

April 2017

## INSIDE THIS ISSUE

- The Effects of Excluding Low-Skill Foreign Workers
- The Immigrant as Innovator
- Variation in Education Costs and Future Earnings
- State Universities Turn to Higher-Tuition Foreign Students
- Imperfect Electricity Markets versus Imperfect Regulation

## Winners and Losers from the H-1B Visa Program

Who are the winners and losers in the special visa program that enables U.S. companies to employ high-skilled foreign workers on a temporary basis in specialized occupations? In **Understanding the Economic Impact of the H-1B Program on the U.S.** (NBER Working Paper No. 23153), [John Bound](#), [Gaurav Khanna](#), and [Nicolas Morales](#) explore how the availability of such workers has affected the welfare of domestic workers, firms, and consumers.

Based on their model, the researchers calculate that the influx of foreign-born computer scientists enabled by the H-1B program had a positive effect on the U.S. IT sector, and consequently the U.S. economy, but had significant distributional effects. They estimate that absent the influx of foreigners, U.S. computer scientists would have earned between 2.6 and 5.1 percent more in 2001. Moreover, some U.S. workers switched to other occupations, lowering the number of domestic computer scientists by between 6 and 11 percent. The

picture is brighter in other respects: Foreign scientists were found to be strong contributors to innovation and productivity. That translated into wage and job gains in related fields,

The influx of foreign computer scientists enabled by the program lowered wages of domestic workers in the field, stimulated growth in related fields, and reduced consumer prices.

and into more choice and lower prices for consumers.

The research focuses on the Internet boom years, when workers in computer-related occupations became the largest share of H-1B visa holders.

The cap on visas was initially 65,000 a year. That became a binding constraint in the mid-1990s and it was raised to 115,000 in 1999. The U.S. Department of Commerce estimates

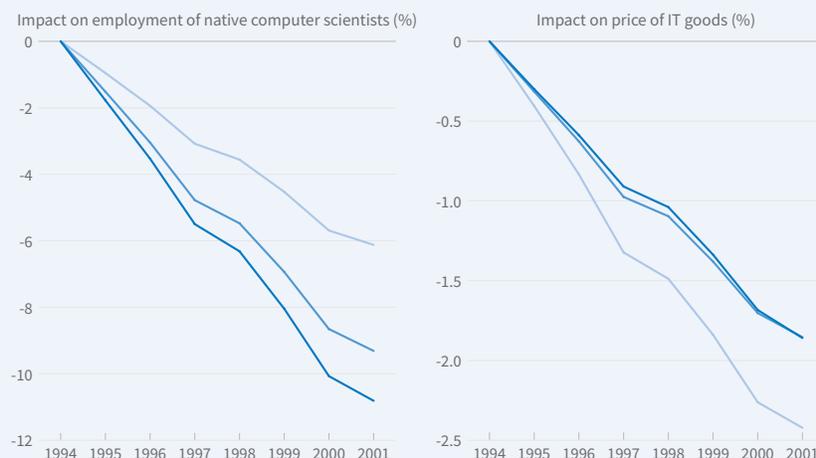
that during the late 1990s, 28 percent of all U.S. programming jobs were held by H-1B visa holders.

Although the H-1B legislation stipulates that visa holders must be paid the prevailing wages for their jobs, critics of the H-1B program argue that visa holders have little bargaining power because they can work only for the companies that sponsor them. "It seems reasonable to assume that employers must expect some cost or productivity advantage when hiring foreigners, however modest," the researchers note. "If not, why would they incur the associated effort and expense?"

The researchers

**H-1B Program Impact on Employment and Prices**

Comparing actual immigrant numbers with 1994 levels



Darker lines assume less substitution between computer science and other college graduates

Source: Researchers' calculations using data from IPUMS, Bureau of Economic Analysis, and other sources

calculate that wages, domestic employment, and, as a result, college enrollment in computer science would have grown even more rapidly than it did, had immigration been restricted. Indeed, the fraction of U.S. college degrees in computer science would have been higher by 1.3 to 2.6 percentage points in 2001. The reduction in labor costs associated with this program spurred growth and innovation in the computer science sector and increased pro-

ductivity in the economy as a whole. Lower labor costs also increased profits, enabling new companies to enter the field. Growth in the computer science sector also sparked expansion in related fields, raising wages for college graduates who were not computer scientists and for non-college graduates.

