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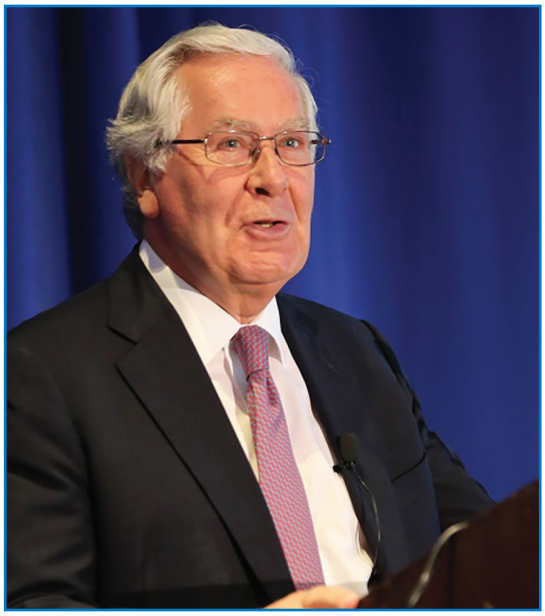

Mervyn King

ALSO IN THIS ISSUE

The 2017 Martin Feldstein Lecture

Uncertainty and Large Swings in Activity

Mervyn King*

It is a great honor, as well as a personal pleasure and privilege, to be invited to deliver the Feldstein Lecture. I have known Marty and Kate for almost 50 years. I met Marty in the summer of 1970, when I presented my first ever paper at the Second World Congress of the Econometric Society in Cambridge, England. The subject was investment, and Marty presented a paper, jointly with the late John Flemming, on the same topic. Those were the early days of computer analysis of data, and paper tape had not yet given way to the new technology of punched cards. But the application of rigorous theory to quantitative empirical analysis was a heady and seductive combination.

A year later I was a graduate student at Harvard with Marty as my mentor. A few years after that, Marty took over the National Bureau, and the first Summer Institute was held. "Oh, to be in Cambridge, England now that spring is here" became "Oh, to be in Cambridge, Massachusetts now that summer's here".[1]

And here we are at the 40th NBER Summer Institute. In the audience, I see economists who had not yet been born at the time of that first workshop in 1978. So in my lecture I want to trace the path that both Marty and I took from microeconomics to macroeconomics. In particular, I shall ask how far the so-called workhorse or canonical models of modern macroeconomics can help us understand what has been going on in the world economy for the past quarter of a century. My focus will be on uncertainty and large swings in economic activity — of the kind we saw in the Great Depression and more recently in the Great Recession of 2008–09 — and the unexpectedly slow and protracted recovery since the financial crisis.

In so doing, I want to draw inspiration from what, in my view, is one

**This is an annotated, lightly edited version of the Martin Feldstein Lecture delivered July 19, 2017, at the NBER Summer Institute. Mervyn King is a former governor of the Bank of England, a member of the British House of Lords, an NBER research associate, and the Alan Greenspan Professor of Economics at New York University. The annual lecture is named in honor of the NBER's president emeritus.*

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of Marty's greatest strengths: his ability to combine a conviction that economics has a great deal to offer in thinking about almost every aspect of our lives — Marty's freshwater characteristic — and an imagination to develop models and new data sources to examine previously unexplored territory — his saltwater dimension.

Introduction

The fundamental question that has divided economists since publication of *The General Theory* in 1936 is whether a market economy with flexible wages and prices is self-stabilizing. The recent financial crisis should have generated a more serious debate about that question. But it takes a great deal to derail a conventional theory. As John Maynard Keynes wrote in the preface to his great work, "The ideas which are here expressed so laboriously are extremely simple and should be obvious. The difficulty lies, not in the new ideas, but in escaping from the old ones."[2]

The crisis did not lead to an intellectual revolution. Instead, debate focused on the appropriate policy response rather than the theoretical basis of current macroeconomics.[3] Indeed, the workhorse model taught in courses on macroeconomics and used by policymakers survived the crisis better than did our economies. Even adding banks and financial rigidities, with new first-order conditions, did not change its basic properties. The central idea is that the economy moves in response to stochastic shocks around a steady-state or stationary long-run equilibrium.

It is interesting to ask how the stochastic, one-sector models so much in favor today came to dominate macroeconomic thinking. Fifty years or so ago, models of economic dynamics and models of economic growth were quite separate. The former stimulated the construction of econometric models with empirically estimated dynamic responses. The latter were concerned with long-run steady growth and later expanded into multisector models of economic development.[4] The first advance was to incorporate the ideas of Frank Ramsey into the formulation of optimal growth paths based on the maximization of expected utility.[5] The second was the explicit modelling of expectations in a stochastic environment. It was natural to relate expectations to the underlying long-run relationships driving the economy, and so rational expectations came to the fore. Multisector models seemed to add little to the insights into behavior afforded by the rational expectations revolution. Attention switched

back, therefore, to one-sector models and the elaboration of stochastic shocks. And so we arrived at today's consensus on the centrality of one-sector DSGE (dynamic stochastic general equilibrium) models.

But these models have their limitations, and two seem to me particularly serious. First, expected utility theory has come to dominate macroeconomic modelling even though its foundations are fragile when analyzing behavior in the presence of large, one-off macroeconomic shocks. Second, the one-sector framework leads policymakers to focus exclusively on the level of aggregate demand rather than on its composition. Both features are, in my view, problematic in understanding the world economy today, as I shall now try to illustrate with a rapid tour of some of the relevant data.

Selected Data

The proposition that the U.S. economy follows a path described by random shocks around a steady-state growth rate is given some support in Figure 1, which plots GDP per head at constant prices from 1900 to 2016.[6] A trend line with a constant annual growth rate of 1.95 percent captures the upward path of GDP per head rather well. By far the largest deviations from this path were, of course, the Great Depression and the boom experienced in the Second World War. It is noticeable that, despite these large swings in activity, from 1950 onwards GDP per head resumed the path that would have been projected from an estimated trend over the period 1900 through 1930.

Figure 1 also shows data for the U.K. The underlying growth rate is remarkably similar, although, unlike the U.S., the U.K. did not experience the wild swings of the 1930s and 1940s. But at the end of the First World War the U.K. suffered a step down in the level of GDP per head and did not return to the previous trend path. This was when the U.S. took over the mantle of the world's financial leader.

Figure 2 plots the distribution of percentage deviations from trend GDP in the U.S. over the full 1900–2016 period. Whatever else can be said, the chart does not look like a normal distribution. If the underlying distribution of shocks is normal, then it must be shifting over time, suggesting non-stationarity of the shocks.

For the period since 1960, Figure 1 shows the trend growth path for real GDP per capita for the U.S. and the U.K. over the 1960–2007 period — the period up to the beginning of the recent financial crisis. The growth rate is almost exactly the same, just over 2 percent a year, in both countries.[7] Again, a constant trend growth path seems to fit reasonably well until the period beginning with the financial crisis. Since then the pattern of growth has been very different from its earlier path. A persistent shortfall from the previous trend is evident. Something significant has changed — and it is a matter of dispute as to whether the underlying productivity growth trend has fallen or whether there is another reason for the pattern of persistently slow growth.

The most striking evidence of non-stationarity is shown in Figure 3. It plots the world real interest rate at a 10-year maturity, as calculated by David Low and myself from interest rates on government bonds issued with inflation protection, from 1985 to the middle of 2017.[8] From around the time when China and the members of the former Soviet Union entered the world trading system, long-term

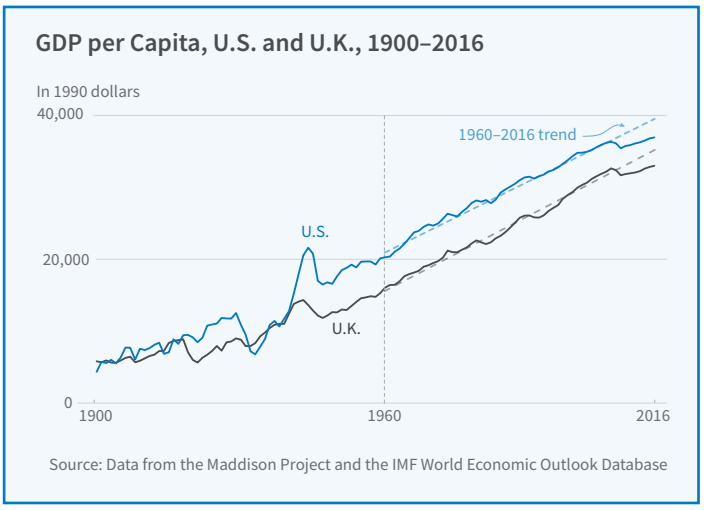

Figure 1

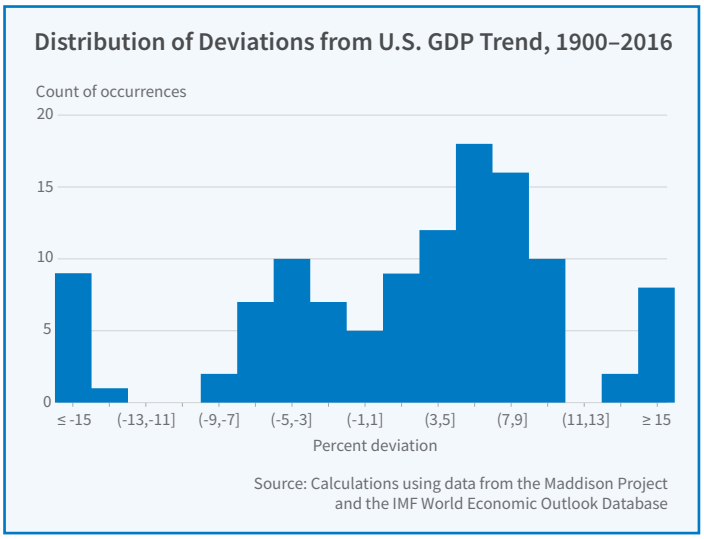

Figure 2

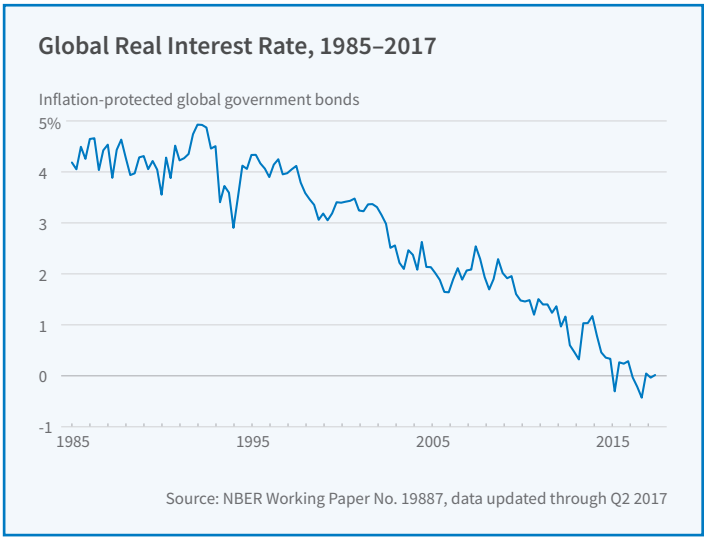

Figure 3

real interest rates have steadily declined to reach their present level of around zero. Such a fall over a long period is unprecedented. And it poses a serious challenge to the one-sector growth model. In order to salvage the model, much effort has been invested in the attempt to explain why the "natural" real rate of interest has fallen to zero or negative levels. But there is nothing natural about a negative real rate of interest. It is simpler to see Figure 3 as a disequilibrium phenomenon that cannot persist indefinitely.

Part of the explanation lies in saving behavior. Figure 4 shows the gross national saving rates for China and Germany from 1980 through 2016. Their saving rates have risen markedly, especially in the case of China and more recently in Germany. Figure 5 shows the saving rates in the U.S. and U.K. over the same period. From the mid-1990s onwards, there has been a decline, again symptomatic of non-stationarity.

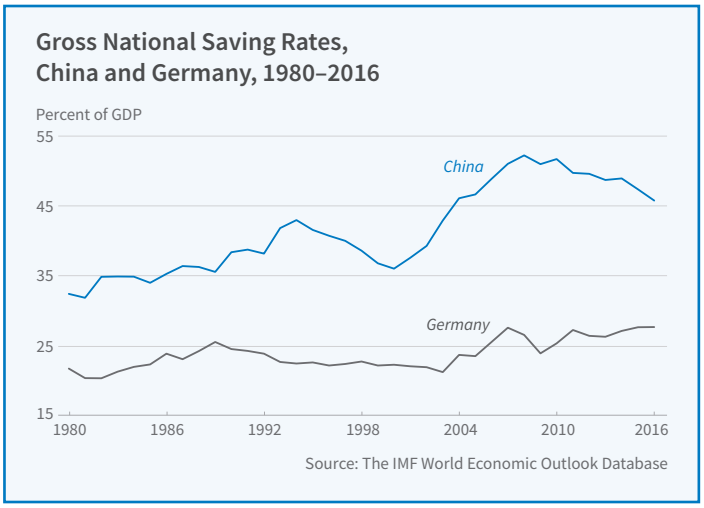

Figure 4

What these charts show is that the experience of the past 25 years cannot easily be described as the outcome of stochastic deviations from a stationary process. The data I have presented provide a *prima facie* case for considering explanations based on a divergence from a sustainable growth path along which the composition and not just the level of aggregate demand is a key driver of growth. To understand this requires going beyond the one-sector workhorse model that has come to dominate macroeconomic teaching and policymaking.

That model, even with modifications to first-order conditions to allow for various new "frictions," has two failings. First, it leans heavily on the assumption of forward-looking agents who optimise over known probability distributions of the shocks hitting the economy. But there is little empirical basis for computing the relevant probability distributions over events that are drawn from a non-stationary economic environment. Second, important movements in the world economy over the past quarter of a century cannot be explained easily in terms of a one-sector model. The minimum that is required is a two-sector view of the world with both tradable and non-tradable goods. How else are we to make sense of the changes in saving and investment rates in the major economies and the continuing current account imbalances?

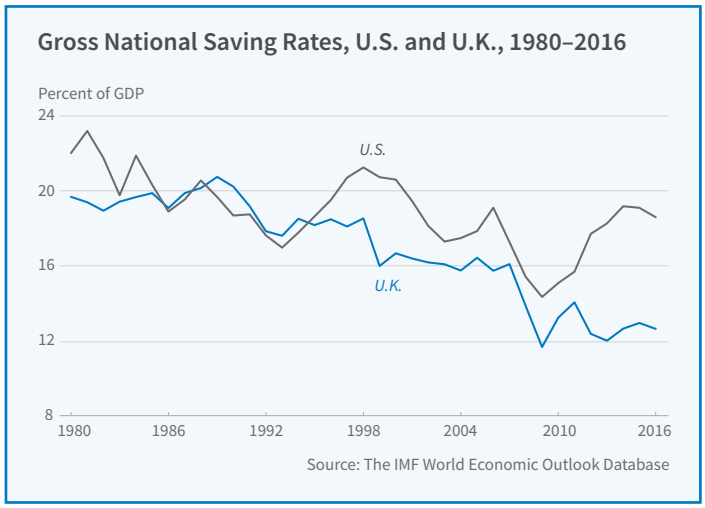

Figure 5

Now, I do not want to suggest that we should abandon the workhorse model, simply that we should be prepared to consider other approaches. Imagine that you had a problem in your kitchen, and summoned a plumber. You would hope that he might arrive with a large box of tools, examine carefully the nature of the problem, and select the appropriate tool to deal with it. Now imagine that when the plumber arrived, he said that he was a professional economist but did plumbing in his spare time. He arrived with just a single tool. And he looked around the kitchen for a problem to which he could apply that one tool. You might think he should stick to economics. But when dealing with economic problems, you should also hope that he had a box of tools from which it was possible to choose the relevant one.[9]

And there are times when there is no good model to explain what we see. The proposition that "it takes a model to beat a model" is rather peculiar. Why does it not take a fact to beat a model? And although models can be helpful, why do we always have to have one?[10] After the financial crisis, a degree of doubt and skepticism about many models would be appropriate.

Let me now turn to the first of the two failings I mentioned — the limitations of expected utility theory.

Uncertainty: The Fallacy of Bayesian Reasoning Outside a Frequentist Framework

I believe we need to face up to the challenge posed by radical uncertainty — a state of affairs in which we cannot enumerate all the possible states of the world and hence cannot attach subjective probabilities to them. The only sensible answers to the questions "Will President Trump still be in the White House in 2021?" and "Will the U.S. economy regain its pre-crisis trend growth path?" are "I don't know." None of the possible outcomes represent a series of

repeated events in a stationary environment in which it would be possible to construct probabilities based on observed frequencies. And the most important future events that will shape the economy cannot even be imagined — new products emerged that were unimaginable 20 years ago.

We have all grown up with the simple-minded methodological view that agents can be modelled "as if" they optimized expected utility computed according to Bayesian updated "personal probabilities." Although useful in some — especially stationary — contexts, the expected utility framework, fundamental to modern macroeconomics, has serious weaknesses that make it unsuited to the analysis of major swings in economic activity.

Let me give a simple example. It relates to my own experience when, as deputy governor of the Bank of England, I was asked to give evidence before the House of Commons Select Committee on Education and Employment on whether Britain should join the European Monetary Union. I was asked how we might know when the business cycle in the U.K. had converged with that on the Continent. I responded that given the typical length of the business cycle, and the need to have a minimum of 20 or 30 observations before one could draw statistically significant conclusions, it would be 200 years or more before we would know.[11] And of course it would be absurd to claim that the stochastic process generating the relevant shocks had been stationary since the beginning of the Industrial Revolution. There was no basis for pretending that we could construct a probability distribution. As I concluded, "You will never be at a point where you can be confident that the cycles have genuinely converged; it is always going to be a matter of judgment."[12]

The fact that the economic processes generating growth and fluctuations do not exhibit "stationarity" is of fundamental importance. It is why so many empirically estimated models break down. The world does not stand still long enough for an observer to measure the frequencies that would enable her to construct estimates of probabilities. And it is not only history that casts doubt on the plausibility of the assumption of stationarity. Learning from experience, including that of others, means that expectations evolve over time and induce a non-stationarity in economic relationships. Large swings in activity do not occur with sufficient frequency to permit a frequentist approach to estimating probabilities. They do not occur in an environment that is stationary over the relevant time scales. And there is no basis on which to construct subjective probabilities other than to succumb to the temptation, described so clearly by Paul Romer, to impose priors to resolve the identification problem.[13]

Equivalence of Probabilistic Reasoning and Complete Markets

What does radical uncertainty mean for macroeconomics? Much of macroeconomics and finance leans heavily on models that assume, either explicitly or implicitly, complete (Arrow-Debreu) markets. As a result, those models are essentially static.[14] What is less well understood is that a world of complete markets is isomorphic to a world in which subjective probabilities can be assigned to all states of the world.[15]

In the mid-19th century, mathematicians started to develop an axiomatic basis for probability theory independent of observed frequencies.[16] Economists have been happy to adopt this approach to uncertainty, even though its originators were conscious of its limits. In his 1954 treatise on the foundations of statistics, L. J. Savage was careful to assess the realism of the axioms that underlay those foundations. They rested on a theory of decisions in which people looked ahead and anticipated all possible branches of the decision tree. Savage described the world in which probabilistic reasoning applied in these words: "... acts and decisions, like events, are timeless. The person decides 'now' once for all; there is nothing for him to wait for, because his one decision provides for all contingencies."[17] It is a "grand decision." But this is exactly the world of complete Arrow-Debreu markets where people buy and sell in a single Walrasian "grand auction."[18] The two worlds are the same, and Savage was clear that the proposition that they describe a wide range of decisions was, in his own words, "utterly ridiculous."

