutions might have worsened the problem by enabling zombie banks to remain in operation and shifting losses from private investors to the public sector.

To address this debate, I examine a database on the causes of bank suspensions compiled by the Federal Reserve Board.<sup>5</sup> It indicates bank examiners’ conclusions concerning the causes of failure for almost all commercial banks operating in the United States at that time. The data demonstrate that both illiquidity and insolvency were substantial sources of bank distress. Periods when large numbers of banks failed were periods of intense illiquidity. Illiquidity and contagion via correspondent networks was particularly intense during the initial banking panic in the fall of 1930 and the last banking panic in the winter of 1933. As the depression deepened, asset values declined, and the Reconstruction Finance Corporation increasingly served as a lender of last resort, insolvency loomed as the principal threat to depository institutions.

In a series of three papers, I examine the transmission of the financial crisis from Europe to the United States in the summer and fall of 1931. The transmission might have occurred by directly affecting financial institutions in the United States, particularly the banks in New York, which had sizeable investments in and deposits from Europe. To determine the magnitude of this channel, my co-authors and I compare the performance of banks with substantial exposure to European deposits and debts with those with little or no exposure to European risks.<sup>6</sup> We demonstrate that the banks with European exposure did not change their behavior during or after the European crisis. In fact, the banks with

European exposure—which tended to be the largest money-center banks in the United States—performed significantly better by almost all measures than banks without European exposure.

Why? New York’s money-center banks predicted financial turmoil in Europe at least two years prior to the event. Recognizing their vulnerability to a trans-Atlantic crisis and realizing that they had to rely on their own efforts to survive the shock, these banks accumulated reserves and capital in preparation for the event. When the crisis came, they wrote down their reserves and both deliberately and collectively continued lending as usual.

Another paper examines a related question: why did bank failures in New York City, at the center of the U.S. money market, peak in July and August 1931, when the banking crisis peaked in Germany and before Britain abandoned the gold standard?<sup>7</sup> The chronological correlation suggests that a connection existed between events in New York and on the continent. Our research initially sought this connection. Instead, we found the correlation to be coincidental. Rather than the exposure to events overseas, bank distress rose in New York because of intensified regulatory scrutiny, which was a delayed reaction to the failure of the Bank of United States. In the summer of 1931, New York’s legislature held hearings regarding the performance of the Superintendent of Banking, whom they accused of lack of vigilance. Before and during the hearings, the bank superintendent directed a wave of examinations of banks in New York City and shut down a series of institutions that failed to pass muster.

A final essay examines the transmission of financial shocks from the periphery to the center of the financial system in the United States. In 1929, nearly all interbank deposits held by Federal Reserve member banks belonged to “shadowy” non-member banks which were outside the regulatory reach of federal regulators. Regional banking panics in the early 1930s drained these interbank deposits from central reserve city

banks of Chicago and New York. Money-center banks responded to the increasing volatility and declining quantity of interbank deposits by changing the composition of their balance sheets. They reduced lending to businesses and individuals, and increased their holdings of cash and government bonds.<sup>8</sup> This interbank channel accounted for a substantial share of the decline in lending during the contraction of the 1930s.

## What Have We Learned?

The financial crisis of 2008 and its aftermath highlight the importance of studying infrequent economic cataclysms. These events seldom occur, but when they do, economic agents and policymakers need to be prepared, because in a short span of time, they must make decisions that have tremendous impact on the lives of ordinary men and women and on the future of the world economy.

By studying the late 1920s and early 1930s, we learn that prosperous economies can have healthy financial systems that harbor hidden flaws. The depth of the structural problems may not be apparent during the boom years. Detecting them may be difficult even for scholars studying events after the fact. The structural flaws that I study are a case in point. Scholars studying the Depression after World War II attributed the weakness of the financial system to an institutional change that they believed had occurred around the time of the Federal Reserve Act.<sup>9</sup> In the nineteenth and early twentieth centuries, the principal defense mechanism for banks beset by runs was the suspension of the conversion of deposits to currency. Suspension of convertibility enabled banks to preserve their assets by strictly enforcing the contracts that depositors signed when they opened accounts. While the suspension of convertibility during crises before the founding of the Federal Reserve is widely recognized, leading scholars asserted that because of regulations associated with the founding of the Federal Reserve, banks could not suspend payments during the Great Depression. My research

drawing on records of the Division of Bank Operations of the Federal Reserve Board finds that during the early 1930s, banks could and frequently did suspend payments to depositors.<sup>10</sup> In the 1920s, the Division of Bank Operations established a nationwide reporting network that gathered information—including examiners' reports—on all bank suspensions, liquidations, and mergers.<sup>11</sup> This data clearly illuminates problems relating to reserves (which I described earlier) as the principal propagators of the commercial banking crises in 1930 and 1933 and a contributor to the financial crises that occurred in the interim.

We also learn that policymakers can take actions to mitigate a financial crisis. When a correspondent cascade knocks banks down like dominoes, rushing liquidity to nodes in the network can stop the chain reaction. The Atlanta Fed took this approach during crises in Florida in 1929 and Tennessee and Mississippi in 1930. Their efforts mitigated the panic and encouraged economic recovery.

<sup>1</sup> G. Richardson, "The Check is in the Mail: Correspondent Clearing and the Collapse of the Banking System, 1930 to 1933," *Journal of Economic History*, 67(3) (2007), pp. 643–71 (also issued as "Correspondent Clearing and the Banking Panics of the Great Depression," NBER Working Paper No. 12716, December 2006.)

<sup>2</sup> K. Mitchener and G. Richardson, "Shadowy Banks and Financial Contagion during the Great Depression: A Retrospective on Friedman and Schwartz," *American Economic Review*, 103 (May 2013), pp. 73–8.

<sup>3</sup> G. Richardson and W. Troost, "Monetary Intervention Mitigated Banking Panics During the Great Depression: Quasi-Experimental Evidence from the Federal Reserve District Border in Mississippi, 1929 to 1933," *Journal of Political Economy* 117 (2009), pp. 1031–76 (also NBER Working Paper No. 12591, October 2006).

<sup>4</sup> M. Carlson, K. Mitchener, and G. Richardson, "Arresting Banking Panics: Fed Liquidity Provision and the Forgotten Panic of 1929," *Journal of Political Economy* 119 (2011), pp. 888–924 (also NBER Working Paper No. 16460, October 2010.)

<sup>5</sup> G. Richardson, "Bank Distress during the Great Depression: The Illiquidity-Insolvency Debate Revisited," *Explorations in Economic History* 44 (2007), pp. 586–607. (also NBER Working Paper No. 12717, December 2006.)

<sup>6</sup> G. Richardson and P. Van Horn, "When the Music Stopped: Transatlantic Contagion During the Financial Crisis of 1931," NBER Working Paper No. 17437, September 2011, and G. Richardson and P. Van Horn, "Fetters of Debt, Deposit, or Gold during the Great Depression? The International Propagation of the Banking Crisis of 1931," *Jahrbuch für*

*Wirtschaftsgeschichte*, 52 (2011), pp. 29–54 (also NBER Working Paper No. 12983, March 2007.)

<sup>7</sup> G. Richardson and P. Van Horn, "Intensified Regulatory Scrutiny and Bank Distress in New York City during the Great Depression," *Journal of Economic History* 69 (2009), pp. 446–65 (also NBER Working Paper No. 14120, June 2008.)

<sup>8</sup> K. Mitchener and G. Richardson, 2013, *op cit*.

<sup>9</sup> M. Friedman and A. Schwartz. *A Monetary History of the United States, 1867–1960*. Princeton: Princeton University Press, 1963, and B. Bernanke, "Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression," *American Economic Review*, 73 (1983), pp. 257–76.

<sup>10</sup> G. Richardson, "Quarterly Data on the Categories and Causes of Bank Distress during the Great Depression," *Research in Economic History* 25 (2008) pp. 37–115 (also NBER Working Paper No. 12715, December 2006.)

<sup>11</sup> G. Richardson, "Bank Distress during the Great Contraction, 1929 to 1933, New Data from the Archives of the Board of Governors," NBER Working Paper No. 12590, October 2006. I found this data in the National Archives. Milton Friedman read the draft of this paper and told me that he and Anna Schwartz had looked for this data long ago, but could not find it, and then listed the questions that I should try to answer with the information.

# The Economics of Variations in Health and Health Care

Jonathan Skinner\*

When my Dartmouth colleague Dr. John Wennberg drove through Vermont in the late 1960s collecting data on hospital admissions, surgical procedures, and doctor visits, he found something unexpected—enormous variability in rates of medical care use across seemingly similar Vermont towns. In some school districts, nearly every school child still retained his tonsils, while in other districts, nearly every school child's tonsils had been removed.

Since 1996, the *Dartmouth Atlas of Healthcare* has used national Medicare claims data to document regional variations in health care patterns, now across 306 “hospital referral regions” in the United States. The most recent data from 2010 shows per capita age-sex-race-price-adjusted Medicare expenditures ranging from \$6,176 in LaCrosse, Wisconsin to \$13,824 in McAllen, Texas. These variations have captured the attention of a now-expanding group of economists, physicians, and other social scientists. Both NBER and Dartmouth have been centers for this research, much of which has been supported with funding through the National Institute on Aging. My work, with various collaborators, has focused on three general questions:

## What are the Causes of Regional Variations in Health Care Utilization?

Health status is one leading candidate for the observed variations; after all, regions in Louisiana or West Virginia

should spend more, given the greater burden of disease and poverty in those states. One study drew on rich survey data of elderly Medicare enrollees with information about income, poverty status, health behaviors such as smoking and drinking, and self-reported health, and found that health and income explained one-third of overall regional variations, leaving two-thirds unexplained.<sup>1</sup> A different approach compared treatment patterns for specific diseases such as heart attacks with highly detailed chart-review information; even this “apples-to-apples” approach finds considerable differences in risk-adjusted spending between the highest and lowest quintile of Medicare patients.<sup>2</sup>

Another explanation for the regional variations is patient preferences and demand more generally—people in high-spending regions may demand, and get, more health care. We have tested this hypothesis using a national survey of Medicare enrollees, where enrollees were asked about their preferences for more intensive diagnoses and treatments.<sup>3</sup> However, we did not find that patient preferences in a region could explain more than a small fraction (generally less than 10 percent) of the overall regional variations in Medicare spending across regions.

If not health or demand, then perhaps these variations are the consequence of “supplier-induced demand”: physicians prescribing more than medically necessary to augment their income. One problem with this explanation is that Medicare is a federally administered program that pays just about the same for procedures (adjusted for local prices) in LaCrosse, Wisconsin as in McAllen, Texas. If McAllen physicians are engaging in classic supply-induced demand behavior, then why aren't LaCrosse physicians?