For consumers, the researchers estimate, the H-1B program has resulted in lower prices for technology-related products, and has led to a higher rate

of product innovation. The innovation effects are particularly important in assessing consumer welfare.

The researchers emphasize that while their estimates are dependent on the assumptions built into the model, the impacts on computer scientists would hold so long as the demand curve for such workers is downward sloping and the domestic supply curve is positively sloped.

— Steve Maas

## The Effects of Excluding Low-Skill Foreign Workers

The 1964 termination of the *bracero* program, which recruited Mexican guest workers to work on American farms, had “little measurable effect on the labor market for domestic farm workers.” That is the conclusion of **Immigration Restrictions as Active Labor Market Policy: Evidence from the Mexican *Bracero* Exclusion** (NBER Working Paper No. 23125), by Michael A. Clemens, Ethan G. Lewis, and Hannah M. Postel.

By bilateral agreement, the *bracero* (a Spanish term for manual laborer) program allowed Mexicans to work seasonally on American farms, starting in 1942. At the program’s height, nearly half a million workers came each year, comprising over a third of the Mexicans then working in the United States. They made up 40 percent of all seasonal farm labor in many states. The 1964 decision to exclude *braceros*

was made explicitly to raise wages and employment for domestic farm workers. It was therefore a significant change in labor market policy for domestic

Termination of the *bracero* program between the U.S. and Mexico at the end of 1964 led employers to adopt more labor-saving technology rather than to raise domestic wages or employment.

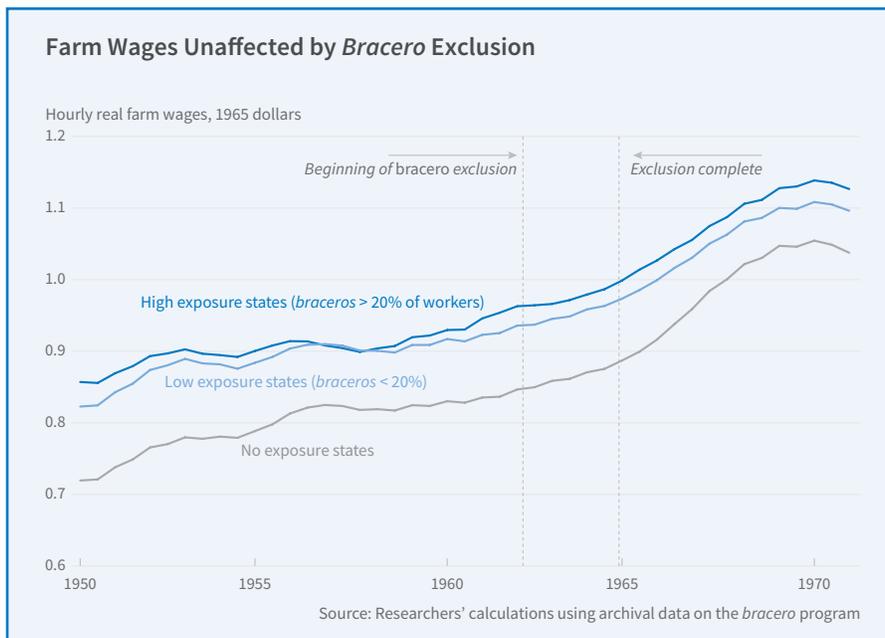
workers in the states and industries that employed the migrant laborers.

The researchers compare labor market

outcomes for native workers before and after exclusion of the Mexican workers in heavily affected, lightly affected, and unaffected states. They find that pre- and post-

exclusion farm wages and farm employment were similar in states highly exposed to exclusion — which lost roughly one third of hired seasonal labor — and in states with no exposure. Moreover, the study shows that *braceros* were not substantially replaced with domestic workers in the years immediately following exclusion; rather, the researchers find evidence that farm owners rapidly adopted new, labor-saving technologies.