This isomorphism between complete markets and the axiomatic basis for probabilistic reasoning is no academic footnote. The world divides into two states. In the first, we can construct probabilities and markets are complete. In the second, radical uncertainty precludes the construction of probabilities and markets are incomplete. In the former, explanations for macroeconomic fluctuations reflect frictions in markets. In the latter, swings in activity are a natural consequence of incomplete markets. In our toolbox there is room for both approaches. But in trying to understand large swings in activity, I favor the second.

It is striking that the two major economists of the 20th century who took radical uncertainty seriously, Keynes and Frank Knight, devoted their attention to the two features of a capitalist economy that distinguish it from a Walrasian equilibrium.[19] Knight explored the nature of entrepreneurship, something that is impossible to analyze outside radical uncertainty and incomplete markets. And Keynes wanted to understand why a capitalist economy was subject to large fluctuations in output and employment. As Keynes was only too well aware, an idea which is simple and obvious, but which is difficult to formalize mathematically, can be resisted almost indefinitely.

The models used today assume frictions of various sorts to explain why unemployment can persist. Yet it was this view against which Keynes fought in the 1930s. He was adamant that even if wages were perfectly flexible, unemployment could persist. In distilling the essence of *The General Theory,* the most penetrating analysis remains, in my view, the 1975 review article by Don Patinkin. He highlights chapter 19, on money wages, in which Keynes describes why a reduction of money wages is not an effective way to reduce unemployment: "The eco-

nomic system cannot be made self-adjusting along these lines."[20] Reductions in money wages increase desired employment, but if they also reduce expectations of future incomes, then aggregate spending may fall and unemployment persist. As Patinkin put it, "thus the General Theory is not a static theory of unemployment equilibrium, but a dynamic theory of unemployment disequilibrium."[21] That is old-fashioned language from the 1970s, but it points to the centrality of the incompleteness of markets, which in turn rests on radical uncertainty.[22]

What has been overlooked in the discussion of monetary policy in the industrialised world today is that a similar argument holds for interest rates. Central banks have flirted with negative interest rates. But for many economists it has been a full-blown affair. The prevailing view that the main obstacle to our achieving macroeconomic stability is the zero lower bound on nominal interest rates is, I believe, more than a little misleading.[23] Negative interest rates have a substitution effect which raises current spending, but such a change in policy may create expectations of future policy actions that would reduce incomes. Aggregate spending could fall rather than rise. Such a possibility is precluded by assumption in the workhorse model.

Rational, or more accurately, model-consistent, expectations proved invaluable in avoiding false inferences about the impact of government interventions. But if markets are incomplete, it is easy to forget that expectations over future prices of goods for which there are no current futures markets will also respond to changes in government policies. The Lucas critique applies equally to incomplete and complete markets. Feedback from negative interest rates to beliefs about future policies, and hence incomes, cannot be ruled out.

When confronted with radical uncertainty, agents develop and evolve narratives to cope with the challenge of making one-off decisions. An entrepreneur thinking of launching a new product does not calculate subjective probabilities and then maximize expected utility. There is no current price signal to guide her decisions. Instead, she develops a narrative within which it is possible to understand the key parameters determining the likely success of the product, and makes a judgment. As Danny Kahneman put it: "No one ever made a decision because of a number. They need a story."[24] When the financial crisis hit in 2007, and took a major turn for the worse in 2008, the reaction of policymakers was not to update their prior probabilities with each new observation. It was to ask: "What is going on here?" Or to quote Chuck Manski in a recent NBER Working Paper,

> "Introspecting about how I revise my own macroeconomic expectations after receipt of new information, I often find it difficult to conjecture an explicit sampling process. Hence, I am unable to consciously update in the Bayesian manner."[25]

Time does not permit a discussion of narratives as a way of describing macroeconomic events — I provided one for the response of spending to the financial crisis in my book *The End of Alchemy*. But I do want to emphasize that I'm using the word "narrative" in a very different sense from that deployed by Robert Shiller in his AEA Presidential Lecture earlier this year. For him, a narrative is "a simple story or easily expressed explanation of events that many people want to bring up in conversation or on news or social media because it can be used to stimulate the concerns or emotions of others."[26] It contrasts with a rational view of the world. For me, a narrative is an entirely rational way to approach the challenge of radical uncertainty. It is a story that integrates the most important pieces of information in order to make a decision, and I provide examples in my book.

A Two-Sector Model with Slow Speed on the Turnpike Approach

I turn now to the limitations of the one-sector nature of the canonical model in macroeconomics. When Marty Feldstein was a young man, multisector growth models were all the rage. The optimal path from an initial starting point was to move toward and then remain close to a balanced growth path along which all sectors grew at the same rate. The early literature was concerned with finding conditions under which the optimal path would be close to the balanced growth path for most of the time — just as in a long car journey the optimal route is to get onto the highway and stay with it until close to the final destination.[27] Hence such results were known as turnpike theorems and they were proven under rather general conditions.

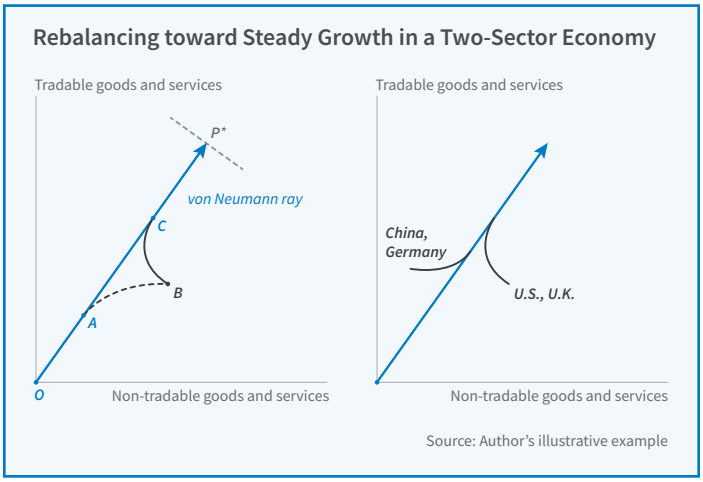

Figure 6

Multisector models fell out of favor largely because of the focus on the steady-state of those models. If all sectors were growing at the same rate, then the models added little to the insights provided by one-sector models. But their real interest lies in the adjustment path off the steady-state. Without burdening you with formalities, Figure 6 shows an illustrative optimal path

for an economy with two sectors, tradable and non-tradable goods and services. In the left panel, the solid line OP shows the balanced growth path — often known as the von Neumann ray — and the prices supporting the path are given by the slope of the line orthogonal to that ray. The dotted line AB shows the path of an economy steadily moving away from balanced growth, as I believe happened in the run-up to the crisis, along which the relative price of the two goods differs from its steady-state value. Having arrived at point B, the economy now needs to rebalance. Starting from point B, the optimal path BC takes the economy along the solid line which shows the optimal trajectory towards and then converging on the balanced growth path.

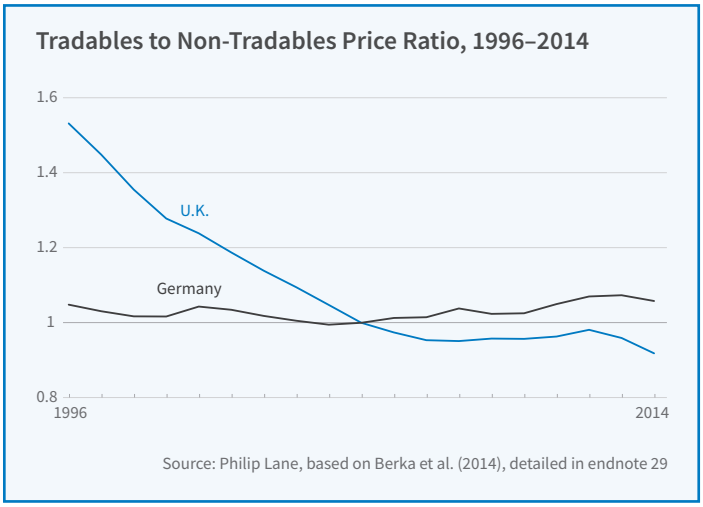

Figure 7

For any initial composition of output, such as B, the optimal path will stay within a certain neighborhood of the von Neumann ray for most of the time. But starting from an unbalanced combination of tradable and non-tradable sectors, the interesting turnpike result is that in order to get back to a balanced economy, it pays to reallocate resources between the two sectors sooner rather than later. In the sector that has overexpanded, that may require a contraction of output and writing off of capital. Focusing on the adjustment to the equilibrium path — or the "traverse" in [John] Hicks' terminology — brings an Austrian flavor to the analysis of growth in the two-sector model, especially with the possibility that it is optimal to discard capital invested in the "wrong" sector.[28] And along the optimal path, measured growth of total output will initially be weak relative to the growth rate along the balanced path. In the one-sector model, the problem does not really arise. Deviations from the steady-state path reflect random shocks, which die away of their own accord.

My two-sector division — between tradable and non-tradable goods and services — is stylized but captures, in my view, an important division reflecting the imbalances in the world economy prior to the crisis, and the need to rebalance now. Figure 7 shows the relative price of tradables versus non-tradables in both the U.K. and Germany over the period 1996 through 2014, using data supplied by Philip Lane, now Governor of the Central Bank of Ireland.[29] It is clear that one of the problems faced by the U.K. in trying to avoid unbalanced growth is the steady fall in the price of tradable goods and services relative to non-tradables. Only following the sharp depreciation of sterling during the financial crisis was that relative price stable. For much of the period, there seems to be evidence that an unsustainably high real exchange rate led inexorably to a current account deficit and the need to rebalance the economy. With the further appreciation of sterling in 2014 and 2015, the fall in the relative price resumed. All this puts the depreciation of sterling since last summer into perspective. In contrast, Germany has experienced, if anything, a rising price of tradables, and it is hence no surprise that its current account surplus has risen to unsustainable levels, around 8½ percent of GDP last year.

The right panel in Figure 6 shows the route back to a balanced growth path for economies with the same technology but with different histories of their tradable goods sectors. It shows the path for economies that have seen their tradable goods sectors expand too rapidly, and for those that have experienced a relative decline in their tradable goods sectors.[30] One could easily imagine that the former illustrates the challenge facing China and Germany today, whereas the latter represents the experience of the U.S. and the U.K. For economies of both types, the task of reallocating resources, including fixed capital, may require a period of low growth and falls in output in some sectors. The real interest rate is important but it is not the only relative price that matters in understanding slow growth today.

The key insight from such models is simple but important: the composition of demand matters. Trying to understand weak growth in the context of a single commodity forces the debate into the arena of either weakness of aggregate demand or slower productivity growth. But the turnpike theorem suggests that weak growth can be the property of an optimal response to the need to rebalance the composition of demand and output. I believe that that is exactly where we are today.

Figure 8 shows the imbalances last year among the four major parts of the

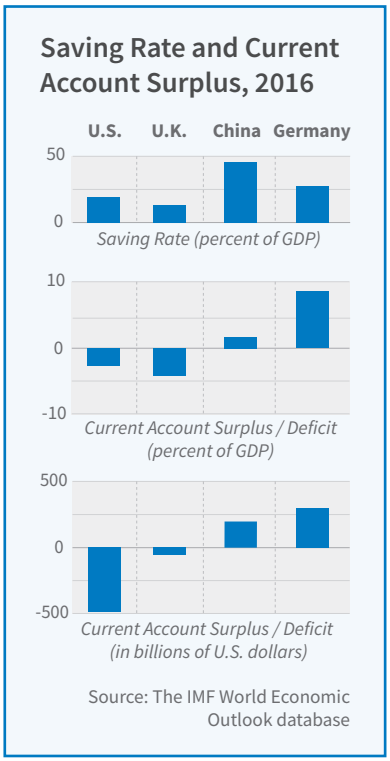

Figure 8

world economy in which current account deficits and surpluses are significant. Both the U.S. and U.K. had substantial current account deficits, amounting in aggregate to around $600 billion, and China and Germany had correspondingly large current account surpluses. All four economies need to move back to a balanced growth path. But far too little attention has been paid to the problems involved in doing that. With unemployment at low levels, the key problem with slower-than-expected growth is not insufficient aggregate demand but a long period away from the balanced path, reflecting the fact that relative prices are away from their steady-state levels. The result is that the shortfall of GDP per head relative to the pre-crisis trend path was over 15 percent in both the U.S. and U.K. at the end of last year. Policies which focus only on reducing the real interest rate miss the point; all the relevant relative prices need to change, too.

Another Story

There are many stories which purport to explain recent growth experience. There is the decline in growth potential emphasized by Robert Gordon,[31] secular stagnation advanced by Lawrence Summers,[32] and others. For example, a recent paper by John Fernald, Robert Hall, James Stock, and Mark Watson attributes slow growth to a declining trend in total factor productivity and a decline in labor force participation.[33] Perhaps, perhaps not. Recent growth has been very similar in the U.S. and U.K. But in the U.K., labor force participation has risen, not fallen. And it is possible to reconcile low unemployment with weak growth as the property of a transition to a two-sector turnpike path during which resources must shift from the non-tradable to the tradable sector. No doubt other explanations will be forthcoming. And in truth it is too soon to tell.

But do not be misled into thinking that, because unemployment is low, an unfortunate sequence of negative shocks has come to an end, and normality is about to be restored. Figure 9 shows the real interest rate that markets expect to hold 10 years from now in the U.S.: the 10-year 10 year forward rate implied by the yield structure of real rates. The crisis dashed hopes that real rates might go back to something more normal and the current expectation is close to only 1 percent a year. It also shows the same implied rate minus the five-year spot real rate. Again, there is little sign of market expectation of normalization. And Figure 10 shows the five-year spot rate staying remarkably close to zero.

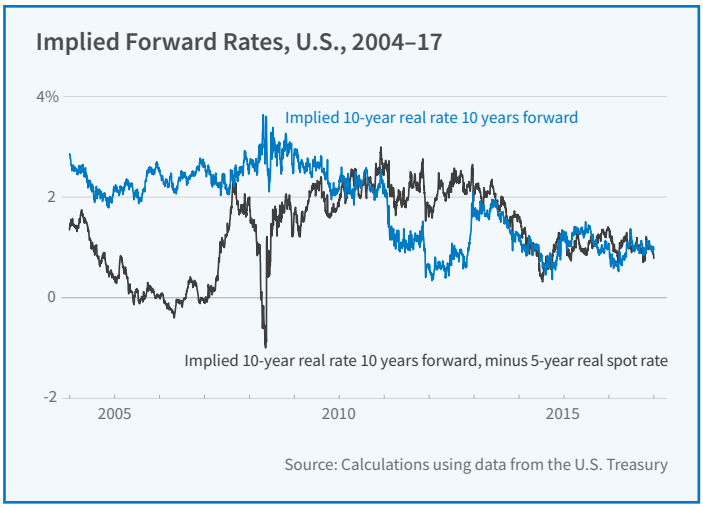

Figure 9

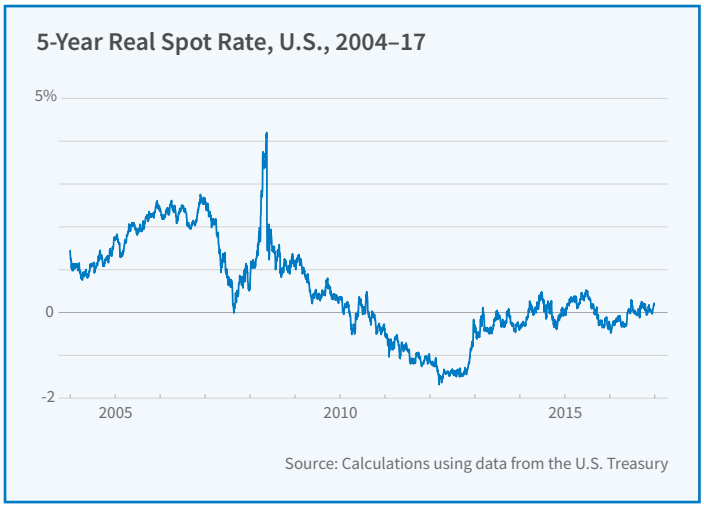

Figure 10

Conclusions

The moral of my story is that it is important not to be constrained by existing models, nor to think that simply tinkering with those models provides an answer to the challenges posed by the crisis and by unexpectedly slow growth over the past decade.

I am not suggesting that we should abandon our existing tools. It is a question of horses for courses. But the workhorse model does not constitute a comprehensive toolkit. Remember the lesson of the good economics plumber — carry many tools with you, and always pose the question: What is going on here? Designing practical policies to improve public interventions is a continuing challenge, and one that Marty has explored throughout his career in a wide variety of fields: health, taxation, saving, social security, monetary and macroeconomic policies, and even defense economics. Taken together, those contributions certainly add up to a life well-lived.

Marty is still a role model for younger economists who want to be the kind of economics plumber that every family would trust with their kitchen. And even after almost 50 years I look forward to a few more decades of learning from my mentor.

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[1] *To be precise, the first lines of Robert Browning's poem* Home-Thoughts, from Abroad, *written in 1845, are:*

"Oh, to be in England
Now that April's there"

Return to text.

[2] *J. M. Keynes,* The General Theory of Employment, Interest and Money, *London: Macmillan and Co., 1936, pp. viii.*

Return to text.