If not the standard supplier-induced demand story, then perhaps a more subtle version applies: that physicians perform clinically unnecessary procedures in

response to peer pressure from referring physicians, or because patients insisted on them. We found that physicians were surprisingly disposed to reporting such effects, but these factors didn't explain regional differences in Medicare expenditures. Instead, physician *beliefs* in the effectiveness of intensive treatments for chronically ill patients (for example those with serious Class IV heart failure) were the best explanation for why some regions spent so much more than others.<sup>4</sup> That many of these beliefs were inconsistent with guidelines set by the American College of Cardiology, and the American Heart Association, at least points to the possibility that some treatments are being provided with very little benefit to patients.

## What are the Consequences of Regional Health Care Variations?

What are the welfare consequences of these variations in spending, in terms of improved health and longevity? If more spending leads to better health, then perhaps some regions are spending too *little*. There is some controversy about the association between spending and health outcomes, with some studies showing zero or even negative associations between spending and survival or quality of life.<sup>5</sup> Still others, using instrumental variables approaches, have shown that higher spending is associated with better health outcomes, for example Joseph Doyle and colleagues' research showing greater health returns to tourists with acute emergency room admissions admitted to higher cost hospitals,<sup>6</sup> or for those patients who happen to be picked up by an ambulance loyal to higher-spending hospitals.<sup>7</sup> Some sense of this ambiguity can be seen in an earlier study by Elliott Fisher and colleagues; using a variety of datasets and measures of both intensity and health

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outcomes, they tested this hypothesis in 42 different ways, and found 23 showed a negative association, 14 a zero association, and five a positive association—in other words, no consistent pattern.<sup>8</sup>

How can this empirical puzzle be explained? One approach is to recognize that health care offers a mind-boggling variety of different treatments, ranging from aspirin for heart attacks (highly effective, nearly costless), to antiretrovirals for HIV and AIDS patients (highly effective, even if costly), to proton beam therapy for prostate cancer (no known medical benefits over alternatives, very expensive). Thus \$1,000 in extra spending could go for valuable treatments that save lives, or it could be devoted to useless (or even harmful) treatments or diagnostic tests. Without knowing more about how the money is spent, it's nearly impossible to discern how some measure of average health care spending *should* be associated with health outcomes, so it is probably not surprising to find confusion as well in the empirical evidence. As it turns out, the productivity literature in economics provides a valuable conceptual and empirical framework for addressing this question of how spending relates to health.

### Why are Productivity Differences so important in explaining Regional Variations?

Nearly every study of spending and outcomes shows a similar pattern—wide variability in both health outcomes and health spending, as shown in the figure. Each dot in the accompanying Figure could represent (for example) outcomes for a specific hospital, or it could be for a region or even a country.<sup>9</sup> Empirically, the correlation between these dots could be positive, negative, or zero; the slope of the line is less important than the scatter-shot nature of the data. The key point is that, relative to the most productive hospital or country in the upper left hand corner of the graph (denoted A), the other hospitals either cost more, get worse health outcomes, or both, as is the case for Hospital B.

Amitabh Chandra and I, following

on earlier work by Wennberg and colleagues, have tried to capture these productivity issues in the context of a simple model that characterizes medical treatments from most cost-effective to least cost-effective.<sup>10</sup> The most cost-effective treatments, like antiretrovirals for AIDS and HIV patients, are deemed “Category I,” while treatments with heterogeneous benefits—helpful for some, but not all patients, such as stents for cardiovascular disease—are “Category II.” Finally, treatments like proton beam therapy with little known value but very high costs are viewed as “Category III” treatments.

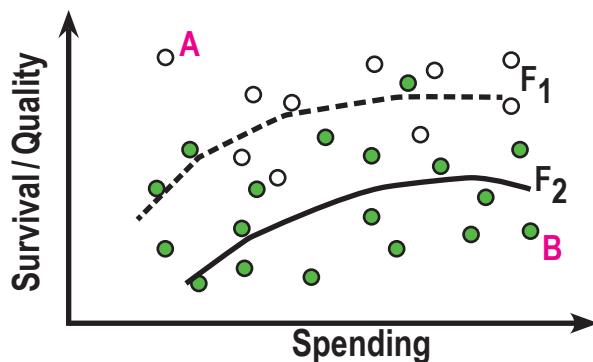
As Douglas Staiger and I found for the treatment of heart attacks, hospitals that adopted Category I treatments like aspirin and beta blockers—pennies per pill—showed consistently better health outcomes with identical costs; in other words, they were the hospitals with the open dots, characterized by the production function  $F_1$  in the Figure below, rather than on  $F_2$  which characterized the slower adopters marked by the green dots.<sup>11</sup> Similarly, the lower production function  $F_2$  can represent health care systems that are investing more heavily in Category III treatments, leading to the same outcomes but at higher costs. This Figure also illustrates why simple correlations between health care spending and health outcomes could be either posi-

tive or negative (or zero), even when the “true” return to spending is still positive, as shown by the generally positive slopes of the production functions.

Thinking about health care as an industry that is far from the production possibility frontier immediately raises the question of why—is there something specific about health care’s lack of market incentives and dominance of third-party payers that might lead to such inefficiencies? One study suggests no, that in fact these differences in productivity in health care are little different from the degree of inefficiency in some other industries, and that the more productive hospitals actually gain market share over time.<sup>12</sup>

There are also several unresolved questions. For example, why do some regions appear to do so much better in adopting “Category I” treatments (such as beta blockers for heart attack patients), and why were these same regions so rapid to adopt other innovations in non-health sectors as well (such as hybrid corn in the 1930s and 1940s)?<sup>13</sup> Second, why are regional variations for private health insurance often so different from patterns for Medicare patients?<sup>14</sup> Finally, will financial reforms such as those being implemented under the Affordable Care Act of 2010 lead existing health care providers to improve their productivity so that they figure out how to offer better quality care at lower cost?

### Hypothetical Spending and Outcome Measures by Hospital, Region, or Country





## Conclusion

Productivity in US health care is a central issue to the economic health of the United States. My work and that of others suggests that between 10 and 20 percent of US health care spending may have very little effect on health outcomes. These efficiency estimates are staggering—20 percent inefficiency in an industry comprising 18 percent of GDP is nearly 4 percent of GDP—and understate the additional efficiency costs of raising tax revenue to pay for the inefficient care.<sup>15</sup>

More importantly, there is likely to be enormous inefficiency because hospitals and providers are so far from the production frontier in *health*, whether because of the slow diffusion of new technologies, poor use of existing technologies, or a lack of knowledge about the value of commonly used treatments for different types of patients. Understanding better how to target and reward productivity improvements in health care can ultimately provide the basis for real productivity growth in health care: both saving money and saving lives.

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Medicare Spending. Part 1: The Content, Quality, and Accessibility of Care," *Annals of Internal Medicine*, 138(4) (2003), pp. 273–87.

<sup>3</sup> D. Cutler, J. Skinner, A. Stern, and D. Wennberg, "Physician Beliefs and Patient Preferences: A New Look at Regional Variation in Health Care Spending," NBER Working Paper No. 19320, August 2013.

<sup>4</sup> Cutler et al., 2013, op. cit.

<sup>5</sup> Institute of Medicine, "Variation in Health Care Spending: Target Decision Making, Not Geography," *Consensus Report*, July 24, 2013.

<sup>6</sup> J. Doyle, Jr., "Returns to Local-Area Health Care Spending: Using Health Shocks to Patients Far From Home," *American Economic Journal: Applied Economics* 3 (2011), pp. 221–43 (also NBER Working Paper No. 13301, August 2007.)

<sup>7</sup> J. Doyle, Jr., J. Graves, J. Gruber, and S. Kleiner, "Do High-Cost Hospitals Deliver Better Care? Evidence from Ambulance Referral Patterns," NBER Working Paper No. 17936, March 2012.

<sup>8</sup> E. Fisher, D. Wennberg, T. Stukel, D. Gottlieb, F. Lucas, et al., "The Implications of Regional Variations in Medicare Spending. Part 2: Health Outcomes and Satisfaction with Care," *Annals of Internal Medicine* 138 (February 18, 2003), pp. 288–98.

<sup>9</sup> A. Garber and J. Skinner, "Is American Health Care Uniquely Inefficient?" *Journal of Economic Perspectives*, 22 (2008), pp. 27–50 (also NBER Working Paper No. 14257, August 2008.)

<sup>10</sup> A. Chandra and J. Skinner,

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<sup>13</sup> J. Skinner and D. Staiger, "Technology Adoption from Hybrid Corn to Beta Blockers," in *Hard to Measure Goods and Services: Essays in Honor of Zvi Griliches, E. Berndt and C. Hulten*, eds. Chicago, University of Chicago Press, 2005 (also NBER Working Paper No. 11251, April 2005.)

<sup>14</sup> M. Chernew, L. Sabik, A. Chandra, T. Gibson, and J. Newhouse, "Geographic Correlation Between Large-Firm Commercial Spending and Medicare Spending," *American Journal of Managed Care* 16 (2) (February 2010), pp. 131–8.

<sup>15</sup> K. Baicker and J. Skinner, "Health Care Spending Growth and the Future of US Tax Rates," in *Tax Policy and the Economy*, Volume 25, J. Brown, ed. Chicago: University of Chicago Press, 2011 (also NBER Working Paper No. 16772, February 2011.)

# International Mobility of Research Scientists

Paula Stephan\*

In the United States, approximately half of all Ph.D.s awarded in science and engineering go to the foreign born.<sup>1</sup> More than two-thirds of temporary residents who receive Ph.D.s in science and engineering work in a research capacity while in graduate school. The proportion is over 80 percent in engineering.<sup>2</sup> Approximately 60 percent of postdoctoral fellows are in the United States on a temporary visa and approximately 42 percent of those with a doctoral degree working in a science and engineering occupation in the United States were born outside the United States. There is evidence that the foreign born contribute disproportionately to exceptional contributions in science and engineering and that highly productive scientists are even more mobile than the underlying scientific population. Despite the importance of the foreign born, it is difficult to make cross-country comparisons regarding their presence and role because of the absence of consistent data across countries. Most OECD countries, for example, collect data on recipients of tertiary degrees by immigration status, but the data do not distinguish between those with Ph.D.s versus other tertiary degrees, nor do they distinguish field of study. Moreover, most countries have an incomplete picture of the migration patterns of scientists born in their country because it is difficult to track individuals working outside their country of origin.

To provide consistent cross-country data on active researchers, my co-authors and I fielded the GlobSci survey of corresponding authors of articles published in 2009 in four fields of science: biology, chemistry, earth and environmental sciences, and materials. The fields were cho-

sen in part because 95 percent or more of all articles published in these disciplines contain the corresponding author's email. We focused on researchers who were studying or working in one of 16 "core" countries: Australia, Belgium, Brazil, Canada, Denmark, France, Germany, India, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States. China was initially included in the survey. However, a low response rate of less than 5 percent for a test sample of Chinese addresses suggested that respondents were either not receiving the invitation or had problems responding to the invitation. The response rate to the web-based survey, which was administered during the spring of 2011, was 40.6 percent. Country of origin was determined by asking the respondents to report country of residence at age 18.