In six states where *braceros* comprised more than 20 percent of seasonal agricultural labor, trends in



real farm wages before and after the program ended were similar to those in 17 states where *braceros* comprised 3 to 4 percent of the agricultural workforce. Wages in both groups of states rose more slowly after *bracero* exclusion than in 23 states that had not had any *braceros*. In both high and low exposure states, average wages rose roughly 14 percent between 1964 and 1969, while

in states with no exposure they rose about 21 percent. The researchers find no evidence that excluding Mexican workers affected the movement of seasonal domestic workers between states.

Farmers accelerated mechanization of the production of tomatoes, sugar beets, and cotton after the *bracero* exclusion. Production of those crops dipped but, at least for tomatoes and cotton,

the declines were modest and short-lived. For crops where no advanced machinery was available, there tended to be larger and lasting declines in production.

The study does not test whether the complex effects of exclusion led to a net benefit or net cost to U.S. productivity overall.

—John Laidler

## The Immigrant as Innovator

Immigrants are over-represented, relative to their population shares, among those who receive patents and develop new technologies. In **Immigration and the Rise of American Ingenuity** (NBER Working Paper No. 23137), [Ufuk Akcigit](#), [John Grigsby](#), and [Tom Nicholas](#) examine the long-run links between immigration and innovation. They find that talented immigrant inventors often have paved the way for long-term innovation, while receiving significantly lower compensation than their native-born counterparts.

Using U.S. Patent and Trade Office and U.S. Census data, the researchers study the “golden age of U.S. invention,” the period from 1880 to 1940. Some immigrant inventors, like the Scottish-born Alexander Graham Bell, made direct innovative contributions. Others made “spillover” contributions, such as those of the Chicago-based French engineer Octave Chanute to the work of Wilbur and Orville Wright. The researchers geographically track where immigrant inventors worked, as well as the geographic and patent classes of their filings. After 1940, when the Census began recording information on wages and income, they also consider the earnings of inventors.

Technology areas where immigrant inventors were prevalent between 1880 and 1940 experienced more patenting and citations between 1940 and 2000 than other sectors. This finding suggests that

there are broad long-run macroeconomic effects of inventions and innovation.

In the ten most inventive states, measured by the average number of pat-

The researchers found that foreign-born inventors, the vast majority of whom came from Europe in the late 1800s and early 1900s, tended to cluster in the

Technology areas where immigrant inventors were prevalent between 1880 and 1940 experienced more patenting between 1940 and 2000.

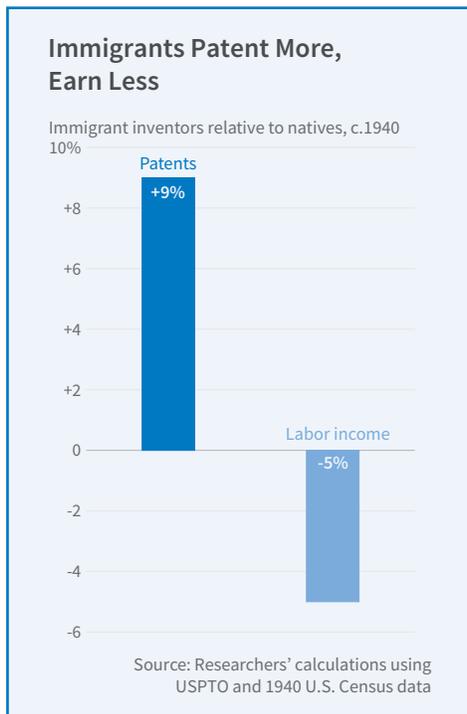
ents per capita between 1880 and 1940, international migrants comprised about one-fifth of the population, compared

Northeast and upper-Midwest regions of the U.S. and were noticeably absent in southern states. Though they were often associated with then cutting-edge fields like chemistry and electricity, they were also involved in other tech areas, such as medical technology.

Not only were areas with more immigrants more likely to generate patents; immigrant inventors were more productive during their lifetimes than native-born inventors. While immigrant inventors had 9 percent more patents and citations than native-born inventors, their labor income was 5 percent lower than their native-born counterparts. The authors label this “evidence of an immigrant inventor wage gap that cannot be explained by differentials in productivity.”

The researchers note that while they study a historical period, the role of immigrants in U.S. innovation is even greater today. While immigrants accounted for 19.6 percent of inventors during the period they reviewed, today the share is about 30 percent.