[3] *Exceptions include P. Romer, "The Trouble with Macroeconomics," Stern School of Business, New York University, September 2016.*
Return to text.
[4] *An interesting discussion of the evolution of growth models may be found in S. Spear and W. Young, "Two-Sector Growth, Optimal Growth, and the Turnpike: Amalgamation and Metamorphosis,"* Macroeconomics Dynamics, *19(2), 2015, pp. 394–424, and in the classic survey paper, F. Hahn and R.C.O. Matthews "The Theory of Economic Growth: A Survey,"* Economic Journal, *74(96), 1964, pp. 779–902.*
Return to text.
[5] *F. Ramsey, "A Mathematical Theory of Saving,"* Economic Journal, *38(152), 1928, pp. 543–59.*
Return to text.
[6] *Data for 1900 through 2010 from the Maddison Project at* www.ggdc.net/maddison/maddison-project/home.htm, *(2013 version), updated from the IMF WEO Database for April 2017. For the methods used to construct these data, see J. Bolt and J.L. van Zenden, "The Maddison Project: Collaborative Research on Historical National Accounts,"* The Economic History Review, *67(3), 2014, pp. 627–51.*
Return to text.
[7] *The computed trend growth rates over 1960–2007 are 2.2 percent a year in the U.S. and 2.3 percent a year in the U.K.*
Return to text.
[8] *The data in M. King and D. Low, "Measuring the 'World' Real Interest Rate," NBER Working Paper No.* 19887, *February 2014, with updates to late 2016 by the authors. The extension to July 2017 relies on the change in the U.S. TIPS real yield published on the U.S. Treasury website, because the Bank of England has temporarily (as of June 2017) suspended publication of real yields while the estimation methodology is reviewed.*
Return to text.
[9] *For a view of the economist as plumber from the perspective of a microeconomist, see E. Duflo, "The Economist as Plumber,"* American Economic Review, *107(5), 2017, pp. 1–26.*
Return to text.
[10] *A similar point is made in R. Reis, "Is Something Really Wrong with Macroeconomics?" London School of Economics, June 2017, mimeo.*
Return to text.
[11] *"In the longer run what is likely to be the potential cost of a one-size-fits-all monetary policy? That is extremely hard to judge and to be confident. The reason why I think one can say you will never really know is that to have enough experience, enough observations, on business cycles to find out whether they have converged — the IMF Study did not cover very long periods — you need 200 or 300 years of data." Select Committee on Education and Employment Minutes of Evidence, Thursday 27 May 1999, Question 46.*
Return to text.
[12] *See previous citation.*
Return to text.
[13] *P. Romer, "The Trouble with Macroeconomics," Stern School of Business, New York University, September 2016.*
Return to text.
[14] *See the discussion in S. Spear and W. Young (endnote 4). As Reis (endnote 10) has argued, there are recent efforts to introduce elements of non-stationarity into small theoretical models. But they have yet to alter the mainstream of thinking about policy and still rest on the assumption of expected utility maximization.*
Return to text.
[15] *This issue is explored more fully in forthcoming work by John Kay and myself.*
Return to text.
[16] *An excellent discussion of the development of probability theory may be found in L. Daston,* Classical Probability in the Enlightenment, *Princeton: Princeton University Press, 1988.*
Return to text.
[17] *L. Savage,* The Foundations of Statistics, *New York: John Wiley & Sons, 1954, p. 17. The page reference is to the 1972 second revised edition.*
Return to text.
[18] *See the discussion of the "grand auction" in M. King,* The End of Alchemy, *New York: W.W. Norton, 2016.*
Return to text.
[19] *J. M. Keynes,* Treatise on Probability, *London: Macmillan and Co., 1921, and F. Knight,* Risk, Uncertainty and Profit, *Boston: Hart, Schaffner & Marx, Houghton Mifflin Co., 1921.*
Return to text.
[20] *J. M. Keynes,* The General Theory of Employment, Interest and Money, *London: Macmillan and Co., 1936, p. 267. Page references are to the* Royal Economic Society Collected Writings of John Maynard Keynes.
Return to text.
[21] *D. Patinkin, "The Collected Writings of John Maynard Keynes: From the Tract to the General Theory,"* Economic Journal, *85, June 1975, p. 257.*
Return to text.
[22] *Many of these arguments about the formation of expectations were expounded at length in the writings of G.L.S. (George) Shackle.*
Return to text.
[23] *I discuss the issue in chapter eight of M. King (endnote 18).*
Return to text.
[24] *Quoted in M. Lewis,* The Undoing Project, *New York: W.W. Norton, 2016, p. 250.*
Return to text.
[25] *C. Manski, "Survey Measurement of Probabilistic Macroeconomic Expectations: Progress and Promise," NBER Working Paper No.* 23418, *forthcoming in* NBER Macroeconomics Annual 2017, *volume 32, M. Eichenbaum and J. Parker, eds., Chicago: University of Chicago Press.*
Return to text.
[26] *R. Shiller, "Narrative Economics,"* American Economic Review Papers and Proceedings, *107, 2017, pp. 967–1004.*
Return to text.
[27] *A useful survey of turnpike models is given in L. McKenzie, "Turnpikes,"* American Economic Review, *88(2), 1998, pp. 1–14.*
Return to text.

[28] *See John Hicks' article on neo-Austrian growth theory: J. Hicks, "A Neo-Austrian Growth Theory,"* Economic Journal, *80(318), 1970, pp. 257–81.*
Return to text.

[29] *Tradable and non-tradable inflation rates are compiled as a weighted average of price changes of individual consumption goods. Price changes and item weights are drawn from the Eurostat HICP database (ec.europa.eu/eurostat/web/hicp/data/database). All items are classified as either tradable or non-tradable, following M. Berka, M. Devereux, and C. Engel, "Real Exchange Rates and Sectoral Productivity in the Eurozone," NBER Working Paper No. 20510, September 2014, Table 1. The non(tradable) consumption weight is the sum of all item weights that are classified as (non) tradables divided by the sum of all item weights.*
Return to text.

[30] *It is important to remember the distinction between traded and tradable goods and services. Although the definitions used in any particular empirical application are somewhat arbitrary, and hence the data need to be used with some circumspection, for Figure 7 the share of tradable goods and services in total output in 2014 was 58.5 percent in Germany and 58.4 percent in the U.K., well above their respective shares in actual trade. An attempt to calculate the relative price of tradables versus non-tradables in the U.S. has been made by Rui Mano of the IMF, and the U.S. too has experienced a fall in the relative price of tradables with a similar proportion between the two sectors, as in the U.K. and Germany.*
Return to text.

[31] *R. Gordon,* The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War, *Princeton: Princeton University Press, 2016.*
Return to text.

[32] *L. Summers, "The Age of Secular Stagnation: What It Is and What to Do About It,"* Foreign Affairs, *March/April 2016.*
Return to text.

[33] *J. Fernald, R. Hall, J. Stock, and M. Watson, 2017, "The Disappointing Recovery of Output after 2009," NBER Working Paper No. 23543, June 2017, forthcoming in* Brookings Papers on Economic Activity.
Return to text.

Old Idea, New Insights: The Ricardian Revival in International Trade

Arnaud Costinot and Dave Donaldson

Two centuries ago, David Ricardo wrote down a simple thought experiment that changed the way economists think about international trade. Suppose the residents of two nations, England and Portugal, differ in their ability to produce two goods, cloth and wine: Portugal is more efficient at both, but its relative advantage over England is weaker in cloth. If these countries are able to trade, what will happen? Who will trade what with whom? Who will gain from the trades? How large will the gains be?

Ricardo's famous example has been used to answer these fundamental questions of international trade in countless textbooks: England imports Portuguese wine and everyone's a winner, all the more so the worse the English are at making wine.

Until recently, however, Ricardo's logic has had surprisingly little impact on the way that economists use data from the world around them to answer questions about trade policy. Extending the logic to a realistic economy with many regions and products had seemed somewhere between impractical and impossible. But thanks to a number of recent innovations — most importantly in the seminal work of Jonathan Eaton and Samuel Kortum — this is rapidly changing.[1] In this research report, we describe some of our recent attempts to connect Ricardo's 200-year-old idea to the real world.

Ricardian Comparative Advantage and Empirical Patterns of Trade

We begin by asking the most basic of empirical questions: How well do the predictions of a Ricardian model line up with data on trade patterns? In a famous challenge, a mathematician, Stan Ulam, once asked Paul Samuelson to name one proposition in the social sciences that is both true and nontrivial. After much reflection, Samuelson's reply was: "Ricardo's theory of comparative advantage."

The practical content of Ricardo's theory has received surprisingly little attention due to the challenges of connecting Ricardo's ideas to data. Together with Ivana Komunjer, we have extended Eaton and Kortum's quantitative model to study inter-industry Ricardian comparative advantage in a way that is amenable to empirical scrutiny.[2]

The basic prediction of the Ricardian model is that countries should export relatively more in sectors in which they are relatively more productive. Our model captures this simple idea by providing closed-form solutions for relative bilateral trade flows as a function of relative observed productivity. Crucially, the model takes into account the fact that countries will not produce all varieties of every good. Rather, a country will only produce those varieties in which it is relatively more efficient. This implies that differences in observed productivity tend to be smaller than true differences in productivity as a result of a selection effect.

Combining standard data on industry-level trade flows and productivity, we find that countries do indeed tend to export goods where their relative productivity is higher, as this Ricardian model would predict. More precisely, a 1 percent change in relative productivity is associated with a 6.5 percent change in relative exports. There is also support for the notion that

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His research has focused on a variety of positive and normative issues in international trade, including the foundations of the theory of comparative advantage, the measurement of the welfare gains from trade, the role of intermediaries in international exchanges, the impact of global supply chains, and the design of optimal trade policy and capital controls.

Costinot grew up in Dunkirk, in the north of France. He currently lives in Brookline, Massachusetts, with his wife, Nadège, and their two children, Paul and Alice.

Dave Donaldson is a research associate in the NBER's Development Economics, Development of the American Economy, and International Trade and Investment Programs, and a professor of economics at MIT. He is a co-editor of the *American Economic Journal: Applied Economics,* an editorial board member of the *Journal of Economic Literature,* the *Journal of International Economics,* the *Review of Economic Studies,* and the *Quarterly Journal of Economics,* and a program director (for trade) at the International Growth Centre.

Donaldson has investigated the welfare and other effects of market integration, the impact of improvements in transportation infrastructure, how trade can mediate the effects of climate change, and how trade affects food security and famine. He has been awarded the 2017 John Bates Clark Medal, as well as an Alfred P. Sloan Research Fellowship, and has benefited from support from the National Science Foundation.

Donaldson is a native of Toronto. He received an undergraduate degree in physics from the University of Oxford and a Ph.D. from the London School of Economics. He lives in Boston with his wife, daughter, and three sons.

observed productivity differences are biased by Ricardian selection. We use our estimates to quantify the welfare impact of this Ricardian channel across sectors. Cross-industry differences in technologies generate only a small part of the gains from trade; comparative advantage operates mostly at the within-industry product level.

Ricardo's Difficult Identification Problem

"Ricardo's difficult idea," as Paul Krugman once referred to the theory of comparative advantage, contains at its core a fundamental barrier to empirical analysis. Ricardo's simple example involved a prediction about trade patterns as a function of four productivity numbers — England's and Portugal's productivity levels in cloth and wine. But how is an analyst to measure England's productivity in an activity, such as wine making, which it does not engage in because it can import wine from Portugal? Without knowledge of this missing productivity number, it is impossible to test the model's predictions about the patterns of trade. Yet the very essence of the model implies that this fourth number should not be observable to an analyst.

This empiricist's Gordian knot — formally, an "identification" problem — is familiar in selection models throughout economics, but standard solutions have been difficult to apply to the study of international trade. Previous attempts to test the Ricardian theory, including our aforementioned paper, are therefore based on strong functional-form assumptions that impose a particular structure on the distribution of productivity across goods (and varieties of the same good) to allow an analyst to infer underlying productivity differences from observed differences.

In recent research, we have drawn on some unique features of the agricultural sector in order to make progress on Ricardian empirical work despite the identification challenges. The key observation is that this is a setting in which a major scientific focus among agronomists is to predict the productivity, for any crop, that any location could achieve as a function of its environmental conditions. For example, the Global Agro-Ecological Zones (GAEZ) project from the Food and Agricultural Organization aggregates such predictions for all major crops and at a detailed geographical level. The project includes information on 2.2 million parcels of land around the globe. This permits one to "observe" not only the productivity of a land parcel in its current use, but also in all potential uses.

In a first paper, we focused on a direct test of the Ricardian model.[3] On the basis of GAEZ potential yield observations, we calculated the Ricardian model's predictions about the pattern of production — which crops growers at different locations would choose to specialize in, at prevailing producer prices. These predicted patterns of production have significant power to predict actual patterns of crop production around the world — perhaps surprisingly so, given the many reasons for actual productivities to differ from those predicted by agronomists.

Moving beyond testing, a core interest is in estimating the gains from trade that exist in the world around us. As in all standard trade models, the Ricardian model postulates that regions differ and those differences give rise to potential gains from specialization afforded by the ability to trade. But how large are the differences, and hence how large are the gains? Unfortunately Ricardo's identification problem again stands in the way. All four of Ricardo's numbers are needed to evaluate the gains from trade, for either England or Portugal. The key is to estimate just how much more efficient the world is when England doesn't have to produce any wine. That efficiency boost depends on how bad England is at producing the wine that it doesn't produce.

In a second recent paper, we again draw on the GAEZ data to measure some of the gains from agricultural trade.[4] In particular, we ask how much of the growth in U.S. agricultural productivity over the period 1880–1997 has come about because of the spatial integration of agricultural markets across the United States. A key challenge to incorporating information from

the GAEZ data in this historical case is that potential yields, for each crop in each location, have changed, in unknown ways, due to technological progress. But under the assumption that those changes do not reverse comparative advantage within any county, we show how to use data from the Agricultural Census since 1880 to infer the unique set of prices and productivity shocks that is consistent with profit maximization and factor-market clearing in any given county and year. These estimated, model-consistent prices correlate well with data on actual state-level prices and show a clear trend toward lower intra-U.S. spatial price dispersion over time. Commodity markets were more integrated in 1997 than in 1880.

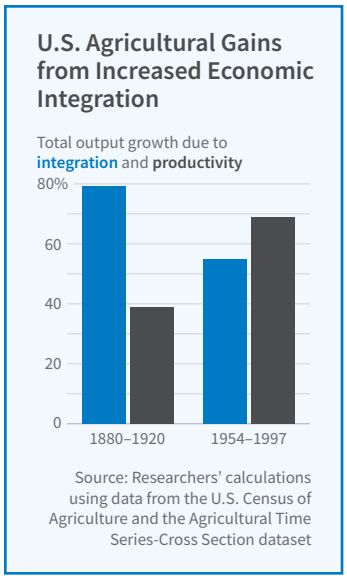

Figure 1

But how large are the benefits from this heightened integration? To shed light on this question, we calculate the change in the value of nationwide output that the 1880 economy would have enjoyed if inter-spatial price gaps in 1880 were set to their later (say 1920) level, rather than to the actual 1880 level. The results are surprising. For example, 1880–1920 gains were 79 percent, approximately the same as the gains that we calculate are due to pure within-location productivity gains. Similar statements are true about a later period, 1954 to 1997. Overall, the increasing exploitation of gains from intra-national trade in this context appear to have been a major, and perhaps underappreciated, contributor to aggregate economic growth.

Comparative Advantage and the Costs of Climate Change

Together with Cory Smith, we have also applied Ricardo's logic to study of the consequences of climate change in agricultural markets around the world.[5]

There is little doubt that a warming climate will portend lower yields for many crops in many locations. But the aggregate consequences of those millions of micro-shocks will depend on the extent to which farmers can shift their growing patterns from one crop to another, and the extent to which consumers can change the trade linkages that connect them to particular farmers.

To examine these possibilities we build a general equilibrium model of trade, in 10 leading crops, among each of 1.7 million land parcels around the world. Each parcel has its own Ricardian productivity capabilities in each crop, so we have 17 million crop-parcel estimates, and trade occurs subject to trading frictions designed to match world trade flows today. We then shock each parcel's productivity level in each crop in the manner that climatologists and agronomists believe will arise due to climate change by 2071–2100. This is feasible because the GAEZ project provides their agronomic predictions both for contemporary climate conditions and also under the expected climate conditions that correspond to each of the scenarios used by the UN's Intergovernmental Panel on Climate Change.

What are the consequences of this change in the 17 million place- and crop-specific productivities? We find that climate change would generate a large negative productivity shock for many countries around the world and that if there were no reallocations around the world, welfare would decrease substantially. The value of crop output would be predicted to fall by about 40 percent. However, there is enough heterogeneity in these shocks over space that after reallocating production according to comparative advantage across crops within each parcel, welfare losses become smaller by a factor of three. Furthermore, there is so much productivity heterogeneity across parcels within countries that there is little to be gained from controlling countries' capacity to adjust their trade flows internationally.

Reducing Ricardian Complexity

The Ricardian world can be a complicated place. The full equilibrium implications of Ricardo's four numbers, in his simple two-by-two setting, took almost three decades to work out, as John Stuart Mill did in 1844.[6] So what is the Ricardian analyst — let alone the reader — to make of the complexity of a model like that discussed above with 17 million productivity ingredients? In recent work with Rodrigo Adao, we have developed a new methodology for simplifying the empirical use of general neoclassical models, a class that includes the Ricardian model as a special case.[7]

We first establish the equivalence between such models and reduced exchange models in which countries directly exchange factor services, extending an original insight from Charles Wilson in the Ricardian case.[8] This

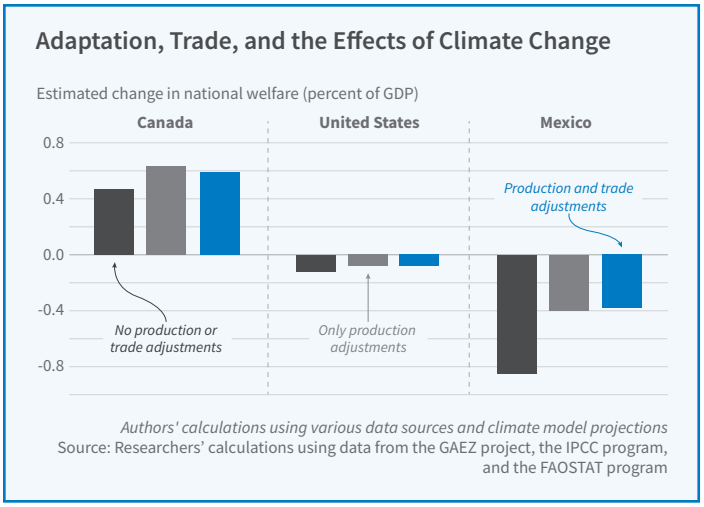

Figure 2

equivalence implies that, for an arbitrary change in trade costs, counterfactual changes in the factor content of trade, factor prices, and welfare only depend on the shape of a reduced factor demand system. We then provide sufficient conditions for estimates of this factor demand system to be recovered non-parametrically. Together, these results offer a strict generalization of the parametric approach used in so-called gravity models — like the version of the Ricardian model developed by Eaton and Kortum — in which the factor demand system is isoelastic.