## Mobility Patterns of the Foreign Born

We find widely varying patterns of immigration and emigration for the more than 17,000 scientists for whom country of origin and country of residence in 2011 could be determined.<sup>3</sup> The country with the largest percentage of Ph.D. scientists who are immigrants was Switzerland (56.7), followed distantly by Canada (46.9), Australia (44.5) and then by the United States (38.4). Virtually no foreign-born scientists reported working in India; only 3 percent of the research-active scientists in Italy and 5 percent in Japan are foreign. Immigrant scientists were asked to evaluate the importance of 14 possible reasons for coming to work or study in their country of residence. Virtually no variation exists across country in response. The "opportunity to improve my future career prospects" and the presence of "outstanding faculty, colleagues or research team" trump all other reasons. Regardless of country, respon-

dents list family reasons or fringe benefits last among reasons for coming to work or study in a foreign country.

Our approach provides information on emigration flows among core countries. We find Indians to be the most likely to emigrate—almost 40 percent of scientists living in India at age 18 were working outside the country at the time of the survey. Approximately one-third of Swiss scientists are outside their home country; the Netherlands and the United Kingdom have the next highest rate of emigration. The country with the lowest percentage of emigrants is Japan (3 percent) but the United States is a close second (5 percent). In all cases, save Belgium, the United States is the most likely destination country. The data also permit us to determine that half or more of the respondents who lived in 13 of the 16 countries at age 18 have an international experience. The three exceptions are the United States, Japan, and Italy. Return rates also vary among emigrants. The country with the highest return rate is Japan (nine out of ten), followed by Spain and Brazil (seven out of eight). Less than one out of two Indian emigrants has returned. The most likely reason that scientists give for return to their country of origin is for "personal or family reasons." Taken together our results suggest that policy levers are extremely important in attracting scientists to work or study abroad, but that they appear to play little role in drawing emigrants to return to their home country.

## Graduate School and Postdoctoral training

In companion research we explore factors related to the probability that students who leave their country of origin for Ph.D. or postdoctoral training come to the United States rather than to another country.<sup>4</sup> We find that those who place

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a higher weight on the prestige/research excellence of the institution as a reason for their choice are significantly more likely to train in the United States than to go elsewhere, as are those who report that opportunities for career advancement played a strong role in their decision to go abroad for study. Individuals who report that the appeal of lifestyle or international experience played an important role in their decision of where to pursue Ph.D. study are significantly less likely to attend graduate school in the United States than go elsewhere.

With regard to postdoctoral study, we find that individuals who place a higher weight on the quality of faculty, the excellence/prestige of the country's institutions, and the career prospects associated with where they train are significantly more likely to come to the United States. The U.S. lifestyle discourages individuals from coming to do postdoctoral study, as does the relative unattractiveness of benefits and working conditions provided to postdoctoral researchers. The current discussion on immigration reform focuses on the importance of visa reform for retaining researchers who complete their studies in the United States. Our research suggests that maintaining the level of research funding and the quality of university research infrastructure are likely to be important if the United States hopes to continue to attract foreign-born students and postdoctoral researchers.

## Networks

Innovation policies, particularly in Europe, have strongly supported international mobility of the highly skilled workforce as a means for enhancing the overall scientific performance of both source and destination countries. Despite the importance attributed to such ties, little empirical research has systematically investigated mobility, in part because of the lack of international comparable data. We draw on the GlobSci survey to explore the link between mobility and the presence of international research networks.<sup>5</sup> We classify researchers into

three mobility states: foreign-born (24.3 percent); returned after one or more periods abroad for a Ph.D., postdoc or employment (29.7 percent); and non-mobile (46.0 percent). We create two measures of the individual's propensity to co-author with those from a different country: the first counts the number of distinct international co-authors on the paper that was included in the GlobSci survey and the second draws on the respondents' answer to a question regarding the number of countries in which the scientist reported having one or more collaborations in the past two years. We find the incidence of international collaboration on the survey paper to be lowest for non-mobile researchers. It is generally highest for the foreign born. We also find non-mobile researchers to report the highest incidence of having had no international scientific collaboration in the past two years. The distribution of the number of countries with which the foreign born and returnees report having had a collaborator is almost the same. Approximately one out of three have collaborated with scientists in four or more countries; slightly more than one out of two has collaborated with scientists in one to three countries.

We examine the presence of significant correlation at the individual level between international mobility and the presence of international co-authors, controlling for the researcher's demographic characteristics, field of research, country of residence, number of co-authors, and whether the scientist is independent or works in a support role, such as a staff scientist. We find the marginal effect of being foreign born on the likelihood of having an international collaboration to be 13.8 percentage points. The marginal effect of being a returnee is 7.4 percent. We also examine the correlates of working with co-authors in four or more countries and find that the foreign born and returnees are significantly more likely to collaborate with scientists in a large number of countries than are the non-mobile. This effect is slightly larger for the foreign born than for those who have returned.

## Performance

Mobility policies, such as visa reform, are predicated on the assumption that the foreign born perform at the same or a higher level than the non-mobile workforce. Likewise, countries that implement policies to encourage emigrants to return do so on the assumption that the mobility experience enhances the productivity of the emigrant and that the country will benefit from the emigrant's return. Empirical evidence on the correlation of mobility and performance in science, however, is inconclusive and often limited to the foreign born in the United States and focused on those who make exceptional contributions. The GlobSci survey allows us to explore the correlation between mobility and performance within our 16 country sample. We are not able to infer causality given the cross-sectional nature of the data, but the results suggest that mobility is a plus for destination countries and that promoting international experience can have positive returns for a country.

We use two measures of performance: two-year citations to the author's article and the Impact Factor of the journal in which the article was published. We limit the analysis to individuals working in universities, medical schools, and government research agencies, and control for article and individual characteristics.<sup>6</sup> We find that holding all else equal, the average foreign-born scientist outperforms a homegrown scientist by 0.84 in terms of Impact Factor of the journal in which the article appeared and by 2.29 in terms of two-year citations to the paper. We also find that scientists who have studied or worked abroad and subsequently returned to work and live in their country of origin outperform the non-mobile by 0.63 in terms of Impact Factor and by 1.69 in terms of total citations.

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<sup>1</sup> P. Stephan, "The I's Have It: Immigration and Innovation, The Perspective from Academe," pp. 84–127 in *Innovation Policy and the Economy*, Volume 10, J. Lerner and S. Stern, eds.



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<sup>2</sup> Black and Stephan find that graduate students constitute 29.3 percent of the first authors of papers published in Science; 40.7 percent of first authors are postdocs. Using data supplied by Bill Kerr they infer ethnicity of the first and last name of the authors, finding that 58.5 percent of the graduate students and 54.4 percent of the postdocs have names that are neither “English” nor “European.” G. Black and P. Stephan, “The Role of Foreign Graduate

Students and Postdoctoral Scholars,” pages 129–61 in *American Universities in a Global Market*, C. Clotfelter, ed. Chicago: University of Chicago Press, 2010.

<sup>3</sup> C. Franzoni, G. Scellato, and P. Stephan, “Foreign Born Scientists: Mobility Patterns for Sixteen Countries,” *Nature Biotechnology*, 30 (2012), pp. 1250–3 (also NBER Working Paper No. 18067, May 2012.) For interactive charts and map see R. Van Noorden, “Global Mobility: Science on the Move,” *Nature*, 490 (2012), pp. 326–9.

<sup>4</sup> P. Stephan, C. Franzoni, and G. Scellato, “Choice of Country by the Foreign

Born for Ph.D. and Postdoctoral Study: A Sixteen-Country Perspective,” NBER Working Paper No. 18809, February 2013.

<sup>5</sup> G. Scellato, C. Franzoni, P. Stephan, “Mobile Scientists and International Networks,” NBER Working Paper No. 18613, December 2012.

<sup>6</sup> C. Franzoni, G. Scellato, and P. Stephan, “The Mover’s Advantage: Scientific Performance of Mobile Academics,” NBER Working Paper No. 18577, November 2012.

## Inflation-Indexed Bonds

Luis M. Viceira\*

### Introduction

Inflation-linked bonds, which in the United States are known as Treasury Inflation Protected Securities (or TIPS), are bonds that pay investors a fixed inflation-adjusted coupon and principal. Their nominal payments adjust automatically with the evolution of a price index describing the cost of a basket of consumer goods such as the Consumer Price Index in the United States. Although the popular press often labels inflation-indexed bonds as “exotic securities,” nothing could be farther from reality.

Inflation-indexed bonds constitute today a significant fraction of outstanding bonds issued by the U.S. Treasury—around 10 percent of total marketable debt, and more than 3.5 percent of GDP. Both institutional investors such as endowments and pension funds and retail investors hold them in their

portfolios, either directly or indirectly through TIPS mutual funds, exchange-traded funds, and asset allocation funds such as target retirement funds. TIPS have become a building block of investors’ portfolios. TIPS also play an important role in policy. Central bankers, professional economists, and market observers routinely follow the evolution of “breakeven inflation,” or the spread between the yields on nominal government bonds and the yields on inflation-indexed bonds of equivalent maturity, as an indicator of real-time inflation expectations from bond market participants.

The relevance of inflation-indexed bonds to investors and policymakers is not unique to the United States. The United Kingdom has a longer and even more established tradition of issuing and investing in inflation-linked bonds (or “gilts” as government bonds are known in the United Kingdom). Inflation-indexed linkers represent more than 30 percent of British public debt, equivalent to almost 10 percent of U.K. GDP. The U.K. government is now considering issuing inflation linkers with super-long maturities (in excess of 50 years) and

even perpetual inflation-indexed gilts. In the Euro area, France, Germany, and Italy regularly issue inflation linkers, linked to either Euro-area inflation or to domestic inflation. Demand for linkers in both the United Kingdom and the Euro area is strong, particularly from pension funds, as pensions in those countries are typically indexed to inflation. After a brief interruption, Japan is re-starting regular issuance of inflation-linked bonds and, among emerging economies, Brazil has become a large issuer of such bonds. Australia, Canada, Chile, Israel, Mexico, Turkey, and South Africa are also economies with non-trivial issuance of inflation linkers. The hedge fund Bridgewater has recently calculated the size of the global inflation-linked market at \$2.5 trillion, larger than the high-yield corporate bond market and twice as large as the dollar-denominated emerging market bond market.

My research on inflation-indexed bonds has been focused on understanding the role of these securities in investors’ portfolios, their pricing and risk, and the impact of institutional factors on the market for inflation-indexed bonds.

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## Inflation-Indexed Bonds in Long-Term Portfolios

A traditional idea in investment practice is that cash (for example, short-term default-free bonds or bills) is the safe asset for all investors. This idea is rooted in a perception that real interest rates are constant. Indeed, if real interest rates are constant, standard models of portfolio choice, whether static or dynamic, show that the optimal investment strategy for investors with low (effectively zero) risk tolerance is a strategy of constantly reinvesting their wealth in default-free real short-term bonds. To the extent that inflation risk is small at short horizons, nominal short-term bonds are good substitutes for inflation-indexed short-term bonds.