—Jay Fitzgerald



with less than 2 percent in the least inventive states.

## Variation in Education Costs and Future Earnings

Are policies designed to encourage students to enroll in the most remunerative professions a cost-effective use of private and public educational dollars? How would tuition vary if it were tied to the instructional costs of each degree program? These are among the questions raised by Joseph G. Altonji and Seth D. Zimmerman in **The Costs of and Net Returns to College Major** (NBER Working Paper No. 23029).

The researchers point out that policies designed to encourage students to seek degrees in lucrative STEM fields, as opposed to the less-remunerative liberal arts, consider only one side of the educational ledger. Engineers earn 30 percent more than teachers, but cost universities 44 percent more to produce. Differences in earnings net of costs on a *per-graduate* basis are still driven primarily by earnings. But costs matter a lot when net returns are measured *per dollar* of instructional spending. The return per dollar of instructional spending may be little different when training electrical engineers and history teachers. Though *per-graduate* returns are of interest to a social planner trying assign students to majors, *per-dollar* returns are relevant for universities facing fixed budgets.

The researchers focus on what universities spend to educate students. This is different from the cost to the students, whose tuition may not cover full costs, and who also may receive outside grants. They also point out that their measure of future earnings is a necessarily incomplete measure of the return to an education, since it excludes any nonmonetary benefits to both the stu-

dent and society, which may differ by major.

The study relies on budget data for the years 2000 to 2014 at the 12 universities in the Florida state system that offer degrees at the bachelor's level or higher. It focuses on the cost of educating the nearly 58,000 stu-

Future earnings differ substantially across college majors, but so do instructional costs. They don't always line up.

dents who enrolled in a university directly out of high school and went on to graduate. Earnings data is limited to students who work in Florida after graduation — 75 percent of the sample. These earners were tracked through early 2010; thus, the oldest workers in the earnings records were 14

played the highest future earnings.

The researchers ask whether budget-constrained universities could become more productive by more efficiently allocating their resources. They note that if a university is allocating its spending effi-

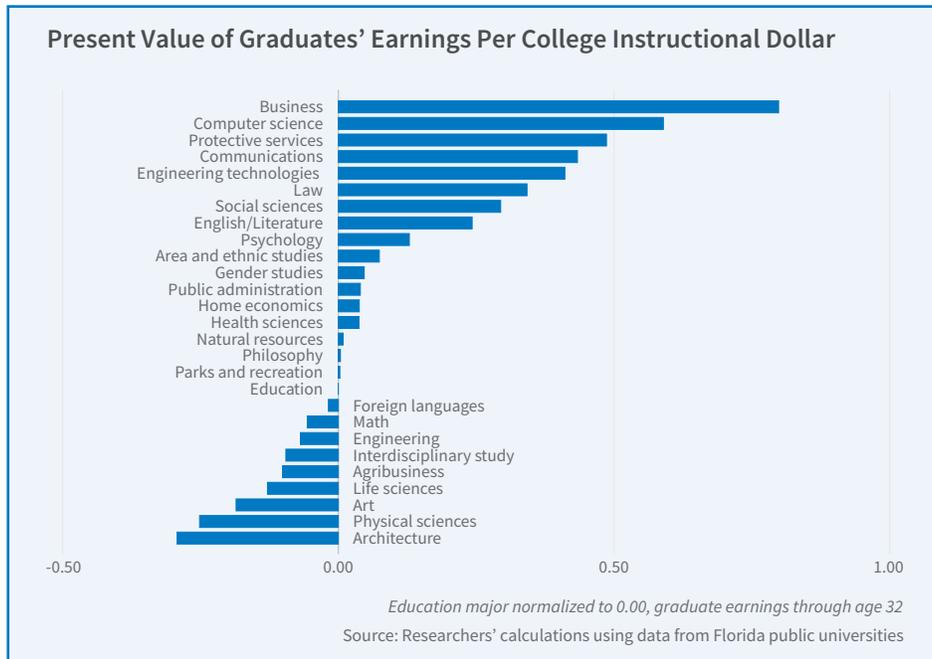
ciently, a marginal dollar of additional spending would have the same return, in terms of society's objectives, in all fields. This return is difficult to calculate, and includes more than earnings. They note that "[I]f schools are currently allocating funding optimally across majors, it

must be the case that degrees in fields with low per-dollar returns such as art, architecture, and even engineering and the physical sciences... offer larger non-pecuniary and public benefits than programs in fields like computer science, business, or law." If this is not the case, universities could raise welfare by reallocating tuition subsidies towards fields with higher social returns.