Implications for Optimal Trade Policy

What does the Ricardian model imply for the design of a nation's optimal trade policy? Should it protect more import sectors with weaker comparative advantage? Conversely, should it subsidize less in export sectors with stronger comparative advantage? Perhaps surprisingly, in spite of the importance of the theory of comparative advantage in the field of international trade, these questions have not previously been investigated formally. The goal of our work with Jonathan Vogel and Iván Werning is to shed light on these questions.[9]

The main theoretical result of our paper is that, in the context of a canonical Ricardian model, optimal import tariffs should be uniform, whereas optimal export subsidies should be weakly decreasing with respect to comparative advantage. While the latter pattern accords well with the observation that countries tend to protect their least competitive sectors in practice, larger subsidies do not stem from a greater desire to expand production in less competitive sectors. Rather, they reflect tighter constraints on the ability to exploit monopoly power by contracting exports. Put simply, countries have more room to manipulate world prices in the sectors in which they have a comparative advantage.

The final part of the paper explores the quantitative importance of these theoretical considerations in the agricultural sector. The market structure in this sector is plausibly close to the neoclassical ideal and, again, agronomic data enable a unique view of comparative advantage. We find that about half of the welfare gains from optimal trade taxes arise from the use of non-uniform trade taxes that vary monotonically with comparative advantage.

Home Demand as a Source of Ricardian Comparative Advantage

In more recent work we have turned to a more basic question: Where do Ricardo's cross-country differences in relative productivities come from? In models that incorporate increasing returns, be they of the Marshallian sort that are external to firms or of the monopolistic competition sort that play out through firm entry in differentiated product markets, the productivity of a given industry in a given nation rises as its output increases. This opens up the possibility, for sufficiently strong aggregate economies of scale, of what Staffan Linder and Krugman call the "home-market effect," in which a region's home demand base will become a source of endogenous Ricardian comparative advantage.[10]

In work with Margaret Kyle and Heidi Williams, we estimate the strength of this effect in the context of the global pharmaceutical industry.[11]

Building on previous work on the effect of demographic changes on innovation and product entry by Daron Acemoglu and Joshua Linn,[12] our paper establishes that countries that for demographic reasons are expected to have high demand for a certain type of drug are actually more likely to be net exporters of that drug. We find that the correlation between predicted home demand and sales abroad is positive and greater than the correlation between predicted home demand and purchases from abroad, which is strong evidence for the role of the home market in creating comparative advantage.

Ricardo's Rejuvenation

New data sources, new modeling strategies, and new empirical procedures have breathed new life into Ricardo's 200-year-old insights about comparative advantage and trade flows. This revitalized line of work has generated important insights on a range of applied questions, including the design of border taxes, the origins of aggregate productivity gains, and the expected harm from climate change. We have recently surveyed many of these new developments.[13] The impact of Ricardo's path-breaking work may be even greater in its third century than in its first two.

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[1] *J. Eaton and S. Kortum, "Technology, Geography, and Trade,"* Econometrica, *70(5), 2002, pp. 1741–79.*
Return to text

[2] *A. Costinot, D. Donaldson, and I. Komunjer, "What Goods Do Countries Trade? A Quantitative Exploration of Ricardo's Ideas," NBER Working Paper No. 16262, August 2010, and* Review of Economic Studies, *79(2), 2012, pp. 581–608.*
Return to text

[3] *A. Costinot and D. Donaldson, "Ricardo's Theory of Comparative Advantage: Old Idea, New Evidence," NBER Working Paper No. 17969, April 2012, and* American Economic Review Papers and Proceedings, *102(3), 2012, pp. 453–8.*
Return to text

[4] *A. Costinot and D. Donaldson, "How Large Are the Gains from Economic Integration? Theory and Evidence from U.S. Agriculture, 1880–1997," NBER Working Paper No. 22946, December 2016.*
Return to text

[5] *A. Costinot, D. Donaldson, and C. Smith, "Evolving Comparative Advantage and the Impact of Climate Change in Agricultural Markets: Evidence from 1.7 Million Fields Around the World," NBER Working Paper No. 20079, April 2014, and* Journal of Political Economy, *124(1), 2016, pp. 205–48.*
Return to text

[6] *J. S. Mill,* Essays on Some Unsettled Questions in Political Economy, *London: Longmans, Green, Reader, 1844; and Dyer, 2nd edition, 1874.*
Return to text

[7] *R. Adao, A. Costinot, and D. Donaldson, "Nonparametric Counterfactual Predictions in Neoclassical Models of International Trade," NBER Working Paper No. 21401, July 2015, and* American Economic Review, *107(3), 2017, pp. 633–89.*
Return to text

[8] *C. Wilson, "On the General Structure of Ricardian Models with a Continuum of Goods: Applications to Growth, Tariff Theory, and Technical Change,"* Econometrica, *1980, 48(7), pp. 1675–702.*
Return to text

[9] *A. Costinot, D. Donaldson, J. Vogel, and I. Werning, "Comparative Advantage and Optimal Trade Policy," NBER Working Paper No. 19689, December 2013, and* Quarterly Journal of Economics, *130(2), 2015, pp. 659–702.*
Return to text

[10] *S. Linder,* An Essay on Trade and Transformation, *Uppsala, Sweden: Almqvist & Wiksells, 1961; P. Krugman, "Scale Economies, Product Differentiation, and the Pattern of Trade,"* American Economic Review, *1980, 70(5), pp. 950–9.*
Return to text

[11] *A. Costinot, D. Donaldson, M. Kyle and H. Williams, "The More We Die, the More We Sell? A Simple Test of the Home-Market Effect," NBER Working Paper No. 22538, August 2016.*
Return to text

[12] *D. Acemoglu and J. Linn, "Market Size in Innovation: Theory and Evidence from the Pharmaceutical Industry," NBER Working Paper No. 10038, October 2003, and* Quarterly Journal of Economics, *2004, 119(3), pp. 1049–90.*
Return to text

[13] *A. Costinot and J. Vogel, "Beyond Ricardo: Assignment Models in International Trade," NBER Working Paper No. 20585, October 2014, and* Annual Review of Economics, *7, 2015, pp. 31–62; D. Donaldson, "The Gains from Market Integration,"* Annual Review of Economics, *7, 2015, pp. 619–47.*
Return to text

Integrated Assessment Models of Climate Change

William Nordhaus

William Nordhaus is Sterling Professor of Economics at Yale University and a research associate in four NBER Programs: Economic Fluctuations and Growth; Environment and Energy Economics; Productivity, Innovation, and Entrepreneurship; and Public Economics. He is a pioneer in analyzing economic consequences of climate change and one of the leading global authorities on climate policy.

Nordhaus developed the DICE and RICE models of the economics of climate change, which are widely used in research on climate-change economics and policies. He also has studied a range of additional topics in both micro- and macroeconomics, including wage and price behavior, health economics, augmented national accounting, the political business cycle, and the dynamics of productivity. He is the author of three treatises on climate policy, *The Climate Casino, Managing the Global Commons,* and *Warming the World*, and is a co-author, with the late Paul Samuelson, of the classic textbook, *Economics*.

Nordhaus served as president of the American Economic Association (AEA) in 2015. He is a member of the National Academy of Sciences and a Fellow of the American Academy of Arts and Sciences, as well as a Distinguished Fellow of the AEA. He also has been a member of the President's Council of Economic Advisers (1977–9), provost of Yale University (1986–8), a member of the Brookings Panel on Economic Activity since 1972, and a director and chair (2013–14) of the board of directors of the Federal Reserve Bank of Boston.

A native of Albuquerque, New Mexico, who received his B.A. from Yale and his Ph.D. from MIT, Nordhaus lives in New Haven with his wife, Barbara, who works at the Yale Child Study Center.

Many areas of the natural and social sciences involve complex systems that link multiple areas and disciplines. This is particularly true for the science, economics, and policy of climate change, which involve a wide variety of fields from atmospheric chemistry to game theory.[1] As understanding progresses across the different fronts, it is increasingly necessary to link the different areas to develop models and policies that reflect the complex interactions. A full analysis would reflect that economic activity drives emissions, which affect atmospheric concentrations, thence climate and the hydrological cycle, which in turn affect human and natural systems, which ultimately contribute to the determination of climate policies.

Integrated assessment analyses and models play a key role in putting the pieces together. Integrated assessment models (IAMs) can be defined as approaches that integrate knowledge from two or more domains into a single framework. These are sometimes theoretical but are increasingly computerized, empirical, dynamic, nonlinear models of varying levels of complexity.

The challenge of coping with global warming is particularly daunting, because it spans many disciplines and parts of society. Ecologists may see it as a threat to ecosystems, marine biologists as a problem leading to ocean acidification, and coastal communities as a lottery with intense hurricanes, while ski resorts may view it as a mortal danger to their already short seasons. It also poses a challenge to natural and social scientists, who must incorporate a wide variety of geophysical, economic, and political disciplines into their diagnoses and prescriptions.

Integrated assessment models of climate change grew organically from energy models. One of the earliest careful comparisons of energy models was the Modeling Resource Group (MRG) analysis of the 1970s.[2] This project, chaired by Nobel Prize-winning economist Tjalling Koopmans, analyzed several energy models that projected energy demands and technologies over a long time horizon. The earlier work of Koopmans on the linear programming approach to production, as well as the Samuelson principle of "markets as maximization," formed the intellectual core of much of the energy modeling starting at that time and proceeding to the present.[3]

The first IAMs in climate change were basically energy models with an emissions model included, and later with other modules such as a carbon cycle model and a small climate model. My early approaches were partial equilibrium energy models with exogenous output.[4] A. S. Manne's model, the first to imbed an energy system in a full economic-growth model, was an important landmark.[5] The earliest versions of my models adopted a growth-theoretic framework similar to Manne's and extended it to geophysical variables.[6]

IAMs are increasingly used in analyses by national governments and in international assessments. Among the most important applications are:

- Making projections that have consistent inputs and outputs of the different components of the system so that, for example, the GDP projections are consistent with the emissions projections.
- Calculating the impacts of alternative assumptions on important variables such as output, emissions, temperature change, and the effect of economic activity on climate.
- Tracing the effects of alternative policies on all variables in a consistent manner as well as estimating the costs and benefits of alternative strategies.
- Estimating the uncertainties associated with alternative variables and strategies along with the value of research and new technologies.

There are dozens of IAMs today, a handful of which have a track record of at least a decade. Models range from small ones like the DICE model described below to enormous ones that may have as many as a half-million variables. Different IAMs are like different animals in terms of comparative strengths and weaknesses in tackling the various questions above. Small comprehensive models can yield a full cost/benefit analysis, but are weak on regional or industrial detail. Larger species provide great detail, but may be unable to trace impacts and damages, are less transparent, and are unable to do full uncertainty analyses. Some models are able to trace the impacts of policies on land use. Others can investigate a wide range of technologies. A few have full damage functions, while others include a limited number of technologies and engineering variables. The great diversity of the modeling ecosystem allows most important questions to be addressed.

The DICE and RICE Models as Examples

The Dynamic Integrated model of Climate and the Economy (DICE) and Regional Integrated model of Climate and the Economy (RICE) models have gone through several revisions since their initial development around 1990. The latest published versions are the RICE-2010 and DICE-2016R2 models. The latest DICE model is available in GAMS, a fine mathematical software system, and a full description of the earlier version is available.[7]

DICE is a globally aggregated model. RICE is essentially the same, except that output and abatement have structures for 12 regions. This discussion will use the term "DICE model," and for most modules the analysis applies equally to the RICE model.

The DICE model views the economics of climate change from the perspective of neoclassical economic growth theory. In this approach, economies make investments in capital, education, and technologies, thereby reducing consumption today in order to increase consumption in the future. The DICE model extends this approach by including the "natural capital" of the climate system as an additional kind of capital stock. By devoting output to emissions reductions, economies reduce consumption today but prevent economically harmful climate change and thereby increase consumption possibilities in the future.

The DICE model has 12 behavioral equations, two variables to be optimized, and several identities. In the GAMS version, the simplest model has about 240 lines of operational code. A run of 1,000 years takes five seconds, so it can be used for projects with multiple states of the world and Monte Carlo experiments.

The RICE model has the same basic economic and geophysical structure, but contains a regional elaboration. The specification of preferences in RICE is different because it must encompass multiple regions. The general preference function is a Bergson-Samuelson social welfare function over regions. The model is specified using the Negishi approach, in which regions are aggregated using time- and region-specific weights subject to budget constraints.

This sketch of a pair of IAMs in the DICE and RICE models makes it clear that they are highly simplified representations of complex economic and geophysical realities — what might be called geo-macroeconomics. While small and comprehensive models have many advantages, they also have major shortcomings because of their simplifications.

A useful analogy here is to return to the animal kingdom. Each model is like an animal that has its fruitful niche in the analytical ecosystem. Small models can be fleet and can adapt easily to a changing environment or new data, while large models take many years to mature but are able to handle much larger and more complex tasks.

Illustrative Results

Here are some representative results using the DICE model. These results are from the most recent version of the model DICE-2016R2.[8] One application is to compare the economic and climate trajectories associated with different policy approaches. Here are four different policy options:

Baseline: No climate-change policies are adopted.

Optimal: Climate-change policies maximize economic welfare, with full participation by all nations starting in 2020.

Temperature-limited: The optimal policies are undertaken subject to a further constraint that global temperature does not exceed 2.5 °C above the 1900 average. (The international goal of 2 °C is not feasible with current DICE estimates without technologies that allow negative emissions by mid-21st century.)

Stern discounting: These are results associated with an extremely low discount rate as advocated by *The Stern Review on the Economics of Climate Change*.[9]

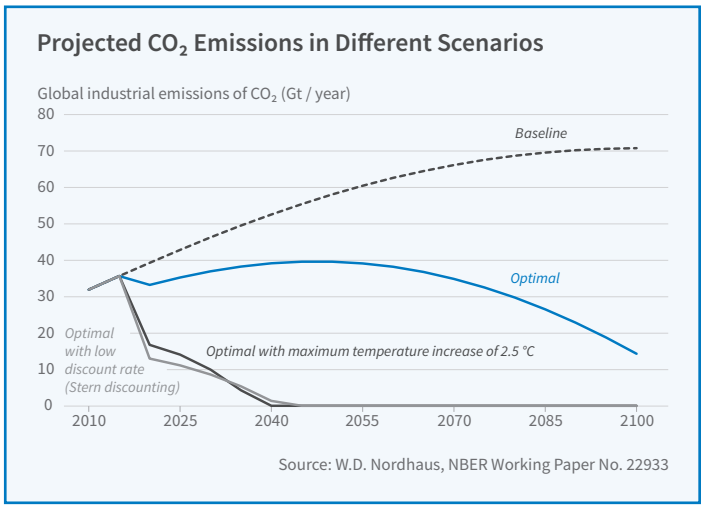

Figure 1

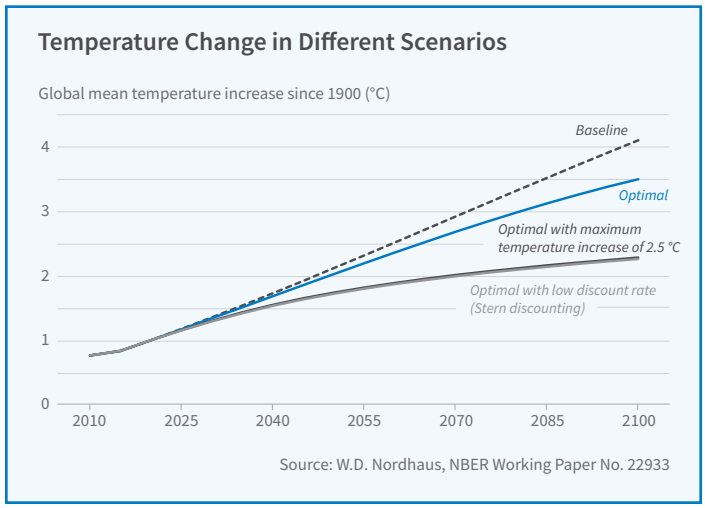

Figure 2

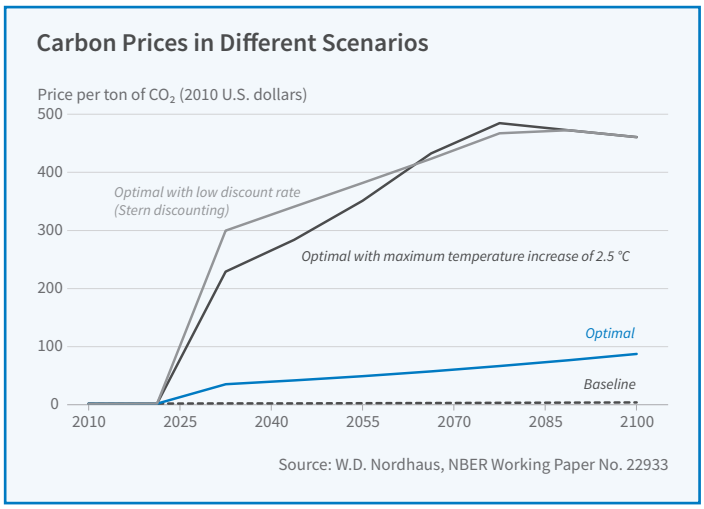

Figure 3

Figures 1–3 show outcomes associated with the four policy options. A few key results emerge. First, emissions differ sharply, with major cuts in emissions in cases with ambitious policies. Second, the temperature in the uncontrolled scenario continues to rise sharply over the current century.

Figure 3 is the outcome that is generated uniquely by IAMs: the carbon prices associated with each policy. This is a concept that measures the marginal costs of reductions of emissions of greenhouse gases. In a market environment such as a cap-and-trade regime, the carbon prices would be the trading price of carbon emission permits. In a carbon-tax regime, they would be the harmonized carbon tax among participating regions. Carbon prices in the baseline scenario are the current average prices in world markets, roughly $2 per ton of CO_2. Prices under the optimal and temperature-limited scenarios at first rise to $35 and $229 per ton of CO_2, respectively, by 2020. The carbon prices associated with the low-discounting scenario are close to those of the temperature-limited policy.