My early research on inflation-indexed bonds with John Campbell shows that this strategy will not be optimal if ex-ante real interest rates vary over time.<sup>1</sup> When future real interest rates are uncertain, a strategy of constantly reinvesting wealth in short-term bonds will preserve investors' initial wealth in the face of random shocks to long-term assets, but not necessarily their ability to spend out of this wealth.<sup>2</sup> If real interest rates decline, investors will have to either adjust downward their spending plans to accommodate this reduction in the yield on their wealth, or else deplete part of their wealth to maintain their consumption plans, with the subsequent impact that this reduction in wealth might have on their future welfare.

In contrast to a strategy of constantly reinvesting wealth in short-term bonds, a strategy of investing in inflation-indexed long-term bonds will protect spending, since these bonds will increase in value as real interest rates decline, thus providing the extra cushion investors need to maintain their spending plans without depleting their initial principal. For long-horizon investors, long-term inflation-indexed bonds are the riskless asset. By investing in a portfolio of inflation-indexed bonds whose cash flows match their consumption spending plans, investors can guarantee a riskless consumption stream.<sup>3</sup> Of course, this portfolio of infla-

tion-indexed bonds will experience short-term fluctuations in price, but these will be irrelevant to a long-horizon investor exclusively interested in ensuring a riskless consumption stream.

Our analysis provides support for the traditional portfolio advice that conservative long-term investors should tilt their portfolios toward long-term bonds. However, it does so with an important qualification: the bonds should be inflation-indexed. Nominal long-term bonds such as Treasury bonds and notes expose long-term investors to inflation risk. If realized inflation turns out to be larger than expected at the time of the investment in nominal bonds, the ability of those bonds to protect real spending will be undermined. By contrast, inflation-indexed bonds are immune to the potentially devastating effects of unexpected inflation.

The insights of this analysis have important implications for the design of savings vehicles for long-term investors, such as investors saving for retirement.<sup>4</sup> It makes clear that assets that preserve capital do not necessarily preserve long-term standards of living. Long-term inflation-indexed bonds, not cash instruments, are the riskless asset for conservative investors who care about financing their long-term spending plans or liabilities, such as investors saving for retirement, traditional pension funds, or endowments. Nominal long-term bonds achieve this objective only when inflation risk is low. The issuance of inflation-indexed bonds by the Treasury has a significant impact on welfare, as it provides long-term investors with a truly riskless long-term investment vehicle.

### Real Interest Risk, Inflation Risk, and the Risk of Long-Term Bonds

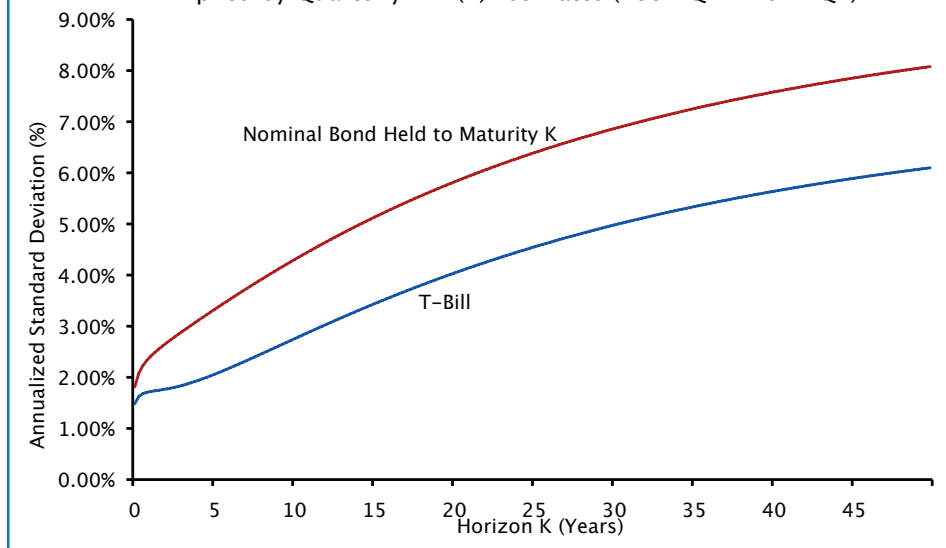
Inflation-indexed bonds are the safe asset for long-term investors. But how much riskier is investing in short-term bonds or in long-term nominal bonds from the perspective of a long-horizon investor? Or the risk of investing in long-term inflation-indexed bonds from the

perspective of a short-horizon investor? To answer these questions, one can apply the tools of modern finance to the analysis of inflation and interest rates to quantify real interest rate risk and inflation risk.

A simple and intuitive way to understand the importance of these two types of risk is to examine the annualized standard deviation (or volatility) across investment horizons of the real return on a strategy consisting of constantly reinvesting capital in Treasury bills, and the real return on another strategy consisting of buying and holding a long-term zero-coupon nominal bond with maturity equal to each investment horizon under consideration.<sup>5</sup> To the extent that short-term inflation risk is modest, the only uncertainty about the long-horizon real return on a strategy of rolling over Treasury bills is the real rate at which the capital will be reinvested. Therefore this strategy exposes long-horizon investors to real interest rate risk. By contrast, the real return on a default-free zero-coupon nominal bond equals the inverse of cumulative inflation over the life of the bond. Therefore the strategy of investing in a variable maturity nominal bond exposes investors to inflation risk at different horizons.

Figure 1 (on the following page) shows the annualized standard deviation of the real return on each strategy across investment horizons. The standard deviation is based on estimates of a VAR(1) model for quarterly bond returns and interest rates for the period 1952–2011.<sup>6</sup> This figure shows that the real return on both strategies exhibits significant “mean-aversion”; that is, the real return volatility on both strategies increases significantly with the investment horizon. The mean aversion of Treasury bill returns is caused by persistent variation in the real interest rate in the postwar period, which amplifies the volatility of returns when Treasury bills are reinvested over long horizons. The mean aversion of the variable-maturity bond is the result of persistent variation in inflation in the postwar period. A positive shock to inflation that lowers the real return on a long-term nominal bond is likely to be followed by high inflation in subsequent periods as well,

Figure 1. Annualized Percent Standard Deviations of Real Returns Implied by Quarterly VAR(1) Estimates (1952.Q1 – 2011.Q4)



and this amplifies the annualized volatility of a long-term nominal bond held to maturity. In relative terms, Figure 1 suggests that inflation risk makes a strategy of buying and holding long-term nominal bonds riskier than a strategy of rolling over Treasury bills at all horizons.

Figure 1 illustrates the long-term implications of persistent variation in inflation and real interest rates for risk, and it helps explain why long-horizon investors should view cash and nominal bonds as risky assets. By contrast, a strategy of investing in a variable-maturity *inflation-indexed* bond would exhibit zero volatility at each horizon; that is, it would overlap with the horizontal axis on Figure 1.

We can use modern arbitrage-free factor models of the term structure of interest rates to estimate and characterize real interest rate risk and inflation risk embedded in bond prices and returns. I have conducted such analysis in several papers jointly written with John Campbell, Robert Shiller, and Adi Sunderam.<sup>7</sup> My early work on inflation-indexed bonds with John Campbell formulates an affine two-factor term structure model in which one factor is the log real interest rate and the other the log expected rate of inflation. An estimation of the model using nominal bond yields and realized inflation for the United

States shows that both factors exhibit substantial persistence and variability over the post-World War II period. The unconditional volatility of the ex-ante real short-term interest rate is about 1 percent per annum (p.a.), almost as large as its unconditional mean of 1.4 percent p.a. The estimated inflation risk premium in ten-year nominal bonds is fairly large, at 1.1 percent p.a. These estimates suggest that conservative investors would have benefited substantially from the consumption insurance provided by long-term inflation-indexed bonds if offered during this period, while they would have been exposed to significant long-term risk if they had invested in either cash instruments or long-term nominal bonds.

By contrast, an estimation of the model for the post-1983 period spanning the Federal Reserve chairmanships of Paul Volcker and Alan Greenspan shows a significant decline in the persistence of expected inflation and an increase in the persistence of the real interest rate relative to the entire postwar period. These results are consistent with the notion that since the early 1980s the Federal Reserve has controlled inflation more aggressively at the cost of greater long-term variation in the real interest rate. Lower persistence in expected inflation implies lower inflation risk and a lower inflation risk premium in nominal bonds, which over this period

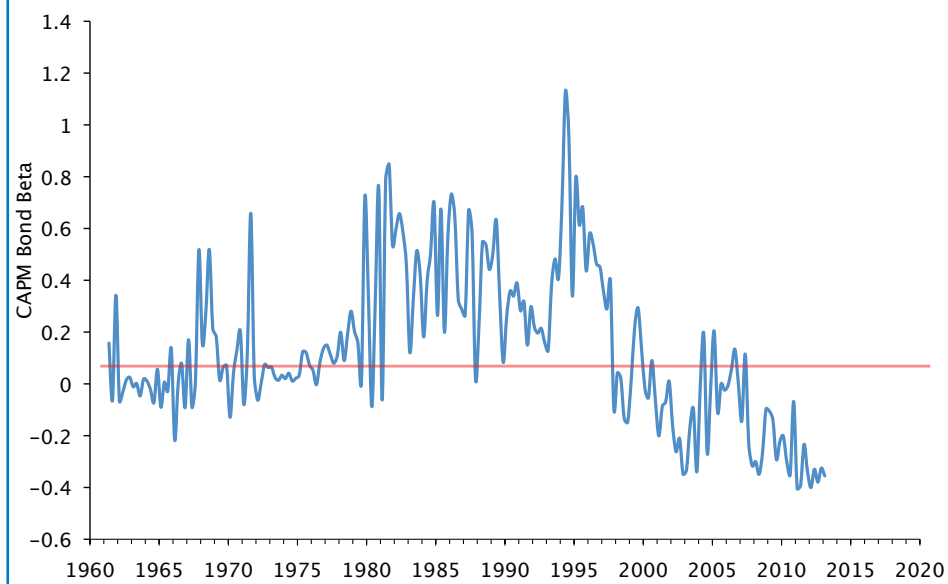
become closer substitutes of inflation-indexed bonds. Indeed, in recent years the short-run volatility of TIPS and Treasury bond returns in the United States has been very similar, and the correlation of their returns has also increased significantly, suggesting that variation in real interest rates has been an important source of variation in bond yields and returns. The U.K. gilt market exhibits a similar pattern.