Over the study

period, a combination of budget cutbacks and a surge in enrollment resulted in disproportionate declines in per-credit spending in some disciplines. The researchers estimate a drop of as much as 40 percent for engineering and health. The large changes raise the question of whether drops in per-credit spending make students less inclined to pursue resource-strapped fields, and lower the value of a degree in the labor market.

— Steve Maas



years out of high school, or around age 32.

The researchers calculate the average total degree cost to be \$39,184, but they also find large disparities across fields. On average, educating engineering students costs \$62,297, double the cost of business students. The cost of educating students in a particular major is not related to future student earnings. Indeed, some of the students who were cheapest to educate — such as business and computer science majors — dis-

## State Universities Turn to Higher-Tuition Foreign Students

Rapid economic growth has increased the numbers of college-ready students in developing economies, especially China, but these countries' research universities have not expanded fast enough to accommodate the increases. As a result, large numbers of international students have applied to universities in the United States at a time when public universities here have faced reductions in state funding, particularly steep cuts associated with the Great Recession.

The result, [John Bound](#), [Breno Braga](#), [Gaurav Khanna](#), and [Sarah Turner](#) demonstrate in **A Passage to America: University Funding and International Students** (NBER Working Paper No. 22981), has been dramatic growth in the number of foreign students at U.S. public research universities.

State universities facing appropriation cuts have three options: increase tuition, cut expenditures, or admit more out-of-state students, who pay much higher tuition than state residents. Universities have increased tuition — with greater increases in states imposing greater funding cuts — but they have also drawn upon the burgeoning supply of students from developing countries who are willing and able to pay full fare.

The researchers examine differences in foreign-student admission rates across institutions and find that they are related not only to the magnitude of state cuts but also to an institution's ability to attract full-paying domestic students and to its attractiveness to foreign students.

Because the supply of domestic, full-paying out-of-state students is limited, only the most popular state universities, such as the University of Michigan and the University of California, Berkeley, can use this applicant pool to compensate for

funding cuts. Increases in foreign-student admissions have been greatest in well-reputed research universities below this top tier. Non-research universities did not significantly increase admissions of for-

Public research universities are accepting surging numbers of students from China, South Korea, and Saudi Arabia in an effort to balance their books.

foreign students as a response to declines in state funding.

The researchers find that these trends tracked closely with the supply of Chinese students, who accounted for more than 90 percent of the increase in foreign students between 2003 and 2013. The rise in Chinese students was due to a general increase in Chinese family wealth, the country's one-

universities. In contrast to the pattern for Chinese students, students from western Europe are mostly found at the top private universities in major cities, because research universities are more plentiful in these stu-

dents' home countries.

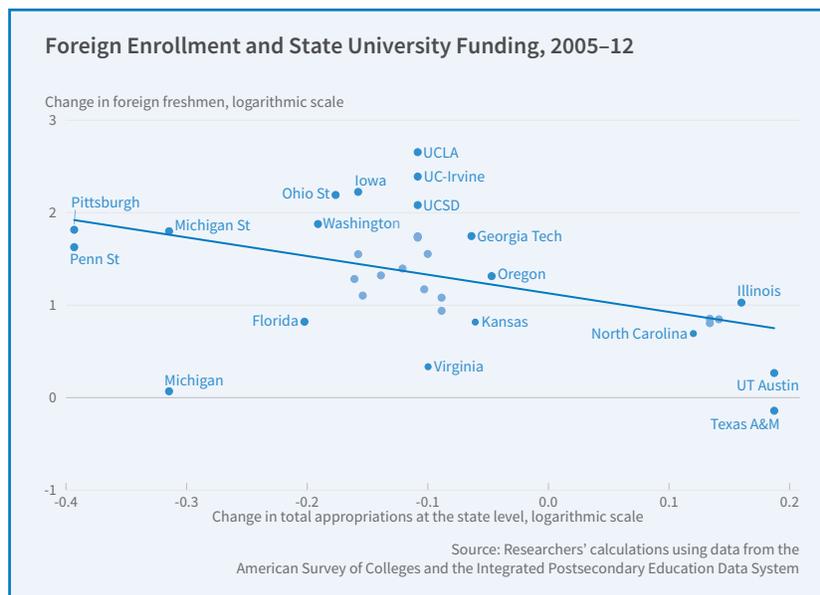
The researchers find that a 10 percent reduction in state funding was associated with a 12 percent increase in foreign enrollment at public research universities, and with a 17 percent increase at more resource-intensive research universities. They find that there is a negative association between additional foreign students and in-state students;