The carbon price is closely linked to an important policy instrument, the social cost of carbon, or SCC. This concept represents the economic cost of an additional ton of carbon dioxide emissions (or, more succinctly, carbon) or its equivalent. The advantage of IAMs is that they can calculate the shadow price of carbon emissions along a reference path of output, emissions, and climate change. In an optimized climate policy, abstracting away from distortions, the social cost of carbon will equal the carbon price or the carbon tax.

Estimates of the SCC are a critical ingredient in climate-change policy. They provide policymakers a guidepost to aim for if they are seeking an economically efficient policy for carbon pricing. Another application is for rulemaking where countries do not have comprehensive policies covering all greenhouse gases. In this context, regulators might use the SCC in a calculation of social costs and benefits of policies involving energy or climate-affecting decisions. For example, the U.S. government has undertaken rulemaking proceedings to determine the SCC for use in such areas as subsidies for the installation of low-carbon energy sources, regulations requiring energy efficiency standards in buildings and motor vehicles, and for power plants. Current regulations using the SCC have more than $1 trillion in benefits, according to the U.S. Environmental Protection Agency.[10]

Estimates of the SCC vary by model and approach. Table 1, on the following page, shows estimates from the most recent DICE model. Two points emerge here. The first is the critical importance of discounting. Looking at 2020, the SCC ranges from $22 to $133 per ton of CO_2 as the real discount rate ranges from 2.5 to 5 percent per year. Second, the SCC is extremely high — around $200 per ton of CO_2 — for damage functions that would justify the temperature-limited objective (2 °C) that has been adopted at international meetings in Copenhagen and Paris.

Social Cost of Carbon (2010 U.S. Dollars / Ton of CO_2)

Scenario	2015	2020	2025	2030	2050
Base parameters					
Baseline	30.0	35.7	42.3	49.5	98.3
Optimal controls	29.5	35.3	41.8	49.2	99.6
2.5 degree maximum					
Maximum	184.1	229.0	284.0	351.0	1,008.4
Max. for 50 years	147.2	183.2	227.2	280.4	615.6
Stern Review discounting					
Uncalibrated	256.5	299.6	340.7	381.7	615.5
Alternative discount rates					
2.5%	111.1	133.4	148.7	162.3	242.6
3%	71.6	85.3	94.4	104.0	161.7
4%	34.0	39.6	44.5	49.8	82.1
5%	18.9	21.7	24.8	28.1	48.4

Source: W.D. Nordhaus, NBER Working Paper No. 22933

Table 1

Calibration in IAMs

IAMs belong to a class of models, both in economics and more generally in applied sciences, that rely on calibration rather than econometric estimation. Calibration involves determination of system parameters and behavior using external evidence rather than statistical systems estimation. Calibration gained widespread use with the introduction of computable general equilibrium models, of which DICE and RICE are examples, and more recently with real business cycle models. Outside economics, important examples of calibrated models are earth-system models such as the familiar climate models, transportation models, and engineering studies. Generally, while estimation is desirable, calibration is necessary when the model reaches a certain complexity or when there are no relevant data to use for estimation. Both of these are true for IAMs of future climate change.

As an example, one of the most controversial aspects of IAMs is the damage function, which relates climate change to economic impacts. Take the "simple" example of tropical cyclones — hurricanes in the United States. Basic physics indicates that a warmer ocean is likely to increase the intensity of hurricanes; more precisely, the probability distribution of damage from wind speed will shift to the right. IAMs need to integrate this finding with economic impacts. A major surprise of research here was that the economic impacts of hurricanes are a high-power function of maximum wind speed; normalized by economic variables such as local capital, damage is estimated to be wind speed to the ninth power.[11]

But that is only a small slice of damage. To construct damage functions, researchers need to aggregate across sectors, regions, levels of development, and climate change scenarios. This has proven the most difficult part of IAMs. In aggregate models, damage is often represented as a quadratic function of global mean temperature. Andrew Moffat and I recently did a systematic review of damage estimates; Figure 4 summarizes the findings of different studies.[12] One important feature of damage studies is that they are generally limited to global temperature increases of up to 3 °C, with the upper limits shown in Figure 2 not well-studied.

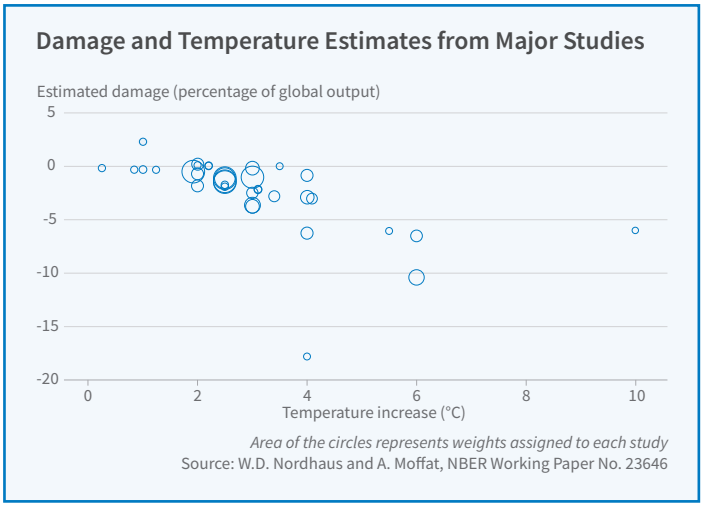

Figure 4

A difficulty in assessing IAMs is the inability to use standard statistical tests because of the lack of a probabilistic structure. One concern, alluded to above, is the major uncertainties associated with the results of IAMs. The uncertainties are particularly pronounced because of the long time periods — literally hundreds of years — required for estimates of optimal policies and the SCC. A recent study using the DICE-2016R2 model examined the uncertainties of major outcomes from parametric uncertainty of five major variables: equilibrium temperature sensitivity, productivity growth, the damage function, the carbon cycle, and the rate of decarbonization. Table 2, on the following page, shows the results. The best guess is the standard DICE model where parameters are set at their expected values, while the others are the distribution of outcomes. For the important SCC calculation, the mean value with full uncertainty is about 15 percent above the best guess. The change in temperature for 2100 is only slightly higher than the best guess. On the other hand, output is much higher because of the large estimated uncertainty of productivity growth.

Another approach to estimating uncertainty, illustrative rather than statistical, is to examine model revisions. For this purpose, I looked at revisions of the DICE model over its quarter-century history. The study found that the major revisions have come primarily from economic aspects of the model, whereas the revisions to environmental modules have been much smaller. Particularly sharp revisions have occurred for global output, damages, and the social cost of carbon. These results indicate that the economic projections are the least precise parts of IAMs and deserve much greater study than has been the case up to now, especially careful studies of economic growth prospects to 2100 and beyond.[13]

Uncertainty Analysis in Baseline Scenario

Variable (All except SCC refer to the year 2100)	Mean	DICE best guess	50th percentile	Standard deviation	Interquartile range	Coef. of variation
Social cost of carbon, 2015 (2010 U.S. dollars)	34.5	30.0	25.3	32.5	39.3	0.94
Temperature increase from 1990 (°C)	4.22	4.10	4.08	1.12	2.01	0.22
Carbon concentrations (ppm)	969.6	826.6	829.8	413.3	488	0.12
World output (trillions 2010 U.S. dollars)	1,433	759	766	1,660	1,056	0.67
CO_2 emissions (Gt / year)	109.4	70.9	71.1	105.2	114.5	0.63
Damages (percent of output)	4.3%	3.8%	3.2%	3.7%	4.9%	0.67
Real interest rate (percent / year)	3.6%	3.6%	3.6%	1.6%	2.2%	0.33

Source: W.D. Nordhaus, NBER Working Paper No. 22933

Table 2

Conclusion

IAMs are important tools for understanding the implications and policy aspects of climate change. They have fundamentally transformed the way economists and environmentalists approach climate policy, shifting from a pure engineering approach — "do this and don't do that" — to approaches like cap-and-trade or carbon taxes that emphasize market mechanisms.

As hurricanes Harvey and Irma remind us, the impacts of weather events can be extremely large. So climate change is likely to continue growing as an economic problem. Improving integrated assessment models is therefore an important research area for economists — full of puzzles, challenges, and policy applications.

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[1] *This research report draws upon W. D. Nordhaus,* The Climate Casino: Risk, Uncertainty, and Economics for a Warming World, *New Haven, CT: Yale University Press, 2013; W. D. Nordhaus, "Integrated Economic and Climate Modeling," in* Handbook of Computable General Equilibrium Modeling, *P. Dixon and D. Jorgenson, eds.: Elsevier, 2013, pp. 1069–131; W. D. Nordhaus, "Projections and Uncertainties About Climate Change in an Era of Minimal Climate Policies," NBER Working Paper No. 22933, December 2016, revised September 2017.*
Return to text

[2] *Report of the Modeling Resource Group, Synthesis Panel of the Committee on Nuclear and Alternative Energy Systems, National Research Council,* Energy Modeling for an Uncertain Future, *Washington, D.C.: The National Academies Press, 1978.*
Return to text

[3] *P. A. Samuelson, "Market Mechanisms and Maximization," Santa Monica, CA: Rand Corporation, P-69, March 28, 1949.*
Return to text

[4] *W. D. Nordhaus, "Can We Control Carbon Dioxide?" International Institute for Applied Systems Analysis Working Paper, WP 75-63, Laxenburg, Austria, June 1975; W. D. Nordhaus, "Economic Growth and Climate: The Case of Carbon Dioxide,"* American Economic Review, *67(1), 1977, pp. 341–6.*
Return to text

[5] *A. S. Manne, "ETA: A Model for Energy Technology Assessment,"* Bell Journal of Economics, *7(2), 1976, pp. 379-406.*
Return to text

[6] *W. D. Nordhaus, "An Optimal Transition Path for Controlling Greenhouse Gases,"* Science, *258, 1992, pp. 1315–9; W. D. Nordhaus,* Managing the Global Commons: The Economics of Climate Change, *Cambridge, MA: MIT Press, 1994.*
Return to text

[7] *W. D. Nordhaus, P. Sztorc, "DICE 2013R: Introduction and User's Manual," October 2013.* http://www.econ.yale.edu/%7Enordhaus/homepage/documents/DICE_Manual_100413r1.pdf
Models available at www.econ.yale.edu/~nordhaus/homepage/DICEmodels09302016.htm.
Return to text

[8] *W. D. Nordhaus, "Projections and Uncertainties about Climate Change in an Era of Minimal Climate Policies," NBER Working Paper No. 22933, December 2016, revised September 2017.*
Return to text

[9] The Economics of Climate Change: The Stern Review, *Cambridge, England: Cambridge University Press, 2007; W. D. Nordhaus, "The 'Stern Review' on the Economics of Climate Change," NBER Working Paper No. 12741, December 2006; and "A Review of the Stern Review on the Economics of Climate Change,"* Journal of Economic Literature, *45, September 2007, pp. 686–702.*
Return to text

[10] *W. D. Nordhaus, "Revisiting the Social Cost of Carbon,"* Proceedings of the National Academy of Sciences, *114(7), 2017, pp. 1518–23.*
Return to text

[11] *W. D. Nordhaus, "The Economics of Hurricanes in the United States," NBER Working Paper No. 12813, December 2006, and* Climate Change Economics, *2010, 1 (1), pp. 1–20.*
Return to text

[12] *W. D. Nordhaus and A. Moffat, "A Survey of Global Impacts of Climate Change: Replication, Survey Methods, and a Statistical Analysis," NBER Working Paper No. 23646, August 2017.*
Return to text

[13] *W. D. Nordhaus, "Evolution of Assessments of the Economics of Global Warming: Changes in the DICE Model, 1992–2017," NBER Working Paper No. 23319, April 2017.*
Return to text

Resource Barriers to Postsecondary Educational Attainment

Michael Lovenheim

U.S. economic growth in recent decades has favored high-skilled, service-based occupations and industries. As a result, the demand for skilled relative to unskilled labor has grown markedly, which has been the source of much attention and concern among policymakers and researchers. Increasingly, the labor market outcomes of working-age adults are linked to their educational attainment. Earnings gains have flowed disproportionately to those with four-year college degrees. One might expect that this growth in the demand for skilled labor would be met with a substantial increase in the production of such labor, but this has not been the case.

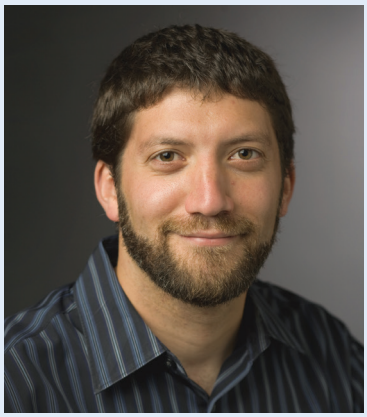
The anemic response of collegiate attainment to persistent increases in labor market returns has occurred alongside rising inequality in postsecondary outcomes.[1] Although education is often discussed as a means to reduce economic inequality and induce upward social mobility, large and growing attainment gaps among students from different socioeconomic backgrounds, coupled with high labor market returns to postsecondary education, have led to concerns that the higher education system is exacerbating inequality.

The fact that the supply of college-educated workers has not kept up with demand along with growing inequality in postsecondary outcomes suggests there are barriers precluding many students from obtaining a postsecondary degree. A particularly important class of barriers, especially for low-income students, centers around financial resources. Such barriers can occur on the demand (i.e., student) or supply (i.e., institutional) side of the higher education market. Demand-side resource constraints mostly consist of difficulties in paying the often high tuition price associated with college enrollment. Supply-side resource barriers are driven by declining state subsidies for public higher education, as well as the higher propensity of lower-income students to attend universities with lower per-student resources.

In a series of research papers, my co-authors and I have examined how family financial resources and postsecondary institutional resources affect collegiate attainment. We estimate resource effects on both the demand and supply sides of the higher education market and provide insight into policies that could reduce barriers to college completion.

Policymakers and researchers have focused a significant amount of attention on college access, with the goal of increasing college enrollment either overall or for specific groups. Much of my research is motivated by the widening gap between enrollment and degree attainment: A large component of both the increased inequality in postsecondary attainment and the sluggish increase in postsecondary attainment overall is degree non-completion. Simply put, if most of the students who enroll in college were to successfully obtain a degree, postsecondary attainment would rise dramatically and inequality in attainment would decline. Increasing the supply and altering the composition of college-educated workers thus requires understanding barriers to completion among the students who enroll, as well as understanding barriers to enrollment.

My collaborators and I have examined how financial resource barriers can affect dimensions of postsecondary investment behavior beyond enrollment, such as what types of colleges students attend and whether students complete college conditional on attending. We look beyond access to the various dimensions along which financial resources can



Michael Lovenheim is a research associate in the NBER Economics of Education and Public Economics Programs. He is an associate professor in the department of policy analysis and management at Cornell University and is co-editor of the *Journal of Policy Analysis and Management*. Lovenheim earned his B.A. in economics from Amherst College in 2000 and received his Ph.D. in economics from the University of Michigan in 2007. He was a Searle Freedom Trust Postdoctoral Fellow at the Stanford Institute for Economic Research for two years prior to joining the Cornell faculty.

Lovenheim's research focuses on empirical, policy-relevant issues in the economics of education and public finance. In higher education, his research examines questions related to the effect of personal and institutional resources on student outcomes and institutional productivity. Lovenheim also has an active research agenda on teacher labor markets, focusing specifically on teachers unions, performance pay, and teacher pension policies. His research on public economics studies questions related to interstate cigarette and alcohol regulation as well as the nutritional effects of consumption taxes. In addition to his academic research, he recently co-authored, with Sarah Turner, a textbook on the economics of education.

influence higher education attainment. This summary describes our recent research findings and discusses their policy implications.

Demand-Side Resource Effects

A popular view among parents, policymakers, and the media is that the cost of college presents a substantial impediment to postsecondary investment for many students. While college tuition and fees have indeed risen precipitously over time, so has financial aid. The United States has one of the most generous financial aid systems in the world, especially for very low-income students. The goal of this system is to decouple students' financial background from their ability to invest in a postsecondary degree. Finding that students' college choices are causally linked to their family's financial resources is evidence that the current financial aid system is not sufficient to achieve this goal.

Prior research has struggled to obtain credible estimates of the causal effect of family financial resource variation on postsecondary attainment. Estimating such an effect is challenging because income and wealth are not randomly assigned across students: Families with lower resources at the time of their children's college entry decision typically had fewer resources throughout the children's lives to invest in their education. The result is that students from lower-resource households tend to be, on average, less academically prepared for college than their counterparts from more affluent backgrounds.

What is needed is a source of family resource variation unrelated to the myriad attributes of students that are correlated with the costs and benefits of attending college, such as motivation and academic achievement. I have exploited differences in the timing and magnitude of the urban housing boom between the late 1990s and mid-2000s, across cities, to generate such variation.[2] This period saw an unprecedented growth in the value of housing as well as in the liquidity of housing wealth; it became much easier to extract equity from the home through home equity loans, lines of credit, and cash-out refinances. Home price increases varied considerably across cities, with some such as Las Vegas and Miami experiencing enormous increases over a short period of time, while others experienced relatively modest growth. The idea underlying my approach is to consider high school seniors in the same year whose parents own a home in cities that experienced different recent housing price growth. Families in high-increase cities received a financial windfall just before their children made college choices, while families in lower-increase cities experienced a much more modest change in resources. I therefore leverage the timing, magnitude, and geographic dispersion of the housing boom to generate variation in household resources that are unrelated to the underlying characteristics of students.

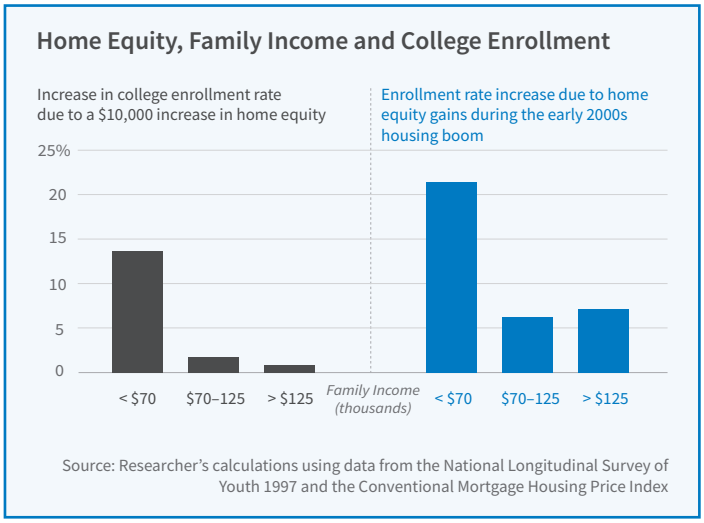


Figure 1

I found college enrollment was responsive to housing wealth during the housing boom. Figure 1 shows the results graphically for families with incomes below $70,000, families with incomes between $70,000 and $125,000, and families with incomes above $125,000. I present the effect of enrollment from a $10,000 home equity increase relative to the mean college enrollment rate for each group, as well as the effect of the mean home equity increase experienced by each group between 2001 and 2005, the heart of the housing boom. For all families, enrollment increases by a statistically significant 1.4 percent for each $10,000 of additional home equity. During the housing boom of the early 2000s, the average homeowner experienced an almost $58,000 increase in home equity, which my estimates indicate increased college enrollment by 7.9 percent relative to the baseline level.