The contrast between the estimates of the real interest rate and expected inflation process for the post-war period and the Volcker-Greenspan sub-period suggests that real interest rate risk and inflation risk might not be constant. Indeed a measure of the systematic risk of nominal bonds such as the covariance of nominal bond returns with aggregate stock returns—or a normalized version of it such as beta or correlation—exhibits considerable low frequency variation over time, even switching its sign, as shown in Figure 2 (on the following page).<sup>8</sup> The CAPM beta of nominal long-term bonds was low or negative on average in the period leading to the run-up in inflation in the late 1970s, was highly positive on average during the 1980s into the second half of the 1990s, and it has been negative since. As the nominal bond-stock covariance declines, nominal bonds become less risky assets since their ability to diversify aggregate stock market risk increases.

Long-term nominal bond returns respond to both real interest rates and to expected inflation. A natural question is whether the pattern shown in Figure 2 reflects a changing covariance of real interest rates with the stock market, or a changing covariance of inflation with the stock market. An examination of the CAPM beta of inflation-indexed bonds and the CAPM beta of breakeven inflation returns—the return on a long-short portfolio, long inflation-indexed bonds and short nominal bonds of equivalent duration—over the period that starts in 1997 suggests that the decline in nominal bond risk in recent years has been the result of a decline in both the real interest risk and the inflation risk of nominal bonds.<sup>9</sup>

The covariance of inflation-indexed bond returns with stock returns has been

Figure 2. CAPM Beta of 10-yr Nominal Bond (1961.Q1–2013.Q1)



negative over this period, implying that real interest rates have been positively correlated with stock returns. The covariance of breakeven inflation returns with stock returns has been positive on average over the same period, implying that inflation has also been positively correlated with stock returns. A positive correlation of either real interest rates or inflation with stock returns makes nominal bond returns negatively correlated with stock returns, since nominal bond prices move inversely with changes in real interest rates and inflation.

Although it is not possible to estimate the covariance of nominal indexed-bond returns with stock returns before they were first issued in 1997, we can still estimate the conditional covariance of stock returns with realized inflation. An estimate of this covariance shows a mirror image of Figure 2.<sup>10</sup> It was mildly positive on average during the 1960s into the 1970s, negative during the late part of the 1970s into the mid-1990s, and it has been strongly positive since the mid-1990s. This estimate suggests that changing inflation risk (that is, a changing covariance of inflation with stock returns) has been an important contributor to the changing nominal bond-stock covariance in the long run.

We observe similar patterns for the

U.K. gilt market, for which we have a longer history of inflation-linked bond returns dating back to the 1980s. The covariance of stock returns with nominal bond returns and inflation-linked bond returns was positive into the late 1990s and it has been negative since; the covariance of stock returns with breakeven inflation returns was negative into the late 1990s, implying positive inflation risk, and it has been positive since.<sup>11</sup> These patterns suggest a decline in both real interest rate risk and inflation risk since the mid-1990s in both the United States and the United Kingdom.

The negative covariance of inflation-indexed bond returns with stock returns in the United States and the United Kingdom during this period implies that inflation-indexed bonds have provided equity investors with an important diversifier of stock market risk, in addition to providing (by construction) long-term conservative investors with the safe asset. The negative covariance of nominal bonds with stock returns, and the positive covariance of breakeven inflation returns with stock returns imply that nominal bonds have also provided equity investors with an important diversifier of stock market risk, and long-term conservative investors with a close substitute of inflation-indexed bonds over this period.

Arguably the period since the late 1990s has been a period during which demand shocks have been the main driver of inflation and also a period of strong central bank credibility, with stable inflation expectations. Under those circumstances, inflation is likely to be pro-cyclical and nominal bond returns negatively correlated with stock returns. The negative covariance of inflation-indexed bond returns with stock returns implies that real interest rates have been pro-cyclical over this period. In fact, the yields on TIPS have been slightly negative during the last recession, and have increased and turned positive only recently as the U.S. economy has strengthened. The evolution of inflation-indexed bond yields is consistent with asset pricing models in which investors exhibit counter-cyclical risk aversion, driving the price of the long-term safe asset up in recessions as their tolerance for risk declines, and down in expansions as they become more risk-tolerant.<sup>12</sup>

To the extent that these factors remain in place, we should expect inflation-indexed bonds and nominal bonds to remain negatively correlated with aggregate stock returns, and for nominal bonds to remain close substitutes of inflation-indexed bonds. However, if inflation turns again countercyclical as it was in the stagflationary period of late 1970s and 1980s, nominal bonds will become risky assets positively correlated with stock returns and poor substitutes of inflation-indexed bonds.

### Inflation-Indexed Bond Return Predictability and the Expectations Hypothesis of Real Interest Rates

The changing covariance of inflation-indexed and nominal bond returns with stock returns raises the question of what these changes in magnitude and switches in sign of the *quantity* of bond risk imply for bond risk premia and the shape of the term structure of real and nominal interest rates. In recent research with John Campbell and Adi Sunderam I have explored this question using a quadratic

model of the term structure of interest rates that incorporates macroeconomic factors—real interest rates and expected inflation—along with a state variable driving the variance of real and nominal interest rates and their covariance with the macroeconomy.<sup>13</sup> This model is one of the first asset pricing models that tries to jointly explain the time variation in multiple asset classes along with the time variation in the co-movement of their returns.

The model generates time-varying real interest rate risk and inflation risk, predicting positive nominal bond risk premia in the early 1980s, when bonds covaried positively with stocks, and negative risk premia in the 2000s and particularly during the downturn of 2007–9, when bonds hedged equity risk. An interesting implication of the model is that a strongly concave yield curve should predict high excess bond returns. In the model, a high bond-stock covariance is associated with a high volatility of bond returns. The high bond-stock covariance generates a high term premium and a steep yield curve at maturities of one to three years, while the high bond volatility lowers long-term yields through a Jensen's inequality or convexity effect. Thus, the concavity of the yield curve is a good proxy for the bond-stock covariance. In this fashion, the model explains the qualitative finding of prior research that a tent-shaped linear combination of nominal forward rates predicts excess nominal bond returns at all maturities.<sup>14</sup>

This model of the term structure of interest rates with a time-varying quantity of bond risk however does not generate enough variability in nominal bond risk premia (or expected nominal bond excess returns) to match the variability uncovered by predictive regressions of nominal bond excess returns on lagged nominal yield spreads and forward rates.<sup>15</sup> Thus while a time-varying quantity of bond risk is a stylized empirical fact that asset pricing models need to incorporate, it is not enough to fully explain the estimated variability in nominal bond risk premia. Asset pricing models that attempt to fully

explain bond return predictability need to consider additional factors such as a time-varying aggregate price of risk or a time-varying volatility of aggregate consumption growth.<sup>16</sup>

The high explanatory power of nominal bond return predictive regressions has raised questions about whether the expectations hypothesis of interest rates—the hypothesis that the yields on long-term bonds reflect expectations of future short-term interest rates plus a constant risk premium—holds for U.S. nominal bonds. Under the expectations hypothesis, expected excess returns on bonds are constant over time, and no state variable should be able to predict bond excess returns.

A natural question to ask then is whether we also observe time-series variability in expected excess returns on inflation-indexed bonds and, if so, how large it is and what drives it. I have explored these questions in my most recent research on inflation-indexed bonds with Carolin Pflueger.<sup>17</sup> Our research finds that, despite the relatively short history of inflation-indexed bonds in the United States, there is strong evidence that their returns are predictable. This evidence of return predictability extends to U.K. inflation-indexed bonds, for which we have a longer history of yields and returns. Specifically, our research finds that the yield term spread (the difference between the yield on a long-dated bond and a short-dated bond) on inflation-indexed bonds forecasts positively the return on inflation-indexed bonds, just like the yield term spread on nominal bonds forecasts positively the return on nominal bonds.

We also find strong evidence that the difference between the nominal yield term spread and the inflation-indexed bond yield term spread, or equivalently the spread between breakeven inflation in long-dated bonds and breakeven inflation in short-dated bonds, also forecasts positively the return differential between nominal bonds and inflation-indexed bonds. In other words, controlling for the predictability of returns on inflation-indexed bonds, nominal bond returns still exhibit “excess predictability.”

## Institutional Factors and the Market for Inflation-Indexed Bonds

It is tempting to interpret the variation in the expected return on inflation-indexed bonds as evidence in expected return space of time variation in real interest risk premia, and the variation in the expected return on nominal bonds in excess of inflation-indexed bonds as evidence of time variation in inflation risk premia.

However, this interpretation is problematic if the yields on inflation-indexed bonds are imperfect proxies for the true real interest rates in the economy. There are several reasons why the yields on TIPS can diverge from true real interest rates. First, the principal and thus the nominal coupons on TIPS adjust to inflation only with a three-month lag, and principal adjustments are taxed as ordinary income. Lagged indexation is unlikely to be a relevant issue in practice, as U.S. inflation exhibits very low variability at short horizons. But taxation could possibly be relevant to the extent that the marginal investor in TIPS is a taxable investor, although the empirical evidence on holdings suggests that a large fraction of TIPS outstanding is held by tax-exempt institutional investors such as pension funds and endowments, and by taxable investors in tax-exempt accounts such as retirement plans.

Second, the principal at issuance on TIPS is protected against deflation. Thus, the yields on TIPS will include a discount relative to true real interest rates, reflecting the value of this deflation put. In practice this deflation put is unlikely to be valuable for most TIPS except for those most recently issued—and in that case the value of the option will depend on how likely a deflationary scenario is. The vast majority of TIPS are aged securities for which accumulated inflation in their nominal principal makes the deflation put far out of the money, and most research on TIPS is based on off-the-run TIPS of this kind. Nonetheless, there is good reason to think that the deflation put was valuable for TIPS issued at the height of the financial crisis in the fall of 2008.<sup>18</sup>



A third factor is liquidity. Market participants and financial economists have long argued that the market for TIPS is not as liquid as the market for nominal Treasury bonds, especially in their early years, when arguably inflation-indexed bonds were not as well established and were not as well understood an asset class as they are today, and during the financial crisis of 2008–9. My research on the role of inflation-indexed bonds in investors' portfolios also suggests TIPS are not likely to be highly liquid securities even in normal times, since they are by design buy-and-hold securities for most investors. Finally, inflation-indexed bonds do not appear to attract the same kind of attention as nominal Treasuries from institutional investors around the globe as a refuge security, a building block for derivative securities, and widely accepted collateral in a wide array of financial transactions.

If TIPS are less liquid than Treasury bonds, this liquidity differential might result in a liquidity discount on the prices of TIPS relative to nominal Treasury bonds or, equivalently, a premium on the yield on TIPS. In that case TIPS yields overestimate real interest rates, and breakeven inflation underestimates expected inflation. The question then is whether this discount really exists, and if so, how large it is in practice, whether it is time varying and whether this variation is correlated with measures of aggregate risk.

I have explored these questions in my research with Carolin Pflueger and found that indeed inflation-indexed bonds trade at a discount relative to nominal Treasury bonds, and that the magnitude of this discount has varied substantially over the history of the TIPS market. Our estimates suggest that it was large—above 100 basis points—during the first few years of the market and at the height of the financial crisis in the fall of 2008 and the winter of 2009, and much lower but still substantial—above 25 basis points—at other “normal” times.