however, they note that this association is not causal. Alternatives in which more in-state students were enrolled would imply higher in-state tuition and/or lower resources per student. University of California President Janet Napolitano described the tradeoff: "Nearly every state in the nation has faced this Hobson's choice, and they have all reached the same decision: open doors to out-of-state students in order to keep the doors open for in-state students."

Although admitting

foreign students has been a potent mechanism for state research universities to mitigate the effects of dwindling state appropriations, the researchers caution that this may not be a sustainable strategy. "The supply of such students to U.S. universities is not likely to remain constant in future decades," they conclude. "Growth in home-country institutions of close quality or negative shocks to home-country economies would likely drain this pool of students from abroad."

—Deborah Kreuze



child policy, and two specific events in 2005: a shift in China's currency valuation policy that allowed the yuan to appreciate, and a relaxation of student visa requirements that simplified the passage of Chinese students into the U.S.

The capacity of non-research universities in China is more in line with demand, so Chinese students seeking degrees from non-research institutions need not go abroad.

Enrollment of Chinese students increased most markedly at public research

## Imperfect Electricity Markets versus Imperfect Regulation

In the last two decades, more than half of the wholesale electricity transmission systems in the United States have adopted some form of market mechanism to determine which power plants would operate. Based on an examination of hourly supply and demand patterns on the U.S. electrical grid, Steve Cicala estimates that these new markets reduced aggregate electricity generation costs by \$3 billion a year. His results are reported in **Imperfect Markets versus Imperfect Regulation in U.S. Electricity Generation** (NBER Working Paper No. 23053).

Electricity production must be exactly synchronized with demand, which has large daily, weekly, and seasonal swings. The integrity of the U.S. electrical grid is maintained by roughly 100 “balancing authorities,” which determine when power plants start up and shut down to match these fluctuations. Historically, these decisions were made by engineers within the vertically integrated utilities that owned the power plants, transmission system, and distribution networks that serve customers. This regulatory structure resulted in a grid built for reliability, rather than substantial inter-regional transmission of electricity. Over 90 percent of power was generated in the local power control area where it was consumed.

With changes in federal regulations (and encouragement from the Federal Energy Regulatory Commission), balancing authorities began to turn their responsibilities over to independent system operators, who use day-ahead and real-time auctions to balance supply

and demand, often across multiple power control areas that were previously operating autonomously. Between 1996 and 2012, 60 former power control areas adopted such “market

Market mechanisms led to increased coordination across utilities and less output from high-cost generators, substantially reducing the cost of producing electricity.

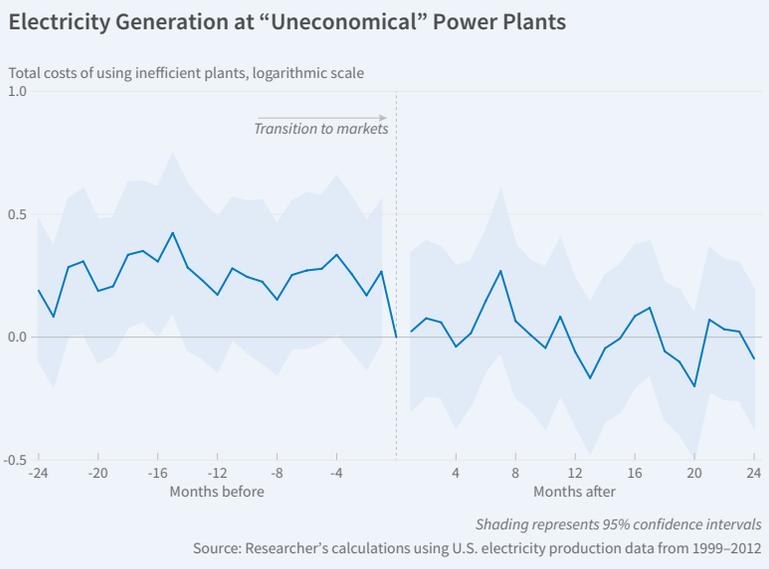
dispatch” overnight by either joining an existing market, or participating in the creation of a new one. Roughly two-thirds of electricity production in the United States is now determined by the outcomes of these markets.