Students in families with earnings under $70,000 per year are particularly responsive to home equity changes: $10,000 of additional home equity increases college enrollment by 13.7 percent relative to the mean level. When multiplied by the average home equity increase experienced by this group in the early 2000s, the effect is 21.4 percent. Among students from higher-income households, enrollment responds more modestly to housing wealth changes. For both higher income groups, the effect of housing wealth is much smaller and is not statistically significantly different from zero. However, the point estimates are positive and are sizable in magnitude when multiplied by the large increases in home equity experienced by these families during the housing boom. The fact that students from higher income households are less affected by housing wealth changes is likely because these students face fewer resource constraints in financing a college education than their less affluent counterparts. I also show that the housing wealth-enrollment relationship was not present prior to the housing boom, which suggests an important role for the increased liquid-

ity of home equity in the early 2000s.

In a follow-up paper, C. Lockwood Reynolds and I use the same source of variation to examine how housing wealth impacts the type of schools students choose, and college completion.[3] We find that when families experience more home price growth when their child is in high school, their child is more likely to attend a state flagship university and is less likely to attend a community college. Interestingly, the flagship effect is driven by increased applications, which suggests that changes in family resources impact the types of schools students consider attending. Low-income students whose families experienced home price increases during the housing boom were more likely to complete a four-year degree as well.

Another way to test for household resource effects is to study variation in the amount of financial aid available to students. This has proved difficult. Because most financial aid is federal, there is little variation in aid eligibility across students that is not directly tied to their family finances and background. Emily Owens and I studied an unusual policy change enacted by the federal government in 2001 that excluded anyone with a drug conviction from receiving federal financial aid.[4] While a small group, students with drug convictions tend to be from more disadvantaged backgrounds, and there may be particularly large social returns to increasing their educational attainment. We compare the change in college enrollment among those with a drug conviction when the rule was implemented to the change among those with no conviction. Our findings indicate that college enrollment within one year of high school graduation dropped by 22 percent among those with a drug conviction relative to those without, which suggests financial resources are a relevant barrier to postsecondary investment for many families. We also present evidence that the reduction in financial aid leads to a reduction in the completion rate of bachelor of arts degrees, a longer time required by college completers to complete a B.A., and an increased likelihood of a subsequent criminal conviction. Excluding these students from financial aid eligibility negatively affects their life outcomes and produces substantial social costs.

Sarah Cohodes, Daniel Grossman, Samuel Kleiner, and I examine another source of household resource variation: access to Medicaid. This occurs earlier in life than the resources I examined in my other research.[5] Medicaid is the primary means through which lower-income children receive health insurance, which can improve their health and their parents' financial standing. This resource variation is different from those previously discussed because it does not just impact the ability to pay for college. Instead, it can affect the level and productivity of early childhood investments in education. We examine the large Medicaid eligibility expansions experienced by those born from 1980 through 1990. Using the fact that children born in different states and years had very different eligibility for Medicaid over the course of their childhood due to state and federal Medicaid law changes, we estimate how Medicaid eligibility translates into educational attainment later in life. We find that a 10 percentage point increase in average Medicaid eligibility during childhood decreases the high school dropout rate by 4 percent and increases the likelihood of B.A. completion by 2.5 percent. These results suggest that policies targeting resources to low-income families with young children can have sizable effects on their ultimate collegiate attainment.

Supply-Side Resource Effects

One reason studying postsecondary institutional resources is important is the high degree of resource stratification within the higher education sector. More selective institutions have higher per-student expenditures, higher-achieving student bodies, and higher-paid and more research-productive faculties. The result is that resources are increasingly being concentrated in a small set of "elite" institutions that serve students with high precollegiate achievement levels. A growing body of research in economics seeks to estimate the labor market return to enrolling in one of these highly selective schools, which is difficult because students with higher earning potential select into these higher quality institutions.

Rodney Andrews, Jing Li, and I contribute to this literature using administrative data on all public school students in the state.[6] We link educational records for all public K-12 students in Texas to postsecondary records for all public higher education students in the state, and merge these data with quarterly earnings records. Linked administrative data are becoming more prevalent in education economics research; they provide both a wealth of information about students over time as well as large sample sizes. We use pre-collegiate demographic and academic achievement information to account for student selection. Our findings indicate that graduating from the University of Texas at Austin or Texas A&M University, the flagship universities in Texas, increases earnings by 12 and 21 percent, respectively, relative to graduating from a non-flagship public university. Graduating from a community college is associated with lower earnings by 11 percent relative to obtaining a degree from a non-flagship public university.

We also examine how college quality affects the distribution of earnings. Going beyond mean earnings effects is important, because the average may mask a large amount of variability in labor market returns across the earnings distribution. We estimate quantile treatment effects of college sector on earnings; the results are presented in Figure 2, on the following page. These curves show the differences in

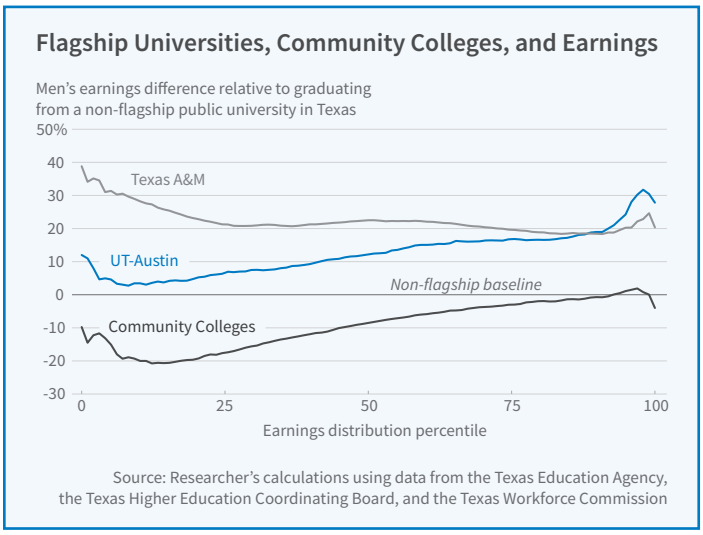


Figure 2

earnings, adjusted for observed student characteristics, between graduates in the given sector and those in the non-flagship four-year sector at each percentile of the earnings distribution. For UT-Austin graduates, the mean effect of 12 percent does a poor job of characterizing the effect on the entire distribution. At the bottom of the distribution, earnings returns to UT-Austin are quite low, and then they grow to more than 30 percent at the top of the distribution. The effects are much more constant among Texas A&M graduates, however. We argue the differences across the two flagship universities are likely due to differences in field of study, as Texas A&M students are much more likely to major in high-earning, low-variance fields such as engineering. Finally, we examine community colleges and show that the earnings penalty to a community college relative to a non-flagship public university is driven by low earners. At the top of the earnings distribution, community college graduates earn the same as their non-flagship four-year counterparts. This is despite the fact that the community college degree requires two fewer years of study; for a portion of students, the payoff to community college enrollment is relatively high.

A second reason economists are interested in the effect of supply-side resources on collegiate attainment is that a large amount of money is spent by federal and state governments to subsidize higher education. For public institutions, state appropriations are a particularly important part of the budget, and they have declined substantially over time. John Bound, Sarah Turner, and I examine whether changes in supply-side resources contribute to declining completion rates over time.[7] Between the mid-1970s and mid-1990s, college completion rates conditional on ever having attended college dropped from 52 to 43 percent. The largest declines were experienced by students attending non-top-50 ranked public four-year schools and community colleges.

Supply-side forces can play two roles in explaining this decline. First, as more students enter college over time, an increasing proportion sort into less selective and less resourced schools because these are the institutions that expand their enrollment due to higher student demand. Second, per-student resources at the less selective institutions have declined due to reductions in state appropriations, as these schools are particularly reliant on state funding. We conduct a decomposition analysis that shows how college completion rates would have changed had institutional resources (proxied by student-faculty ratios) and the distribution of students across postsecondary sectors not changed over time. We find that the increase in student-faculty ratios can explain about a quarter of the completion rate decline, while the rest can be explained by students increasingly attending lower-quality colleges and universities. Thus, we argue that supply-side resource changes can explain all of the observed decline in college completion rates.

In a follow-up paper, we conduct a similar decomposition analysis with respect to lengthening time to degree among B.A. recipients over time.[8] While the supply-side effects are not as strong, we find reductions in per-student resources in the less selective public four-year sector to be a core contributor to the longer time it is taking students to complete B.A. degrees.

Comprehensive Interventions

Students from low-income backgrounds face several barriers to postsecondary success, including difficulty in financing postsecondary enrollment, lack of information about the postsecondary system that leads to less enrollment and enrollment in lower-quality colleges, and lower pre-collegiate academic achievement. There has been a policy trend toward attempting to address these multiple dimensions of disadvantage that low-income students face using comprehensive interventions. Examples of such programs are the Longhorn Opportunity Scholarship (LOS) in Texas, the Susan Thompson Buffett Foundation (STBF) scholarship in Nebraska, and the ASAP program at the City University of New York.

Andrews, Scott Imberman, and I study the LOS program in Texas using the linked administrative data discussed previously.[9] The LOS program is run by the UT-Austin and consists of recruiting students at urban, low-income, and heavily minority high schools, offering grant aid if they enroll at UT-Austin, and providing a series of academic support services once they are enrolled. This program thus combines demand-side and supply-side resource supports. We find that among high-achieving students who were the targets of this program, the LOS intervention substantially increased the likelihood that students both enrolled at and graduated from UT-Austin. Among students from targeted high schools

who attended UT-Austin, earnings increased by 82 percent 12 or more years after high school relative to similar students who were not exposed to this program. These results show that combining supply-side and demand-side resource increases for disadvantaged students can be particularly effective in supporting their postsecondary attainment and future earnings.

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[1] *M. J. Bailey and S. Dynarski, "Gains and Gaps: Changing Inequality in U.S. College Entry and Completion," NBER Working Paper No. 17633, December 2011, and published as "Inequality in Postsecondary Education" in G. J. Duncan and R. J. Murnane, eds.,* Whither Opportunity? Rising Inequality, Schools, and Children's Life Chances, *New York, NY: Russell Sage, 2011, pp. 117–32.*
Return to text

[2] *M. F. Lovenheim, "The Effect of Liquid Housing Wealth on College Enrollment,"* Journal of Labor Economics, *29(4), 2011, pp. 741–71.*
Return to text

[3] *M. F. Lovenheim and C. L. Reynolds, "The Effect of Housing Wealth on College Choice: Evidence from the Housing Boom", NBER Working Paper No. 18075, May 2012, and* Journal of Human Resources, *48(1), 2013, pp. 1–35.*
Return to text

[4] *M. F. Lovenheim and E. G. Owens, "Does Federal Financial Aid Affect College Enrollment? Evidence from Drug Offenders and the Higher Education Act of 1998," NBER Working Paper No. 18749, February 2013, and* Journal of Urban Economics, *81, 2014, pp. 1–13.*
Return to text

[5] *S. Cohodes, D. Grossman, S. Kleiner, and M. F. Lovenheim, "The Effect of Child Health Insurance Access on Schooling: Evidence from Public Insurance Expansions," NBER Working Paper No. 20178, May 2014, and* Journal of Human Resources, *51(3), 2016, pp. 727–59.*
Return to text

[6] *R. J. Andrews, J. Li, and M .F. Lovenheim, "Quantile Treatment Effects of College Quality on Earnings: Evidence from Administrative Data in Texas," NBER Working Paper No. 18068, May 2012, and "Quantile Treatment Effects of College Quality on Earnings,"* Journal of Human Resources, *51(1), 2016, pp. 200–38.*
Return to text

[7] *J. Bound, M. F. Lovenheim, and S. Turner, "Why Have College Completion Rates Declined? An Analysis of Changing Student Preparation and Collegiate Resources," NBER Working Paper No. 15566, December 2009, and* American Economic Journal: Applied Economics, *2(3), 2010, pp. 129–57.*
Return to text

[8] *J. Bound, M. F. Lovenheim, and S. Turner, "Increasing Time to Baccalaureate Degree in the United States," NBER Working Paper No. 15892, April 2010, and* Education Finance and Policy, *7(4), 2012, pp. 375–424.*
Return to text

[9] *R. J. Andrews, S. A. Imberman, and M. F. Lovenheim, "Recruiting and Supporting Low-Income, High-Achieving Students at Flagship Universities," NBER Working Paper No. 22260, May 2016.*
Return to text

Economic Development and Gender Equality: Exceptions to the Rule

Seema Jayachandran

Seema Jayachandran is an associate professor of economics at Northwestern University and a research associate in the NBER Development Economics and Health Care Programs.

Jayachandran's recent work focuses on gender equality in developing countries. She also is currently working on projects related to environmental conservation, health, labor markets, and education.

Jayachandran co-chairs the health sector of the Abdul Latif Jameel Poverty Action Lab and serves on the board of the Bureau for Research and Analysis of Economic Development. She is a reviewing editor at *Science* and an associate editor for the *American Economic Review,* the *Quarterly Journal of Economics,* and the *Journal of Economic Perspectives.*

Jayachandran received her Ph.D. in economics from Harvard University in 2004. She also holds an M.A. in physics from Harvard, an M.A. in physics and philosophy from the University of Oxford, and an S.B. in electrical engineering from MIT. Prior to joining Northwestern, she was on the faculty at Stanford University from 2006–11 and a Robert Wood Johnson Scholar in Health Policy Research at the University of California, Berkeley from 2004–06. She is a recipient of an NSF CAREER Award and a Sloan Research Fellowship.

Women lag further behind men in poor countries than in rich countries in terms of educational outcomes, health status, decision-making power in the family, and other aspects of well-being. As a rule, the process of economic development levels the playing field for women in the labor market. As an economy grows, its service sector expands, while agriculture and other primary industries shrink in importance; women have a comparative advantage in jobs that require brains rather than brawn. Similarly, economic development brings about — and is often enabled by — lower lifetime fertility for women, which frees up their time to invest in their careers. Better career prospects for women, in turn, lead parents to invest more in their daughters' educations, and economically empowered women have more say in their households. I have recently reviewed the large literature on how economic progress brings about progress for women.[1]

However, there are also exceptions to the rule — ways in which cultural norms about gender stubbornly persist in the face of economic progress.[2] My recent research, focusing on India, has examined situations in which movement toward gender equity has leveled off or regressed. Specifically, my colleagues and I have examined negative ramifications of parents' favoritism toward their eldest son and obstacles to women's success in the labor market. This summary describes some of our findings.

Implications of Parents' Strong Desire to Have a Son

In India, older couples live with their eldest son, and the eldest son gets priority for inheritance. He also plays important roles in Hindu funeral rites. Having a son to fulfill these roles is therefore very important to couples, and they tend to favor their eldest son over their other children. This eldest son preference strongly shapes couples' fertility decisions and their investments in their children, with important implications for child health. It creates not only inequality between boys and girls, but also among boys and among girls, and it can reduce average child health outcomes.

Rohini Pande and I found that eldest son preference helps explain India's unexpectedly high rate of stunting among children under age five.[3] Height is a commonly used measure of child well-being, not because we care about height per se, but because height reflects the nutrition and illness a child has experienced during the critical early years of life. Childhood stunting has been linked to low cognitive ability, poor health, and low earnings later in life. India is a poor country, so it is unsurprising that stunting is more prevalent than in a rich country such as the United States, but researchers have been puzzled by the high level of stunting in India compared to other countries at a similar level of economic development. Pande and I compare India to a set of sub-Saharan African countries which, though they are poorer than India, have lower levels of stunting.

We find that child height varies considerably among siblings, and specifically that there is a strong drop-off with birth order. This birth order gradient is observed in almost all societies, but it is especially strong in India. Firstborn Indian children are no shorter than their sub-Saharan African counterparts. The India height puzzle is mostly concentrated among later-born children, as shown in Figure 1, on the following page.

Firstborn children's genes do not differ systematically from the genes of younger siblings. Infrastructure for clean water and sanitation also do not vary much among siblings; if anything, they improve over time, which would help later-born children. Disparities within families suggest that parents' choosing to provide more inputs for some children than for others

explains a lot of the height puzzle. We find that health inputs such as vaccinations and prenatal visits also exhibit an unusually steep drop-off with birth order in India.

We also investigate the role of eldest son preference, and find that it is at the root of India's steep birth order gradient. If parents dote on the first-born son, there will be a steep birth-order gradient among boys. How favoritism for eldest sons hurts later-born girls relative to their older sisters is more subtle. First, an earlier-born girl is less likely to have a brother yet, and so is less likely to be competing with a boy for resources when she is young. We find much less inequality among siblings in regions of India where son preference is weaker, such as the matrilineal state of Kerala, and for Muslims, who do not have strong eldest son preferences, compared to Hindus.

A second key channel is parents deciding to have more children than originally planned in order to have a son. Consider a couple who desire two children; they will likely view the birth of a second daughter as an unpleasant surprise and decide to keep trying for a son. They will need to start economizing because now they will have more children to support than they had planned, and those spending cutbacks hit the second-born daughter in her critical early years. This behavior generates some quite specific predictions, which are borne out in the data, about how parents' investments depend on the composition of the sibling group.

Finally, we show that within-family inequality lowers average child health outcomes in India. With diminishing returns to investment, concentrating investments on a favored child hurts aggregate outcomes. Parents might be maximizing their own well-being by favoring one child, but given potential positive externalities of a healthier and more skilled workforce, their favoritism could be inefficient, and a drag on India's economic progress.

In an earlier paper, Ilyana Kuziemko and I studied another way that Indian parents' desire to have a son as quickly as possible has negative spillovers, specifically for girls.[4] When parents without a son give birth to a girl, their eagerness to "try again" for a son reduces the duration that their daughter is breastfed. Some mothers know that breastfeeding suppresses fecundity and therefore wean their newborn girl quickly. Others might simply become pregnant again — nursing does not make a woman completely infecund — which triggers them to stop breastfeeding. In contexts where water and food are unsanitary, a shortened duration of breastfeeding can be harmful to child health. We find that this behavior is an important contributor to girls' mortality in India. This harm to girls is an unintended consequence rather than a conscious choice resulting from a decision to invest more in sons than daughters. It nevertheless disadvantages girls.