Our estimates are based on regressions of breakeven inflation on variables that proxy for inflation expectations and variables that proxy for liquidity, both market-

wide liquidity—such as the on-the-run off-the-run spread in the nominal Treasury market—and TIPS market liquidity—such as trading volume on TIPS relative to nominal Treasuries. We find that liquidity proxies explain almost as much variation in breakeven inflation as inflation proxies—and this holds even if we exclude the financial crisis from the sample.<sup>19</sup> A measure of historical breakeven inflation adjusted for liquidity in this way suggests that bond market inflation expectations are much more stable and larger on average than raw measures of breakeven inflation imply. In particular, while breakeven inflation experienced a very significant decline in the fall of 2008, suggesting a scenario of extremely low inflation and even severe deflation over the next several years, liquidity-adjusted inflation suggested a much milder fall in inflation expectations and (or) inflation risk premia. U.K. inflation-linked gilts also appear to carry a discount relative to U.K. nominal gilts, although smaller and less variable over time.

Under the assumption that the liquidity differential between inflation-indexed bonds and nominal bonds is all a discount in the price of inflation-indexed bonds, we can measure liquidity-adjusted inflation-indexed bond yields and returns. Using these inflation-adjusted returns, we find that there is still substantial evidence of excess return predictability in liquidity-adjusted inflation-indexed bond returns as well as in breakeven inflation returns in both the United States and the United Kingdom, which we interpret as evidence of a time-varying real interest risk premium and a time-varying inflation risk premium. We also test whether supply effects of the sort suggested by the preferred habitat theory with limits to arbitrage drive the return predictability on inflation-indexed bonds, but we find no evidence of such effects.

Interestingly, we find that changes in the relative liquidity discount on TIPS are negatively correlated with aggregate stock market returns. Since the liquidity discount on TIPS increases when the market falls, it makes TIPS systematically riskier and thus further lowers their prices relative to those that would prevail

if the liquidity discount were constant. That is, the liquidity discount in TIPS prices—or equivalently the liquidity premium on TIPS yields—partly reflects a liquidity *risk* premium on TIPS, which is also time varying.

If the significant relative liquidity discount is all in the price of TIPS, my research suggests that long-term investors for whom short-term liquidity is not important have historically extracted an additional benefit from holding TIPS in the form of a price discount. This in turn implies that the U.S. Treasury and more generally the sellers of TIPS have “left money on the table,” not raising as much revenue as they could have by issuing nominal Treasury bonds. In related research, Matthias Fleckenstein, Francis Longstaff, and Hanno Lustig also show strong evidence that inflation derivatives are subject to severe mispricing, from which the Treasury could benefit by arbitraging the cash and derivatives market for inflation.<sup>20</sup>

An alternative interpretation is that TIPS are priced according to their fundamentals, but that nominal Treasury bonds carry a price premium investors are willing to pay for holding them. This implies that TIPS holders are not benefiting from a discount, but it still implies that the Treasury could raise more revenue by issuing nominal bonds instead of TIPS. Of course, revenue maximization need not be the only reason for a government to issue bonds. The government can contribute to improvement of social welfare by completing markets. My research on the key role of TIPS on the portfolios of long-term investors, such as individual investors saving for retirement, shows that issuing TIPS can be welfare-enhancing. The shift in the provision of pension benefits in the United States from defined benefit to defined contribution suggests that the importance of TIPS for savers has, if anything, increased over time.

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<sup>1</sup> J. Y. Campbell and L. M. Viceira, “Who Should Buy Long-Term Bonds?” *American Economic Review*, 91 (1)

(March 2001) (also NBER Working Paper No. 6801, November 1998.)

<sup>2</sup> As vividly described in the Wall Street Journal article of July 7, 2003, "As Fed Cuts Rates, Retirees Are Forced To Pinch Pennies—With Interest Income Down, Seniors in Florida Complex Are Facing Tough Choices—A \$1.63 Splurge at Burger King."

<sup>3</sup> Campbell and Viceira, 2001, *op. cit.*; and J. Wachter, "Risk Aversion and Allocation to Long-Term Bonds," *Journal of Economic Theory* 112 (October 2003), pp. 325–33.

<sup>4</sup> L. M. Viceira, "Life-Cycle Funds," Chapter 5 in *Overcoming the Saving Slump: How to Increase the Effectiveness of Financial Education and Saving Programs*, A. Lusardi, ed., Chicago: University of Chicago Press, 2008; F. J. Gomes, L. J. Kotlikoff, and L. M. Viceira, "Optimal Life-Cycle Investing with Flexible Labor Supply: A Welfare Analysis of Life-Cycle Funds," *American Economic Review: Papers and Proceedings* 98 (May 2008), pp. 297–303 (also NBER Working Paper No. 13966, April 2008).

<sup>5</sup> J. Y. Campbell and L. M. Viceira, "The Term Structure of the Risk-Return Trade-off," *Financial Analysts Journal*, 61 (1) (2005), pp. 34–44 (also NBER Working Paper No. 11119, February 2005.)

<sup>6</sup> This is an updated version of Figure 1 in Campbell and Viceira, 2005, *supra*.

<sup>7</sup> Campbell and Viceira, 2001, *op. cit.*; J. Y. Campbell, R. J. Shiller, and L. M. Viceira, "Understanding Inflation-Indexed Bond Markets," *Brookings Papers on Economic Activity* (Spring 2009), pp. 79–120, (also NBER Working Paper No. 15014, May 2009); J. Y. Campbell, A. Sunderam, and L. M.

Viceira, "Inflation Bets or Deflation Hedges? The Changing Risks of Nominal Bonds," NBER Working Paper No. 14701, February 2009.

<sup>8</sup> This is an updated version of Figure 1 in L. M. Viceira, "Bond Risk, Bond Return Volatility, and the Term Structure of Interest Rates," *International Journal of Forecasting* 28 (2012), pp. 97–117; see also Campbell, Sunderam, and Viceira, 2009, *op. cit.*

<sup>9</sup> Campbell, Shiller, and Viceira, 2009, *op. cit.*

<sup>10</sup> See Figure 7 in Campbell, Sunderam, and Viceira, 2009, *op. cit.*

<sup>11</sup> See Figure 7 in Campbell, Shiller, and Viceira, 2009, *op. cit.*

<sup>12</sup> J. Y. Campbell and J. Cochrane, "By Force of Habit: A Consumption-based Explanation of Aggregate Stock Market Behavior," *Journal of Political Economy* 107 (1999), pp. 205–251 (also NBER Working Paper No. 4995, January 1995); and J. A. Wachter, "A Consumption-based Model of the Term Structure of Interest Rates," *Journal of Financial Economics* 79 (February 2006), pp. 365–99.

<sup>13</sup> Campbell, Sunderam, and Viceira, 2009, *op. cit.*

<sup>14</sup> J. Cochrane and M. Piazzesi, "Bond Risk Premia," *American Economic Review* 95 (2005), pp. 138–60 (also NBER Working Paper No. 9178, September 2002.)

<sup>15</sup> J. Y. Campbell and R. J. Shiller, "Yield Spreads and Interest Rate Movements: A Bird's Eye View," *Review of Economic Studies* 58 (1991), pp. 495–514 (also NBER Working Paper No. 3153, September 1991); Cochrane and Piazzesi, 2005, *op. cit.*

<sup>16</sup> Wachter, 2006, *op. cit.*; R. Bansal

and I. Shaliastovich, "A Long-Run Risks Explanation of Predictability Puzzles in Bond and Currency Markets," *Review of Financial Studies* 26(1) (2013), pp. 1–33 (also NBER Working Paper No. 18357, September 2012).

<sup>17</sup> C. E. Pflueger and L. M. Viceira, "Inflation-Indexed Bonds and the Expectations Hypothesis," *Annual Review of Financial Economics* 3 (December 2011), pp. 139–58 (also NBER Working Paper No. 16903, March 2011.); C. E. Pflueger and L. M. Viceira, "Return Predictability in the Treasury Market: Real Rates, Inflation, and Liquidity," manuscript, Harvard University, April 2013 (also NBER Working Paper No. 16892, March 2011.)

<sup>18</sup> Campbell, Shiller, and Viceira, 2009, *op. cit.*; J. H. Wright, "Comment on Understanding Inflation-Indexed Bond Markets," *Brookings Papers on Economic Activity*, Spring 2009, pp. 126–38.

<sup>19</sup> Pflueger and Viceira, 2013, *op. cit.*; S. D'Amico, D. H. Kim, and M. Wei, "Tips from TIPS: The Informational Content of Treasury Inflation-Protected Security Prices," *Staff Working Paper*, Federal Reserve Board, Finance and Economics Discussion Series, 2010; J. H. Wright, R. S. Gurkaynak, and B. Sack, "The TIPS Yield Curve and Inflation Compensation," *American Economic Journal: Macroeconomics* 2 (2010), pp. 70–92.

<sup>20</sup> M. Fleckenstein, F. A. Longstaff, and H. Lustig, 2010, "Why does the Treasury Issue TIPS? The TIPS-Treasury Bond Puzzle," forthcoming in the *Journal of Finance* (also NBER Working Paper No. 16358, September 2010.)

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## NBER Profile: Gary Richardson

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Gary Richardson is a Research Associate in the NBER's Programs on the Development of the American Economy and Monetary Economics, and a Professor of Economics at the University of California at Irvine. In addition, he serves as the official historian of the Federal Reserve System, and recommends policies regarding the preservation, organization, and dissemination of the historical records of the Federal Reserve.

Richardson received his Ph.D. in economics from the University of California at Berkeley in 1999. As an undergraduate, he studied political science and history

at the University of Chicago and worked as a research assistant and writer at public-interest organizations in Washington, D.C., before beginning graduate studies.

Richardson's research focuses on the history of the causes and consequences of financial crises, particularly those that occurred in the United States before and during the Great Depression. He also studies the impact of financial regulation on the performance of financial institutions. His current research examines the evolution of financial institutions, including regulatory agencies and the Federal Reserve.

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## NBER Profile: Jonathan Skinner

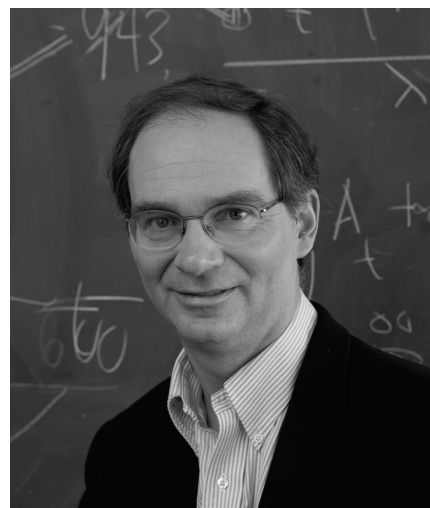
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Jonathan Skinner is a Research Associate in the NBER's Programs on Health Care, Aging, and Public Economics. He is also the James O. Freedman Presidential Professor in Economics at Dartmouth College and a professor at the Geisel School of Medicine's Institute for Health Policy and Clinical Practice.