higher cost plants are used to produce power even though lower cost plants are available. In some cases, using high cost plants is appropriate when lower cost generators are unavailable as a result of

normal grid operations such as maintenance, refueling, start-up costs, and transmission congestion. Withholding lower-cost units from auction is also how firms exert market power. He also measures changes in trade across power control areas, and the associated gains from offsetting higher-cost generation.

He uses the staggered roll-out of markets to estimate the impact these new mechanisms have on production costs by comparing changes in operations following market adoption to those of areas that have not undergone any changes. Because fuel price changes unrelated to market transitions impact the measurement of cost savings, he uses machine learning algorithms to predict the system operator’s complex rules for dispatching generators in the absence of markets, and compares observed and predicted behavior across groups. He finds that markets encouraged both increased trade across areas, and reduced usage of higher cost units. The 20 percent improvement in each of these metrics reduced production costs by about \$3 billion per year.

—Linda Gorman



Using data on fuel costs, capacities, heat efficiency, and the operations of nearly all generating units in the U.S., Cicala constructs power supply curves ranking production units from lowest to highest cost for each of the 98 areas at an hourly resolution from 1999 to 2012. He then estimates the excess costs that occur when

### NBER

The National Bureau of Economic Research is a private nonprofit research organization founded in 1920 and devoted to objective quantitative analysis of the American economy. Its officers are:

James M. Poterba—President & Chief Executive Officer  
Martin B. Zimmerman—Chairman  
Karen N. Horn—Vice Chairman

The NBER Digest summarizes selected Working Papers recently produced as part of the Bureau's program of research. Working Papers are intended to make preliminary research results available to economists in the hope of encouraging discussion and suggestions for revision. The Digest is issued for similar informational purposes and to stimulate discussion of Working Papers before their final publication. Neither the Working Papers nor the Digest has been reviewed by the Board of Directors of the NBER.

The Digest is not copyrighted and may be reproduced freely with appropriate attribution of source. Please provide the NBER's Public Information Department with copies of anything reproduced.

Individual copies of the NBER Working Papers summarized here (and others) are available free of charge to Corporate Associates and to the affiliates of other organizations, such as universities and colleges, with subscriptions. For all others, there is a charge of \$5.00 per downloaded paper or \$10.00 per hard copy paper. Outside of the United States, add \$10.00 per order for postage and handling. Advance payment is required on all orders. To order, call the Publications Department at (617) 868-3900 or visit [www.nber.org/papers](http://www.nber.org/papers). Please have the Working Paper Number(s) ready.

Subscriptions to the full NBER Working Paper series include all 1000 or more papers issued each year. Subscriptions are free to Corporate

Associates. For others within the United States, the standard rate for a full subscription is \$9665; for academic libraries and faculty members, \$7730. Higher rates apply for foreign orders. The on-line standard rate for a full subscription is \$2325 and the on-line academic rate is \$1075.

Partial Working Paper subscriptions, delineated by program, are also available. For further information, see our Web site, or please write: National Bureau of Economic Research, 1050 Massachusetts Avenue, Cambridge, MA 02138-5398.

Requests for Digest subscriptions, changes of address, and cancellations should be sent to Digest, NBER, 1050 Massachusetts Avenue, Cambridge, MA 02138-5398 (please include the current mailing label), or by sending email to [subs@nber.org](mailto:subs@nber.org). Print copies of the Digest are only mailed to subscribers in the U.S. and Canada; those in other nations may request electronic subscriptions at [www.nber.org/drsuscribe/](http://www.nber.org/drsuscribe/).