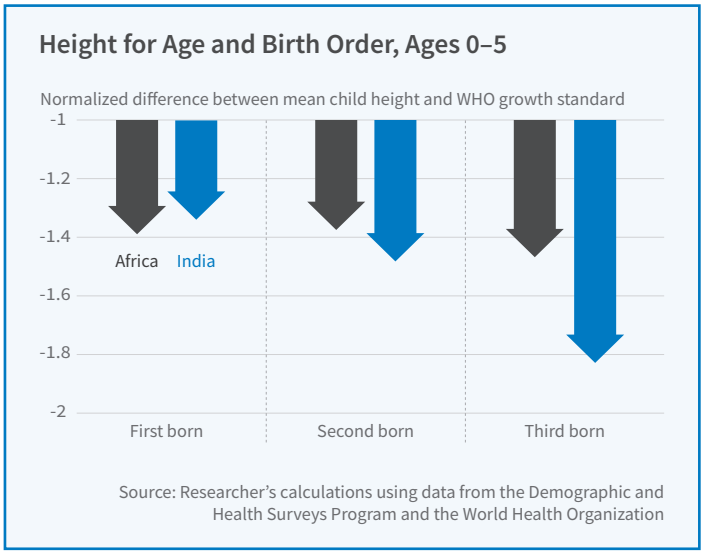

Figure 1

The Worsening Problem of 'Missing Women'

Perhaps the most extreme consequence of the desire for sons is selective abortion of female fetuses. Amartya Sen called attention to this problem of "missing women" in 1990, and it has worsened in India, as well as in China and elsewhere, in the three decades since.[5] One reason is increased access to ultrasound tests and other technology that can determine fetal sex. My research has highlighted another contributing factor: the move toward smaller families. Rapidly changing norms about family size in India have collided with the persistent cultural importance of eldest sons.[6] It is not the case that parents in India want all their children to be boys; if they were to have two children, most would ideally want one son and one daughter. But the exalted role of the eldest son means that having at least one son is very important. Couples who want four or five children are very likely to end up with a son naturally (94 and 97 percent, respectively), but at a family size of two — which is increasingly the desired family size in India — a quarter of couples would end up with two daughters if they did not intervene, and thus many opt for sex-selective abortions. Using a novel way of eliciting fertility preferences, I show that the growing desire for small families explains a third to a half of India's worsening sex imbalance in recent decades.

These findings also highlight a paradox. Because women might value daughters more than men do, and because female education strengthens women's say in household decisions, we might expect that educating women would reduce the prevalence of gender selection. However, there is also another important force: Educated women typically want fewer children, which increases their "need" to resort to gender selection. Empowering women will not necessarily eliminate the problem of "missing women." This conclusion raises the question of how, if at all, policy might address the challenge of "missing women." In current work, Diva Dhar, Tarun Jain, and I are evaluating whether incorporating classroom discussions of gender norms into the government secondary school curriculum makes adolescents less tolerant of gender discrimination and begins to reshape those norms.[7]

Female Employment and Friends' Support

Another way in which India's cultural norms might be constraining its growth relates to female employment. The female labor force participation rate has been rising in most developing countries recently, but in India it has fallen over the past decade.[8] Social restrictions on women's ability to interact with men outside their family or to travel unaccompanied within their village or city are barriers to women's employment. Many women turn to home-based self-employment, such as tailoring clothes or making incense sticks, but the same social restrictions can hurt the success of these small businesses, in part because the women have limited opportunity to network with and learn from peers. Erica Field, Pande, Natalia Rigol, and I evaluated a popular type of program to help small-scale entrepreneurs, namely business skills training.[9] In one variant of the program, we added the feature that women could bring a friend with them to the classes. Program participants took out more business loans and earned higher incomes, but only in the variant where they could bring a friend. We cannot say for sure what led to this result, but having a friend's support seemed to give women the wherewithal to set more ambitious business goals and achieve them. In this case, without reshaping the cultural norm, redesigning a program in light of the norm promoted entrepreneurship among women.

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1 *S. Jayachandran, "The Roots of Gender Inequality in Developing Countries," NBER Working Paper No. 20380, August 2014, and* Annual Review of Economics, *7, 2015, pp. 63–88.*
Return to text

2 *There is a growing literature that discusses how cultural norms are shaped by economic forces, then linger even after the economic environment has transformed. See, for example, A. F. Alesina, P. Giuliano, N. Nunn, "On the Origins of Gender Roles: Women and the Plough," NBER Working Paper No. 17098, May 2011, and* Quarterly Journal of Economics, *128(2), 2013, pp. 469–530.*
Return to text

3 *S. Jayachandran and R. Pande, "Why Are Indian Children So Short?," NBER Working Paper No. 21036, March 2015, and* American Economic Review, *107(9), 2017, pp. 2600–29.*
Return to text

4 *S. Jayachandran and I. Kuziemko, "Why Do Mothers Breastfeed Girls Less Than Boys? Evidence and Implications for Child Health in India," NBER Working Paper No. 15041, June 2009, and* Quarterly Journal of Economics, *126(3), 2011, pp. 1485–538.*
Return to text

5 *A. Sen, "More Than 100 Million Women Are Missing,"* The New York Review of Books, *37(20), 1990, pp. 61–6.*
Return to text

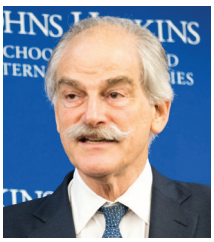
6 *S. Jayachandran, "Fertility Decline and Missing Women," NBER Working Paper No. 20272, July 2014, and* American Economic Journal: Applied Economics, *9(1), 2017, pp. 118–39.*
Return to text

7 *D. Dhar, T. Jain, and S. Jayachandran, "Intergenerational Transmission of Gender Attitudes: Evidence from India," NBER Working Paper No. 21429, July 2015.*
Return to text

8 *R. Heath and S. Jayachandran, "The Causes and Consequences of Increased Female Education and Labor Force Participation in Developing Countries," NBER Working Paper No. 22766, October 2016, and forthcoming in S. Averett, L. Argys, and S. Hoffman, eds.,* Oxford Handbook on the Economics of Women, *New York, NY: Oxford University Press, 2018.*
Return to text

9 *E. Field, S. Jayachandran, R. Pande, and N. Rigol, "Friendship at Work: Can Peer Effects Catalyze Female Entrepreneurship?," NBER Working Paper No. 21093, April 2015, and* American Economic Journal: Economic Policy, *8(2), 2016, pp. 125–53.*
Return to text

Karen Horn



John Lipsky

Karen Horn Elected Chair of NBER Board of Directors, John Lipsky Elected Vice Chair

Karen N. Horn was elected chair of the NBER's Board of Directors at the board's September 25 meeting. She succeeds Martin Zimmerman, a professor of business administration at the University of Michigan's Ross School of Business and former vice president for corporate affairs at Ford Motor Company, who had served since 2014. Horn, a partner in the Brock Capital Group, is a former chair and CEO of Bank One and a former president of the Federal Reserve Bank of Cleveland. She was also managing director and president of Global Private Client Services at the Marsh subsidiary of Marsh and McLennan. She received her Ph.D. from Johns Hopkins University and was elected to the NBER Board of Directors in 1993.

The board also elected director John Lipsky, a senior fellow at Johns Hopkins' Paul H. Nitze School of Advanced International Studies, as vice chair. Lipsky, who received his Ph.D. at Stanford and joined the NBER board in 1998, served as first deputy managing director of the International Monetary Fund between 2006 and 2011. Prior to his IMF service, he was vice chair of the JPMorgan Investment Bank. Lipsky is co-chair of the Aspen Institute's Program on the World Economy and a life member of the Council on Foreign Relations.

Four New Directors Join NBER Board

Philip Hoffman

George Mailath

Philip Hoffman, the Rea A. and Lela G. Axline Professor of Business Economics and History at the California Institute of Technology, is the new representative of the Economic History Association (EHA). His research combines economic theory and historical evidence to explain long-term changes in politics, society, and the economy, with particular attention to economic growth and political development. He is currently studying cross-country differences in long-term patterns of economic development, the evolution of financial institutions, and the way states develop the capacity to levy taxes and provide public goods. He has served as president of the EHA and as co-editor of the *Journal of Economic History,* and has been a John Simon Guggenheim Fellow. He received his A.B. from Harvard College and his Ph.D. from Yale University. He succeeds Alan Olmstead as the EHA representative.

George Mailath, Walter H. Annenberg Professor in the Social Sciences and professor of economics at the University of Pennsylvania and Goldsmith Professor in the Research School of Economics at Australian National University (ANU), is the new representative of the University of Pennsylvania. His research focuses on microeconomic theory, particularly on pricing, repeated games, non-cooperative and evolutionary game theory, social norms, and the theory of reputations. Mailath is a Fellow of the American Academy of Arts & Sciences, the Econometric Society, the Game Theory Society, and the Society for the Advancement of Economic Theory. He has served on the Councils of the Econometric Society and the Game Theory Society. Mailath received his undergraduate degree from ANU and his Ph.D. from Princeton.

Karen Gordon Mills, a senior fellow at Harvard Business School and president of MMP Group, Inc., which invests in financial services, consumer products, and other technology-enabled businesses, is a new at-large board member. Mills served as the 23rd administrator of the U.S. Small Business Administration, 2009 to 2013, overseeing the agency's initiatives to assist small businesses during the economic recovery following the 2008 financial collapse. She is an expert on the economic health and well-being of the nation's small businesses and on U.S. competitiveness. Mills is the author of seminal research on

capital markets for small businesses. She chairs the advisory committee of the Private Capital Research Institute, co-chairs the Bipartisan Policy Center's Main Street Finance Task Force, and is a member of the Council on Foreign Relations and the Harvard Corporation. Mills earned an A.B. in economics from Harvard and an MBA from Harvard Business School, where she was a Baker Scholar.

Ingo Walter, Seymour Milstein Professor of Finance, Corporate Governance, and Ethics emeritus at New York University's Stern School of Business, is the inaugural representative of New York University (NYU) on the board. In 2016, the board added NYU to the list of institutions invited to nominate NBER directors. Walter's principal areas of teaching and research include international banking and capital markets, corporate governance, and risk management. He has authored or co-authored papers in most of the professional journals in these fields and is the author, coauthor or editor of 27 books, most recently *Regulating Wall Street*. He received B.S. and M.S. degrees from Lehigh University and his Ph.D. from NYU.

In addition, at-large director Don Conlan, retired president of the Capital Group Companies, and Andrew Postlewaite of the University of Pennsylvania, formerly that university's representative on the board, were elected to emeritus status.

Karen Mills

Ingo Walter

Leah Boustan and William Collins Are New Co-Directors of the Development of American Economy Program

Leah Boustan

William Collins

Leah Boustan, a professor of economics at Princeton University, and William Collins, the Terence E. Adderley Jr. Professor of Economics at Vanderbilt University, are the new co-directors of the Development of the American Economy (DAE) Program. Boustan, who joined the Princeton faculty this year, previously taught at UCLA. She has been an NBER research associate since 2012, and before that a faculty research fellow since 2007. Collins, who became a faculty research fellow in 1999 and a research associate in 2004, has been a member of the Vanderbilt faculty since 1998.

Boustan's research focuses on U.S. labor markets, with particular emphasis on the history of migration. She explores rich historical datasets to provide new context and perspective for current labor market outcomes. Her 2016 book, *Competition in the Promised Land: Black Migrants in Northern Cities and Labor Markets*, has been widely celebrated. Boustan received her B.A. from Princeton and her Ph.D. from Harvard.

Collins, who also is a professor of history at Vanderbilt and served as department chair 2011–14, is currently editor of *The Journal of Economic History*. His research focuses on the evolution of U.S. cities, racial wage differentials, and labor market dynamics. He recently co-edited, with Robert Margo, the NBER volume *Enterprising America: Businesses, Banks, and Credit Markets in Historical Perspective*. Collins received his B.A. and his Ph.D. from Harvard.

Gita Gopinath and Pierre-Olivier Gourinchas Are New Co-Directors of International Finance and Macroeconomics Program

Gita Gopinath

Pierre-Olivier Gourinchas

Gita Gopinath, the John Zwaanstra Professor of International Studies and of economics at Harvard, and Pierre-Olivier Gourinchas, who holds joint appointments as a professor in the economics department and as the S. K. and Angela Chan Professor of Global Management in the Haas School of Business at the University of California, Berkeley, are the new co-directors of the International Finance and Macroeconomics (IFM) Program. Gopinath was appointed an NBER faculty research fellow in 2004, and became a research associate in 2011. Prior to joining the Harvard faculty, she taught at the University of Chicago. Gourinchas, an NBER research associate since 1998, was on the faculty at the Stanford Graduate School of Business and at Princeton University before moving to Berkeley.

Gopinath's research spans a range of topics, including exchange rate pass-throughs, monetary unions, and sovereign debt markets. She is managing editor of *The Review of Economic Studies* and an economic adviser to the chief minister of the Indian state of Kerala. She received her B.A. from Lady Shri Ram College at the University of Delhi and her Ph.D. from Princeton.

Gourinchas studies capital flows and global imbalances, debt crises, and, more generally, international macroeconomic policy. He received the Bernácer Prize, recognizing the best under-40 European macroeconomist, in 2007, and has served as a member of the French Council of Economic Advisers. He is the editor of the *Journal of International Economics.* A graduate of the École Nationale des Ponts et Chaussées in Paris, he received his Ph.D. from MIT.

David Autor and Alex Mas Are New Co-Directors of Labor Studies Program

David Autor

Alex Mas

David Autor, the Ford Professor of Economics at MIT, and Alex Mas, a professor of economics and public affairs in the economics department and the Woodrow Wilson School at Princeton University, are the new co-directors of the Labor Studies Program. Autor joined the NBER as a faculty research fellow in 1999 and became a research associate in 2006. Mas, who taught at the University of California, Berkeley before joining the Princeton faculty, was appointed a faculty research fellow in 2006 and a research associate in 2009.

Autor's research spans a wide range of issues in labor economics, including the employment effects of trade, the impact of technological change on labor demand and the wage distribution, and the effect of disability insurance on labor market participation. He is director of the NBER's Disability Research Center, a former editor of the *Journal of Economic Perspectives,* and a member of the American Economic Association's executive committee. He received his B.A. from Tufts University and his Ph.D. from Harvard.

Mas has studied the impact of unions on pay and productivity, the consequences of credit market disruptions for labor demand by small firms, the role of fairness considerations, norms, and social interactions in wage-setting, and the links between residential segregation and labor market outcomes. He is director of the Industrial Relations Section at Princeton, and the editor of the *American Economic Journal: Applied Economics.* He served as chief economist of the U.S. Department of Labor in 2009–10, and as associate director for economic policy and chief economist in the U.S. Office of Management and Budget, 2010-11. Mas is a graduate of Macalaster College; he received his Ph.D. from Princeton.

CEPRA/NBER Conference on Aging and Health

The NBER's Conference on Aging and Health, supported by the Center for Performance and Research Analytics, took place in Lugano, Switzerland, on June 1–3. Fabrizio Mazzonna of Università della Svizzera Italiana, NBER Program on Aging Director Jonathan S. Skinner of Dartmouth College, and Massimo Filippini of ETH Zurich and Università della Svizzera Italiana organized the meeting. These researchers' papers were presented and discussed:

- **Mathilde C. M. Godard**, GATE-LSE, CNRS, University of Lyon, and **Pierre Koning** and **Maarten Lindeboom**, Vrije Universiteit Amsterdam, "Screening Disability Insurance Applications and Targeting"
- **Corina D. Mommaerts**, University of Wisconsin at Madison, "Long-Term Care Insurance and the Family"
- **Fabrizio Mazzonna** and **Osea Giuntella**, University of Pittsburgh, "Sunset Time and the Economic Effects of Social Jetlag: Evidence from U.S. Time Zone Borders"
- **Marika Cabral**, University of Texas at Austin and NBER, and **Mark R. Cullen**, Stanford University and NBER, "Estimating the Value of Public Insurance Using Complementary Private Insurance" (NBER Working Paper No. 22583)
- **Pieter Bakx**, Institute of Health Policy & Management, Erasmus University Rotterdam; **Bram Wouterse**, CPB Netherlands Bureau for Economic Policy Analysis; **Eddy Van Doorslaer**, Erasmus School of Economics, Erasmus University Rotterdam; and **Albert Wong**, National Institute for Public Health and the Environment, "The Health Effects of a Nursing Home Admission"
- **Teresa Bago d'Uva** and **Owen O'Donnell**, Erasmus University Rotterdam, and **Eddy Van Doorslaer**, Erasmus School of Economics, Erasmus University Rotterdam, "Who Can Predict Their Own Demise? Heterogeneity in the Accuracy of Longevity Expectations"
- **Itzik Fadlon**, University of California, San Diego and NBER, and **Torben Heien Nielsen**, University of Copenhagen, "Family Health Behaviors"
- **Nicole Maestas**, Harvard University and NBER, and **Kathleen Mullen** and **David Powell**, RAND Corporation, "The Effect of Population Aging on Economic Growth, the Labor Force, and Productivity" (NBER Working Paper No. 22452)
- **Amitabh Chandra**, Harvard University and NBER, and **Douglas Staiger**, Dartmouth College and NBER, "Predicting the Impact of Hospital Closures on Patient Outcomes"
- **Florian Heiss**, University of Düsseldorf; **Daniel L. McFadden**, University of California, Berkeley and NBER; **Lauren Scarpati**, University of Southern California; and **Joachim Winter** and **Amelie C. Wuppermann**, University of Munich, "The Housing Crisis of the Late 2000s and Causal Paths between Health and Socioeconomic Status"

Summaries of these papers are at: www.nber.org/confer/2017/CAHs17/summary.html

26th NBER-TCER-CEPR Conference

The 26th NBER-TCER-CEPR Conference, "Corporate Governance," took place in Tokyo on June 22. This meeting was sponsored jointly by the Centre for Economic Policy Research in London, the NBER, the Tokyo Center for Economic Research, the Center for Advanced Research in Finance, and the Center for International Research on the Japanese Economy. Franklin Allen, of Imperial College London, CEPR, and NBER, Shin-ichi Fukuda of Tokyo University, and Takeo Hoshi of Stanford University and NBER organized the meeting. These researchers' papers were presented and discussed:

- **Randall Morck**, University of Alberta and NBER; **M. Deniz Yavuz**, Purdue University; and **Bernard Yeung**, National University of Singapore, "State-run Banks, Money Growth, and the Real Economy"
- **Franklin Allen**; **Elena Carletti**, Bocconi University and CEPR; and **Yaniv Grinstein**, Interdisciplinary Center Herzliya and European Corporate Governance Institute, "International Evidence on Firm Level Decisions in Response to the Crisis: Shareholders vs. Other Stakeholders"
- **Benjamin E. Hermalin**, University of California, Berkeley, "Biased Monitors: Corporate Governance When Managerial Ability is Mis-Assessed"
- **Naoshi Ikeda**, **Kotaro Inoue**, and **Sho Watanabe**, Tokyo Institute of Technology, "Enjoying the Quiet Life: Corporate Decision-Making by Entrenched Managers"
- **Hideaki Miyajima** and **Ryo Ogawa**, Waseda University, and **Takuji Saito**, Keio University, "Changes in Corporate Governance and President Turnover: The Evidence from Japan"
- **Takeo Hoshi**, "Decline of Bank-Led Restructuring in Japan: 1980–2010"

Summaries of these papers are at: www.nber.org/confer/2017/TRIO17/summary.html

East Asian Seminar on Economics

The NBER, the Australian National University, the Peking University China Center for Economic Research, the Chung-Hua Institution for Economic Research (Taipei), the Hong Kong University of Science and Technology, the Korea Development Institute, the National University of Singapore, the Tokyo Center for Economic Research, and Tsinghua University (Beijing) jointly sponsored the NBER's 28th Annual East Asian Seminar on Economics, "Inequality." It took place in Manila, Philippines, on June 29–30. Research Associates Takatoshi Ito of Columbia University and Andrew K. Rose of the University of California, Berkeley, organized the conference. These researchers' papers were presented and discussed:

- **Nicholas Bloom**, Stanford University and NBER; **Fatih Guvenen**, University of Minnesota and NBER; **David Price**, Stanford University; **Jae Song**, Social Security Administration; and **Till M. von Wachter**, University of California, Los Angeles and NBER, "Firming up Inequality" (NBER Working Paper No. 21199)
- **Bo Chen**, Shanghai University of Finance and Economics; **Miaojie Yu**, Peking University; and **Zhihao Yu**, Carleton University, "Measured Skill Premium and Input Trade Liberalization: Evidence from Chinese Firms"
- **Pi Chen** and **Suling Peng**, Chung-Hua Institution for Economic Research, "Wage Inequality in Taiwan and Its Causes"
- **Masayuki Inui** and **Nao Sudo**, Bank of Japan, and **Tomoaki Yamada**, Meiji University, "Effects of Monetary Policy Shocks on Inequality in Japan"

- **Yukinobu Kitamura**, Hitotsubashi University; **Takeshi Miyazaki**, Kyushu University; and **Taro Ohno**, Shinshu University, "Income Tax Reforms and Intra-Generational Redistribution: Evidence from Japan"

- **Joshua Aizenman**, University of Southern California and NBER, and **Yothin Jinjarak** and **Ilan Noy**, Victoria University of Wellington, "Vocational Education, Manufacturing, and Income Distribution: International Evidence and Case Studies"

- **Ronald Mendoza** and **Miann Banaag**, Ateneo School of Government (Manila), "Political and Economic Inequality: Insights from Philippine Data on Political Dynasties"

- **Dan Liu**, Shanghai University of Finance and Economics, and **Christopher M. Meissner**, University of California, Davis and NBER, "Geography, Income, and Trade When Income Inequality Matters"

- **Jakob B. Madsen**, Monash University (Melbourne), "Piketty's Third Law of Capitalist Economics and the Dynamics of Inequality in Britain, 1210–2013"

Summaries of these papers are at: www.nber.org/confer/2017/EASE17/summary.html

International Seminar on Macroeconomics

The NBER's 40th International Seminar on Macroeconomics, hosted by the Bank of Lithuania, took place in Vilnius, Lithuania, on June 30–July 1. The seminar was organized by Research Associates Jeffrey Frankel of Harvard University and Hélène Rey of London Business School. These researchers' papers were presented and discussed:

- **Thomas Drechsel** and **Silvana Tenreyro**, London School of Economics, "Commodity Booms and Busts in Emerging Economies"

- **Jonas Heiperz**, Paris School of Economics; **Amine Ouazad**, HEC Montreal; **Romain Rancière**, University of Southern California and NBER; and **Natacha Valla**, European Investment Bank and Paris School of Economics, "Balance-Sheet Diversification in General Equilibrium: Identification and Network Effects" (NBER Working Paper No. 23572)

- **Antonio Fatás**, INSEAD, and **Lawrence H. Summers**, Harvard University and NBER, "The Permanent Effects of Fiscal Consolidations" (NBER Working Paper No. 22374)

- **Wenxin Du** and **Joanne Im**, Federal Reserve Board, and **Jesse Schreger**, Harvard University and NBER, "The U.S. Treasury Premium"

- **Cristina Arellano**, Federal Reserve Bank of Minneapolis and NBER; **Yan Bai**, University of Rochester and NBER; and **Gabriel Mihalache**, Stony Brook University, "Default Risk, Sectoral Reallocation, and Persistent Recessions"

- **Marc Flandreau**, University of Pennsylvania, "Sovereign Debt Enforcement: Historical Evidence on the Role of Financial Engineering"

- **Bartosz Mackowiak** and **Marek Jarocinski**, European Central Bank, "Monetary Fiscal Interactions and the Euro Area's Malaise"

- **Ambrogio Cesa-Bianchi**, Bank of England; **Andrea Ferrero**, University of Oxford; and **Alessandro Rebucci**, Johns Hopkins University and NBER, "International Credit Supply Shocks"

Summaries of these papers are at: www.nber.org/confer/2017/ISOM17/summary.html

40th Annual NBER Summer Institute

The NBER hosted its 40th annual Summer Institute during a three-week period in July. The 2,965 registered participants took part in 52 distinct meetings led by more than 100 organizers. About one in six participants — 608 researchers — were attending their first Summer Institute. There were 99 graduate student participants. More than two thirds of the participants were not NBER affiliates.

Lord Mervyn King, former Governor of the Bank of England and an NBER research associate, delivered the 2017 Martin Feldstein Lecture on "Uncertainty and Large Swings in Activity." He examined the capacity of standard macroeconomic models to explain sharp declines in economic activity, such as those associated with the Great Depression or the 2008 global financial crisis. He recommended that researchers be open to new models, and that they recognize the inherent uncertainty associated with virtually all modeling exercises in macroeconomics. An edited text of the lecture appears earlier in this issue of *The NBER Reporter*.

The 2017 Methods Lectures focused on data linking. Research Associates John Abowd of Cornell University and the U.S. Bureau of the Census, Martha Bailey of the University of Michigan, and Joseph Ferrie of Northwestern University described statistical tools and matching algorithms for merging large administrative data sets. They also presented various applications of these tools, describing linkages between decennial Census data files and between firm and employee data sets. In addition, Jonathan Schwabish of the Urban Institute lectured on "Data Visualization," presenting a range of new tools and techniques for the visual display of data.

All of the presentations — the Feldstein Lecture, the Methods Lectures, and the presentation on data visualization — have been videotaped and can be accessed through the NBER Videos tab on the left side of the NBER homepage.

Japan Project

The NBER held a meeting on the Japanese economy in Tokyo on July 31. The seminar was organized by Shiro Armstrong of the Australian National University, Research Associate Charles Horioka of the Asian Growth Research Institute (Kitakyushu), Research Associate Takeo Hoshi of Stanford University, Tsutomu Watanabe of the University of Tokyo, and Research Associate David Weinstein of Columbia University. These researchers' papers were presented and discussed:

- **Koichiro Ito**, University of Chicago and NBER; **Takanori Ida**, Kyoto University; and **Makoto Tanaka**, GRIPS (National Graduate Institute for Policy Studies, Tokyo), "Information Frictions, Inertia, and Selection on Elasticity: A Field Experiment on Electricity Tariff Choice"

- **J. Mark Ramseyer**, Harvard University, and **Eric B. Rasmusen**, Indiana University, "Outcaste Politics and Organized Crime in Japan: The Effect of Terminating Ethnic Subsidies"

- **Kozo Ueda**, Waseda University; **Kota Watanabe**, Meiji University; and **Tsutomu Watanabe**, "Product Turnover and Deflation: Evidence from Japan"

- **Makoto Saito**, Hitotsubashi University, "On Large-Scale Money Finance in the Presence of Black Markets: A Case of the Japanese Economy during and Immediately after World War II"

- **Kentaro Nakajima**, Hitotsubashi University, and **Kensuke Teshima**, Instituto Tecnológico Autonomo de México, "Identifying Neighborhood Effects among Firms: Evidence from Location Lotteries of the Tokyo Tsukiji Fish Market"

- **Wataru Miyamoto**, Bank of Canada; **Thuy Lan Nguyen**, Santa Clara University; and **Dmitriy Sergeyev**, Bocconi University, "Government Spending Multipliers under the Zero Lower Bound: Evidence from Japan"

Summaries of these papers are at: nber.org/confer/2017/JPMs17/summary.html

Economic Dimensions of Personalized and Precision Medicine

The NBER's Conference on Economic Dimensions of Personalized and Precision Medicine was supported by the USC Schaeffer Center for Health Policy & Economics and Columbia University. The conference took place in Santa Monica, CA, on September 13–14. Research Associates Ernst R. Berndt of MIT and Dana Goldman of the University of Southern California, and John Rowe of Columbia University organized the meeting. These researchers' papers were presented and discussed:

- **Ernst R. Berndt**, and **Mark Trusheim**, MIT, "The Information Pharms Race and Competitive Dynamics of Precision Medicine"
- **Manuel I. Hermosilla**, Johns Hopkins University, and **Jorge A. Lemus**, University of Illinois at Urbana-Champaign, "Therapeutic Translation in the Wake of the Genome"
- **John A. Graves** and **Josh Peterson**, Vanderbilt University, "Rational Integration of Genomic Health Care Technology: Evidence from PREDICT"
- **Kristopher Hult**, University of Chicago, "Measuring the Potential Health Impact of Personalized Medicine: Evidence from MS Treatments"
- **Rachel Lu**, Chang Gung University (Taiwan); **Karen Eggleston**, Stanford University and NBER; and **Joseph T. Chang**, Chang Gung Memorial Hospital, "Economic Dimensions of Personalized and Precision Medicine in Asia: Evidence from Breast Cancer Treatment in Taiwan"
- **Mark Pauly**, University of Pennsylvania and NBER, "Cost Sharing in Insurance Coverage for Precision Medicine"
- **Frank R. Lichtenberg**, Columbia University and NBER, and **Rebecca A. Pulk**, **Marc S. Williams**, and **Eric Wright**, Geisinger Health System, "The Social Cost of Suboptimal Medication Use and the Value of Pharmacogenomic Information: Evidence from Geisinger"
- **Amitabh Chandra**, Harvard University and NBER; **Craig Garthwaite**, Northwestern University and NBER; and **Ariel Dora Stern**, Harvard University, "Characterizing the Drug Development Pipeline for Precision Medicines"
- **David H. Howard**, Emory University; **Jason Hockenberry**, Emory University and NBER; and **Guy David**, University of Pennsylvania and NBER, "Personalized Medicine When Physicians Induce Demand"
- **Philippe Gorry**, University of Bordeaux, "Empirical Economic Analysis of Orphan Drug Innovation"

Summaries of these papers are at: www.nber.org/confer/2017/PPMf17/summary.html

Economics of Artificial Intelligence

The NBER's Conference on Artificial Intelligence took place in Toronto on September 13–14. Research Associates Ajay K. Agrawal, Joshua Gans, and Avi Goldfarb of the University of Toronto organized the meeting. These researchers' papers were presented and discussed:

- **Iain M. Cockburn**, Boston University and NBER; **Rebecca Henderson**, Harvard University and NBER; and **Scott Stern**, MIT and NBER, "The Impact of Artificial Intelligence on Innovation"
- **Erik Brynjolfsson**, MIT and NBER; **Daniel Rock**, MIT; and **Chad Syverson**, University of Chicago and NBER, "Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics"
- **Paul Milgrom**, Stanford University, and **Steven Tadelis**, University of California, Berkeley and NBER, "Market Design"
- **Susan Athey**, Stanford University and NBER, "Impact on Economics"
- **Ajay K. Agrawal**, **Joshua Gans**, and **Avi Goldfarb**, "Prediction, Judgment, and Complexity"

- **Catherine Tucker**, MIT and NBER, "Privacy"
- **Daniel Trefler** and **Avi Goldfarb**, University of Toronto and NBER, "Trade"
- **Colin Camerer**, California Institute of Technology, "Behavioral Economics"
- **Jeffrey D. Sachs**, Columbia University and NBER, "Income Distribution"
- **Philippe Aghion**, College de France; **Benjamin Jones**, Northwestern University and NBER; and **Charles I. Jones**, Stanford University and NBER, "Artificial Intelligence and Economic Growth"
- **Joel Mokyr**, Northwestern University, "Historical Context and the Long Run"
- **Carl Shapiro**, University of California, Berkeley and NBER, and **Hal Varian**, University of California, Berkeley, "Machine Learning, Market Structure, and Competition"
- **Joseph E. Stiglitz**, Columbia University and NBER, and **Anton Korinek**, Johns Hopkins University and NBER, "Artificial Intelligence, Worker-Replacing Technological Change, and Income Distribution"
- **David Autor**, MIT and NBER, and **Anna Solomons**, Utrecht University, "Robocalypse Now: Does Productivity Growth Threaten Employment?"

Summaries of these papers are at: www.nber.org/confer/2017/AIf17/summary.html

Tax Policy and the Economy

The NBER's Conference on Tax Policy and the Economy took place in Washington, DC, on September 14. Research Associate Robert A. Moffitt of Johns Hopkins University organized the meeting. These researchers' papers were presented and discussed:

- **Alex Rees-Jones**, University of Pennsylvania and NBER, and **Dmitry Taubinsky**, University of California, Berkeley and NBER, "Taxing Humans: Normative Implications of Biased Responses to Taxes"
- **James Andreoni**, University of California, San Diego and NBER, "The Benefits and Costs of Donor Advised Funds"
- **Andrew Samwick**, Dartmouth College and NBER, "Means-Testing Federal Health Entitlement Benefits" (NBER Retirement Research Center Paper No. NB 12-16)
- **Jeffrey Clemens**, University of California, San Diego and NBER, and **Benedic N. Ippolito**, American Enterprise Institute, "Implications of Medicaid Financing Reform for State Government Budgets"
- **Bruce D. Meyer**, University of Chicago and NBER, and **Wallace K. C. Mok**, Chinese University of Hong Kong, "Disability, Taxes, Transfers, and the Economic Well-Being of Women"
- **Caroline M. Hoxby**, Stanford University and NBER, "Online Postsecondary Education and the Higher Education Tax Benefits: An Analysis with Implications for Tax Administration"

Summaries of these papers are at: www.nber.org/confer/2017/TPE17/summary.html

Program Meeting

Economic Fluctuations and Growth

The NBER's Program on Economic Fluctuations and Growth met in Cambridge on July 15. Research Associates Mark Bils of the University of Rochester and Gita Gopinath of Harvard University organized the meeting. These researchers' papers were presented and discussed:

- **Nuno T. Coimbra**, Paris School of Economics, and **Hélène Rey**, London Business School and NBER, "Financial Cycles with Heterogeneous Intermediaries" (NBER Working Paper No. 23245)
- **Philippe Aghion**, College de France; **Antonin Bergeaud**, Banque de France; **Timo Boppart**, IIES, Stockholm University; **Peter J. Klenow**, Stanford University and NBER; and **Huiyu Li**, Federal Reserve Bank of San Francisco, "Missing Growth from Creative Destruction"
- **David W. Berger** and **Ian Dew-Becker**, Northwestern University and NBER, and **Stefano Giglio**, University of Chicago and NBER, "Uncertainty Shocks as Second-Moment News Shocks"
- **Emmanuel Farhi**, Harvard University and NBER, and **David Baqaee**, London School of Economics, "The Macroeconomic Impact of Microeconomic Shocks: Beyond Hulten's Theorem" (NBER Working Paper No. 23145)
- **Daron Acemoglu**, MIT and NBER, and **Pascual Restrepo**, Boston University, "Robots and Jobs: Evidence from U.S. Labor Markets" (NBER Working Paper No. 23285)
- **Òscar Jordà**, Federal Reserve Bank of San Francisco; **Katharina Knoll**, **Dmitry Kuvshinov**, and **Moritz Schularick**, University of Bonn; and **Alan M. Taylor**, University of California, Davis and NBER, "The Rate of Return on Everything, 1870–2015"

Summaries of these papers are at: www.nber.org/confer/2017/EFGs17/summary.html

NBER Books

Measuring Entrepreneurial Businesses: Current Knowledge and Challenges

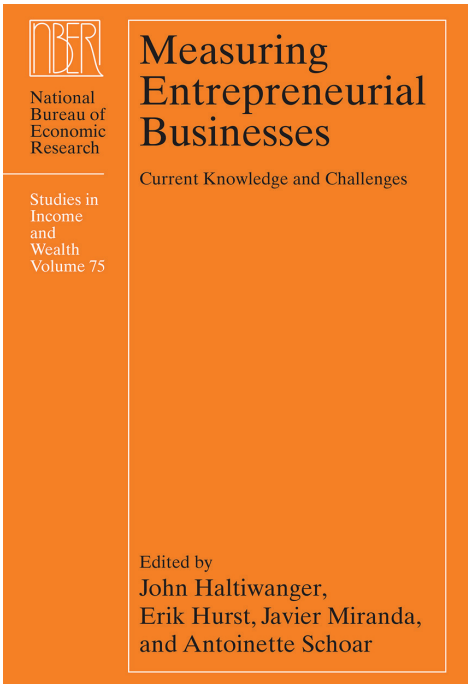
(Studies in Income and Wealth, Volume 75)

John Haltiwanger, Erik Hurst, Javier Miranda, and Antoinette Schoar, editors

Cloth $130

Start-ups and other entrepreneurial ventures make a significant contribution to the U.S. economy, particularly in the tech sector, where they comprise some of the largest and most influential companies. Yet for every high-profile, high-growth company like Apple, Facebook, Microsoft, and Google, many more fail. This enormous heterogeneity poses conceptual and measurement challenges for economists concerned with understanding their precise impact on economic growth.

Measuring Entrepreneurial Businesses brings together economists and data analysts to discuss the most recent research covering three broad themes. The first chapters isolate high- and low-performing entrepreneurial ventures and analyze their roles in creating jobs and driving innovation and productivity. The next chapters focus on specific challenges entrepreneurs face and how these have varied over time, including over business cycles. The final chapters explore core measurement issues, with a focus on new data projects under development that may improve our understanding of this dynamic part of the economy.



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