Skinner's research interests include the economics of government transfer programs, technology growth and disparities in health care, and the savings behavior of aging baby boomers. He is an associate editor of the *American Economic Journal: Economic Policy*, and a former

editor of the *Journal of Human Resources*. In 2007 he was elected to the Institute of Medicine of the National Academy of Sciences. Skinner received his M.A. and Ph.D. in Economics from the University of California, Los Angeles and a B.A. in political science and economics from the University of Rochester. He has also taught at the University of Virginia, the University of Washington, Stanford University, and Harvard University.

Skinner lives with his wife, Martha, in Hanover, New Hampshire, where bears are occasional visitors to their backyard. He enjoys hiking, Nordic skiing, and sailing, particularly with family and co-authors.





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## NBER Profile: *Paula Stephan*

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Paula Stephan is a Research Associate in the NBER's Program on Labor Studies and a Professor of Economics at the Andrew Young School at Georgia State University. She received her B.A. degree in Economics from Grinnell College and her Ph.D. in Economics from The University of Michigan. She has held visiting positions at Wissenschaftszentrum Berlin für Sozialforschung, Katholieke Universiteit Leuven, and the Department of Economics and Statistics "Cognetti de Martiis" at the University of Turin, and has been a Wertheim Fellow at Harvard University.

Stephan's research focuses on the economics of science and the careers of scien-

tists and engineers. She is a member of the Board of Reviewing Editors of *Science*, and her book, *How Economics Shapes Science*, was published by Harvard University Press in 2012. She is a fellow of the American Association for the Advancement of Science. She was chosen as *Science* Careers' Person of the Year for 2012. She has served on the National Advisory General Medical Sciences Council of the National Institutes of Health, and on numerous committees of the National Research Council.

Stephan lives in Atlanta with her husband Bill Amis; they enjoy spending time in Paris, where they have a small apartment, and in Turin, Italy.

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## NBER Profile: *Luis M. Viceira*

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Luis M. Viceira is a Research Associate in the NBER's Program on Asset Pricing. He is also the George E. Bates Professor at the Harvard Business School, where he has been on the faculty since 1998. He received his M.A. and Ph.D. in Economics from Harvard University. He is a director of the European Finance Association, a Research Fellow and member of the Scientific Council of Netspar (the Network for Studies on Pensions, Aging, and Retirement), a Fellow of the TIAA-CREF Institute, and a trustee of the Financial Accounting Foundation. Viceira is a financial economist interested in the study of asset allocation models, with an emphasis on models that explore the asset allocation implications of empirical regularities in asset pricing and on life-cycle investing, asset pricing, with an emphasis on models of the term

structure of interest rates, household finance, and international finance. His research has been published in the *Journal of Finance*, the *Journal of Financial Economics*, the *Review of Financial Studies*, the *American Economic Review*, the *Quarterly Journal of Economics*, and the *Review of Finance*, among others. He is also the author of the book *Strategic Asset Allocation* with John Y. Campbell. Viceira is also interested in the design of pension fund systems, the design of investment strategies for long-term investors, the management and organization of large institutional investors, and product innovation in the money management industry.

Viceira lives in Belmont, Massachusetts with his wife Marta and his two children, Luis and Elena. He loves swimming, skiing, and reading history and fiction.





### Economics of Digitization

The NBER held a conference on the “Economics of Digitization” in Utah on June 6 and 7, 2013. The organizers were Shane Greenstein of Northwestern University and NBER, Avi Goldfarb of the University of Toronto, and Catherine Tucker of MIT and NBER. The following papers were discussed:

- **Ajay Agrawal** and **Nicola Lacetera**, University of Toronto and NBER; **John Horton**, of Desk Research; and **Elizabeth Lyons**, University of Toronto, “Digitization and the Contract Labor Market: A Research Agenda”
- **Michael Baye**, **Babur De Los Santos**, and **Matthijs Wildenbeest**, Indiana University, “Searching for Physical and Digital Media: The Evolution of Platforms for Finding Books”
- **Catherine Mann**, Brandeis University, “Information Lost (Apologies to Milton)”
- **Randall Lewis** and **David Reiley**, Google, Inc., and **Justin Rao**, Microsoft Research, “Measuring the Effects of Advertising: The Digital Frontier”
- **Joshua Gans**, University of Toronto and NBER, and **Hanna Halaburda**, Harvard University, “Some Economics of Pure Digital Currencies”
- **Matthew Gentzkow** and **Jesse Shapiro**, University of Chicago and NBER, “Ideology and the Demand for News Online”
- **Erik Brynjolfsson**, MIT and NBER, and **Lynn Wu**, University of Pennsylvania, “The Future of Prediction: How Google Searches Foreshadow Housing Prices and Sales”
- **Hal Varian**, Google, Inc., and the University of California, Berkeley, “Bayesian Variable Selection for Nowcasting Economic Time Series”
- **Joel Waldfogel**, University of Minnesota and NBER, “And the Bands Played On: Digital Disintermediation and the Quality of New Recorded Music”
- **Megan MacGarvie**, Boston University and NBER, and **Petra Moser**, Stanford University and NBER, “Copyright and the Profitability of Authorship — Evidence from Book Contracts in the Romantic Period”
- **Tatiana Komarova**, London School of Economics; **Denis Nekipelov**, University of California, Berkeley; and **Evgeny Yakovlev**, New Economic School, “Estimation of Treatment Effects from Combined Data: Identification versus Data Security”
- **Brett Danaher**, Wellesley College, and **Michael Smith** and **Rahul Telang**, Carnegie Mellon University, “Pro Copyright Enforcement in a Digital Age”
- **Timothy Simcoe**, Boston University and NBER, “The Endogenous Modularity of the Internet”
- **Scott Wallsten**, Technology Policy Institute, “What Are We Not Doing When We’re Online, And How Much Is That Worth?”

- **Susan Athey**, Stanford University and NBER, and **Scott Stern**, MIT and NBER, “The Nature and Incidence of Software Piracy: Evidence from Windows”

Summaries of these papers are available at: [www.nber.org/confer/2013/DIGs13/summary.html](http://www.nber.org/confer/2013/DIGs13/summary.html)

## Twenty-Fourth Annual EASE Conference

The NBER, the Australian National University, the China Center for Economic Research, the Chung-Hua Institution for Economic Research, the Hong Kong University of Science and Technology, the Korea Development Institute, the National University of Singapore, and the Tokyo Center for Economic Research jointly sponsored the NBER’s 24th Annual East Asian Seminar on Economics. The conference, which was hosted by Victoria University of Wellington, School of Economics and Finance, took place on June 21 and 22, 2013 in Wellington, New Zealand. Takatoshi Ito, University of Tokyo and NBER, and Andrew K. Rose, University of California, Berkeley and NBER, organized the conference, which focused on “Crises in the Open Economy.” These papers were discussed:

- **Kristin Forbes**, MIT and NBER; **Marcel Fratzscher**, DIW Berlin and Humboldt University Berlin; and **Roland Straub**, European Central Bank, “Capital Controls and Prudential Measures: What Are They Good For?”
- **Yuming Fu**, **Wenlan Qian**, and **Bernard Yeung**, National University of Singapore, “Transaction Tax and Housing Market Speculators”
- **Yothin Jinjarak**, University of London; **Ilan Noy**, Victoria University of Wellington; and **Huanhuan Zheng**, Chinese University of Hong Kong, “Capital Controls in Brazil — Stemming a Tide with a Signal?”
- **Dongchul Cho**, Korea Development Institute, and **Changyong Rhee**, Asian Development Bank, “Effects of Quantitative Easing on Asia: Capital Flows and Financial Markets”
- **Pengfei Wang** and **Zhiwei Xu**, Hong Kong University of Science and Technology, and **Jianjun Miao**, Boston University, “A Bayesian DSGE Model of Stock Market Bubbles and Business Cycles”
- **Kathryn Dominguez**, University of Michigan and NBER, “Exchange Rate Implications of Reserve Changes”
- **Ju-Yin Tang**, National Taiwan University, and **Chung-Shu Wu**, CIER, “Trade Credit, Bank Credit, and Financial Crises: The Case of Taiwan”
- **Kosuke Aoki**, University of Tokyo, and **Kalin Nikolov**, European Central Bank, “Financial Disintermediation and Financial Fragility”
- **Joshua Chan**, **Renée Fry-McKibbin**, and **Cody Yu Ling Hsiao**, Australian National University, “A Regime Switching Skew-Normal Model for Measuring Financial Crisis and Contagion”
- **Bo Zhao**, Peking University, “Rational Housing Bubble”
- **Maurice Obstfeld**, University of California, Berkeley and NBER, “Finance at Center Stage: Some Lessons of the Euro Crisis”
- **Tokuo Iwaisako**, Hitotsubashi University, “Preparing for the Next Crisis in JGB Market”

Summaries of these papers may be found at: <http://www.nber.org/confer/2013/ease13/summary.html>

## Thirty-sixth International Seminar on Macroeconomics

The NBER's 36th International Seminar on Macroeconomics (ISOM) took place on June 21 and 22, 2013 at the Bank of Italy in Rome. NBER Research Associate Richard Clarida, Columbia University, and Lucrezia Reichlin, London Business School, organized the program. The following papers were discussed:

- **Ugo Albertazzi**, Banca d'Italia, and **Margherita Bottero**, Bank of Italy, "The Procyclicality of Foreign Bank Lending: Evidence from the Global Financial Crisis"
- **David Miles** and **Jochen Schanz**, Bank of England, "The Relevance or Otherwise of the Central Bank's Balance Sheet"
- **Eric Swanson** and **John Williams**, Federal Reserve Bank of San Francisco, "Measuring the Effect of the Zero Lower Bound on Yields and Exchange Rates in the U.K. and Germany"
- **Galina Hale**, Federal Reserve Bank of San Francisco; **Jean Imbs**, Paris School of Economics; and **Elliot Marks**, Federal Reserve Bank of San Francisco, "Bank Linkages, Diversification, and Contagion"
- **Martin Evans**, Georgetown University, "Hot Money and Dark Matter"
- **Jiandong Ju**, University of Oklahoma; **Kang Shi**, Chinese University of Hong Kong; and **Shang-Jin Wei**, Columbia University and NBER, "On the Connections between Intertemporal and Intra-temporal Trades"
- **Alejandro Justiniano**, Federal Reserve Bank of Chicago; **Giorgio Primiceri**, Northwestern University and NBER; and **Andrea Tambalotti**, Federal Reserve Bank of New York, "The Effects of the Saving and Banking Glut on the US Economy"
- **David Backus** and **Thomas Cooley**, New York University and NBER, and **Espen Henriksen**, University of California, Davis, "Demography and Low-Frequency Capital Flows"

Summaries of these papers may be found at: <http://www.nber.org/confer/2013/ISOM13/summary.html>

## Japanese Economy Meeting

The NBER together with the Center on Japanese Economy and Business, the Center for Advanced Research in Finance, and the Australia-Japan Research Centre, held a meeting on the Japanese economy in Tokyo on July 26 and 27, 2013. The organizers were: Jennifer Corbett, Australian National University; Charles Horioka, University of the Philippines and NBER; Takeo Hoshi, Stanford University and NBER; Kazuo Ueda, University of Tokyo; and David Weinstein, Columbia University and NBER. The following papers were discussed:

- **Raymond Fisman**, Columbia University and NBER, and **Yasushi Hamao** and **Yongxiang Wang**, University of Southern California, "The Impact of Interstate Tensions on Economic Exchange: Evidence from Shocks to Sino-Japanese Relations"
- **Mathias Hoffmann**, University of Zurich, and **Toshihiro Okubo**, Keio University, "By a Silken Thread: Regional Banking Integration and Pathways to Financial Development in Japan's Great Recession"
- **Tsutomu Watanabe**, University of Tokyo; **Satoshi Imai**, Statistics Bureau of Japan; and **Chihiro Shimizu**, Reitaku University, "How Fast Are Prices in Japan Falling?"

- **John Tang**, Australian National University, “Railroad Expansion and Entrepreneurship: Evidence from Meiji Japan”
- **Ayako Kondo**, Yokohama National University, and **Hitoshi Shigeoka**, Simon Fraser University, “The Effectiveness of Government Intervention to Promote Elderly Employment: Evidence from Elderly Employment Stabilization Law”
- **Jiro Yoshida**, Pennsylvania State University, and **Ayako Sugiura**, Tokyo Association of Real Estate Appraisers, “Multidimensional Green Values: A Case of Green Condominiums with Longer Life Spans”
- **Takao Kato**, Colgate University; **Daiji Kawaguchi**, Hitotsubashi University; and **Hideo Owan**, University of Tokyo, “Dynamics of the Gender Gap in the Workplace: An Econometric Case Study of a Large Japanese Firm”
- **Mary Amity**, Federal Reserve Bank of New York, and **David Weinstein**, Columbia University and NBER, “How Much do Bank Shocks Affect Investment? Evidence from Matched Bank-Firm Loan Data” (NBER Working Paper No. 18890)

Summaries of these papers may be found at: <http://www.nber.org/confer/2013/JPMs13/summary.html>

## The Changing Frontier: Rethinking Science and Innovation Policy Conference

An NBER conference on “The Changing Frontier: Rethinking Science and Innovation Policy” organized by NBER Research Associates Adam Jaffe of Motu Economic and Public Policy Research and Ben Jones of Northwestern University, took place in Chicago on August 2 and 3, 2013. The following papers were discussed:

- **Lee Branstetter**, Carnegie Mellon University and NBER; **Guangwei Li**, Carnegie Mellon University; and **Francisco Veloso**, Carnegie Mellon University, “The Globalization of R and D: China, India, and the Rise of International Co-invention”
- **Maryann Feldman** and **Lauren Lanahan**, University of North Carolina, “State Science Policy Experiments in the Laboratories of Democracy”
- **Chris Forman**, Georgia Institute of Technology; **Avi Goldfarb**, University of Toronto; and **Shane Greenstein**, Northwestern University and NBER, “Information Technology and the Distribution of Inventive Activity”
- **Paula Stephan**, Georgia State University and NBER, “The Endless Frontier: Reaping What Bush Sowed?”
- **Hezekiah Agwara**, **Philip Auerswald**, and **Brian Higginbotham**, George Mason University, “Algorithms and the Changing Frontier”
- **Timothy Bresnahan**, Stanford University, and **Jason Davis** and **Pai-Ling Yin**, MIT, “Economic Value Creation in Mobile Applications”
- **Ajay Agrawal**, University of Toronto and NBER; **John McHale**, National University of Ireland; and **Alexander Oettl**, Georgia Institute of Technology, “Collaboration, Stars, and the Changing Organization of Science: Evidence from Evolutionary Biology”
- **Richard Freeman**, Harvard University and NBER; **Ina Ganguli**, SITE, Stockholm School of Economics; and **Raviv Murciano-Goroff**, Stanford University, “Why and Wherefore of Increased Scientific Collaboration”



- **Annamaria Conti**, Georgia Institute of Technology, and **Christopher Liu**, University of Toronto, “The (Changing) Knowledge Production Function: Evidence from the MIT Department of Biology — 1970–2000”
- **Ramana Nanda**, Harvard University, and **Kenneth Younge** and **Lee Fleming**, University of California, Berkeley, “Innovation and Entrepreneurship in Renewable Energy”
- **Joshua Gans**, University of Toronto and NBER, and **Fiona Murray**, MIT and NBER, “Credit History: The Changing Nature of Scientific Credit”

Summaries of these papers are available at: <http://www.nber.org/confer/2013/RSIPs13/summary.html>

## Conference on State and Local Health Plans for Active and Retired Public Employees

An NBER Conference on State and Local Health Plans for Active and Retired Public Employees took place in Wyoming on August 16 and 17, 2013. NBER Research Associates Robert Clark of North Carolina State University and Joseph Newhouse of Harvard University organized the meeting. The following papers were discussed:

- **Robert Clark**, North Carolina State University and NBER, and **Olivia Mitchell**, University of Pennsylvania and NBER, “How Does Retiree Health Insurance Influence Public Sector Employee Saving?”
- **Sita Slavov**, American Enterprise Institute, and **John Shoven**, Stanford University and NBER, “The Role of Retiree Health Insurance in the Early Retirement of Public Sector Employees”
- **Robert Clark**, North Carolina State University and NBER; **Melinda Morrill**, North Carolina State University; and **David Vanderweide**, North Carolina General Assembly, “The Effects of Retiree Health Insurance Plan Characteristics on Retirees’ Choice and Employers’ Costs”
- **Robert Novy-Marx**, University of Rochester and NBER, and **Joshua Rauh**, Stanford University and NBER, “Funding Soft Liabilities”
- **Paige Qin**, Harvard University, and **Michael Chernow**, Harvard University and NBER, “Compensating Wage Differentials and the Impact of Health Insurance in the Public Sector on Wages and Salary”
- **Byron Lutz** and **Louise Sheiner**, Federal Reserve Board, “Examining the Whole Picture: Retiree Health Obligations and the Long-Term Budget Outlook for the State and Local Government Sector”
- **Maria Fitzpatrick**, Cornell University and NBER, “Retiree Health Insurance for Public School Employees: Does It Affect Retirement and Mobility?”
- **Jeffrey Clemens**, University of California, San Diego and NBER, and **David Cutler**, Harvard University and NBER, “Who Pays for Public Employee Health Costs?”

Summaries of these papers may be found at: <http://www.nber.org/confer/2013/SLHP13/summary.html>

### 36th Annual Summer Institute

The NBER hosted its 36th annual Summer Institute during a three-week period in July. The attendance total reached a new high, 2,449 participants, and the number of first-time participants, 599, was also a record. More than two-thirds of the participants were not affiliated with the NBER.

NBER Research Associate Lawrence Summers of Harvard University delivered the Martin Feldstein lecture on the topic of “Economic Possibilities for Our Children.”

Matthew Gentzkow, Christian

Hansen, Jesse Shapiro, and Matthew Taddy of the Booth School of Business at the University of Chicago, and Victor Chernozhukov of the Massachusetts Institute of Technology, presented the 2013 “Econometrics Methods Lectures.” Their topic was “Econometric Methods for High-Dimensional Data.” Their lectures, which spanned two days, have been recorded and posted on the NBER website at: [http://www.nber.org/econometrics\\_minicourse\\_2013](http://www.nber.org/econometrics_minicourse_2013)

As in past years, the 2013 Summer

Institute drew participants from a wide range of institutions. For the first time, more than 400 institutions were represented at the meetings. There were nearly 500 research presentations, which touched on many different topics. The presentations were organized into 53 distinct research meetings. A full list of meetings and the papers presented may be found at: [http://www.nber.org/confer/2013/SI2013/SI2013\\_rev.html](http://www.nber.org/confer/2013/SI2013/SI2013_rev.html)

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## Program and Working Group Meetings

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### Economic Fluctuations and Growth Program Meeting

The NBER’s Program on Economic Fluctuations and Growth met in Cambridge on July 13, 2013. NBER Research Associates Peter Klenow of Stanford University, and Valerie Ramey of the University of California, San Diego organized the meeting. These papers were discussed:

- **Daron Acemoglu**, MIT and NBER; **Ufuk Akcigit**, University of Pennsylvania and NBER; **Nicholas Bloom**, Stanford University and NBER; and **William Kerr**, Harvard University and NBER, “Innovation, Reallocation, and Growth” (NBER Working Paper No. 18993)
- **Mark Aguiar**, Princeton University and NBER; **Manuel Amador**, Stanford University and NBER; and **Emmanuel Farhi** and **Gita Gopinath**, Harvard University and NBER, “Crisis and Commitment: Inflation Credibility and the Vulnerability to Sovereign Debt Crises”
- **Shigeru Fujita**, Federal Reserve Bank of Philadelphia, and **Giuseppe Moscarini**, Yale University and NBER, “Recall and Unemployment”
- **Robert Hall**, Stanford University and NBER, “High Discounts and High Unemployment”

- **David Lagakos**, University of California, San Diego and NBER; **Benjamin Moll**, Princeton University and NBER; **Tommaso Porzio**, Yale University; and **Nancy Qian**, Yale University and NBER, “Experience Matters: Human Capital and Development Accounting” (NBER Working Paper No. 18602)
- **Saki Bigio**, Columbia University, and **Jennifer La’O**, Columbia University and NBER, “Financial Frictions in Production Networks”

Summaries of these papers may be found at: <http://www.nber.org/confer/2013/EFGs13/summary.html>

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## Bureau Books

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## Tax Policy and the Economy, Volume 27

*Tax Policy and the Economy, Volume 27*, edited by Jeffrey R. Brown, is available from the University of Chicago Press in October 2013.

Taxation policy was a central part of the policy debates over the “fiscal cliff.” Given the importance of fiscal issues, careful empirical research can help inform the policy dialogue. In keeping with the NBER’s tradition of carrying out rigorous but policy-

relevant research, this volume offers insights on a number of key tax policy questions. It features six papers by leading scholars who examine the tax treatment of tuition at private K-12 schools; the potential streamlining of the federal rules for post-secondary financial aid and the use of tax return information in this process; the effect of tax and benefit programs on incentives to work; the macroeconomic effects of fis-

cal adjustments; and the set of factors that contributed to the weakening U.S. fiscal outlook in the last decade.

Jeffrey R. Brown is a Research Associate in the NBER’s Programs on Aging and Public Economics and the William G. Karnes Professor of Finance at the University of Illinois at Urbana-Champaign.

The price of this volume is \$60.00 for a clothbound volume.

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