FRBSF Economic Letter

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Productivity Growth: Causes and Consequences
Conference Summary

This Economic Letter *summarizes the papers presented at the conference "Productivity Growth: Causes and Consequences" held at the Federal Reserve Bank of San Francisco on November 18–19, 2005, under the sponsorship of the Bank's Center for the Study of Innovation and Productivity. The papers are listed at the end and are available at http://www.frbsf.org/economics/conferences/0511/index.html*

The study of productivity growth is among the most important pursuits of economic science. Assessments of it influence macroeconomic policy and in the long run productivity growth drives improvements in the standard of living, the mix of goods and services available, as well as the mix of jobs in an economy. The seven papers presented and discussed at the conference covered the entire spectrum of the process of productivity growth, from its fundamental cause—invention—to the diffusion and adoption of invented technologies, to the consequences of technological change, such as longer life spans.

Causes of productivity growth

A paper by Jones explored the genesis of technology and productivity growth—that is, the process of invention. In particular, he examined how this process, which typically builds on prior knowledge, is affected by the growing volume of knowledge. In Jones's model, inventors decide on the balance between acquiring knowledge that is narrow but deep and knowledge that is broad but shallow. The model predicts that, as the volume of knowledge grows deeper and broader over time, invention requires levels of depth and breadth that are increasingly difficult, in general, for a single individual to attain. As a result, inventors (researchers) would likely deepen their knowledge and become more specialized by spending more time learning rather than inventing, and they would likely gain more breadth of knowledge by engaging in more teamwork. Jones tested this hypothesis using U.S. data from 1975–2000 and found favorable results: the average time students spent in doctoral programs increased, the average age of inventors at the time of their first invention increased, and the number of inventors per patent increased. Another testable implication of Jones's model is that, looking across technological fields, inventions in deeper, more mature fields should be generated by larger teams with more specialized team members. As Jones demonstrated, this prediction is supported by data on U.S. patents.

Two closely related papers explored how new technologies diffuse or spread across parts of an economy. Conley and Udry considered the role of social networks in this diffusion process. Identifying such networks has been an elusive goal in the field of productivity research. Conley and Udry found a unique setting ideal for achieving this identification: pineapple farming in Ghana. In recent years, Ghanaian farmers have increasingly switched from traditional crops, such as maize and cassava, to the more profitable crop of pineapples, which has involved learning new technologies, such as the use of modern fertilizers. A basic part of the learning is discovering the best trade-off between the cost of the fertilizer and the value of the crop per acre. Conley and Udry use surveys to identify the social networks for a sample of farmers, some of whom adopted pineapple farming and some of whom did not. They find that communication with farmers who have *successfully* adopted pineapple farming is a strong predictor of whether a given farmer subsequently adopts the same technology (that is, the same use of fertilizer) for growing pineapples. In contrast, and consistent with their model, such

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networking is found to play no role in cultivation decisions for other crops whose technologies are widely known. These findings point to the potential importance of networking as a channel for the diffusion of technology. They also suggest, though, that factors that limit social networks, such as barriers to communication, may slow technology adoption in developing countries.

Skinner and Staiger explored technology diffusion by investigating the empirical patterns of technology adoption among the U.S. states. It is widely recognized that the pace and extent of adopting new technologies—from telephones to color television to computers—starts out slowly and picks up speed over time. This pattern generally reflects the fact that newly rolled out technologies tend to be costly, which limits the number of purchasers or users; then, over time, as quality improves and costs decline, these technologies are diffused more quickly and more widely. Cross-country, or regional, differences in the timing and pace of technology adoption generally are attributed in part to differences in income levels, with lower-income regions typically the slower to adopt.

However, such economic differences may not account for all regional differences in the pace of adopting technology. For example, Skinner and Staiger found that some states were much slower to adopt the use of beta blockers—that is, they found that doctors as a group in those states were much slower to prescribe beta blockers to patients in the hospital recovering from heart attacks. Skinner and Staiger argue that, because the drug's cost is low and its benefits are clear, economic factors, such as differences across states in income or prices, are unlikely to explain the wide cross-state differences in the rate at which this medical practice is adopted. In developing an alternative explanation, the authors point out that states that were slow to adopt hybrid corn during the first half of the twentieth century generally are the same states that recently have been slow to adopt beta blockers as a treatment for heart attacks. In fact, they find this pattern for the adoption of other technologies, as well. The authors posit that states with faster adoption rates may have characteristics that facilitate technology diffusion more generally. One characteristic correlated with faster adoption rates appears to be education, and communications networks may also play a role.

Baily et al. investigate whether competitive pressures influence technology adoption decisions. Specifically, their paper looks at the timing and extent of process innovations adopted by U.S. automakers from 1987 to 2002, a period in which foreign automakers increasingly penetrated the U.S. market and were themselves adopting these innovations. The authors argue that nearly half of the productivity increase over this period in the U.S. domestic auto industry was driven by the adoption of improved process technologies, such as "lean manufacturing" techniques. Another quarter of the measured increase in productivity is argued to have come from the product innovation of introducing new vehicle lines, especially SUVs, for which there was apparently unmet demand and on which U.S. manufacturers could realize larger mark-ups.

Gordon and Dew-Becker sought to determine the cause of the rather stark divergence in productivity growth in the European Union (EU) relative to the strong performance in U.S. since 1995. The authors pointed out that about half of the comparative slowdown in EU productivity growth was due to the acceleration in growth in the U.S., while the other half was due to a deceleration in Europe. Previous research had shown that information technology (IT) played a big role in the U.S. acceleration in the second half of the 1990s, so one might think the slowing in EU productivity might be due to developments affecting the IT sector in Europe. On the contrary, Gordon and Dew-Becker show that the slowdown in Europe was quite broad-based and not due just to weakness in IT-related industries. A common explanation for the EU slowdown is that institutional and legal barriers limit flexibility, and it is frequently illustrated by a story about zoning laws in Europe that prevent big-box stores, like Wal-Mart and Target, from expanding and establishing the ultra-efficient distribution systems they have in the U.S., which some argue have contributed to higher U.S. labor productivity.

Gordon and Dew-Becker offered a different story: Somewhat ironically, the labor market reforms enacted in the mid-1990s in many EU countries actually had a negative effect on productivity growth—at least temporarily. The authors claimed that, by relaxing rigid work rules and high wage floors, EU employers could hire more low-wage, low-productivity workers and substitute away from high-skill workers and capital. Indeed, before the mid-1990s, productivity growth in the EU was above that for the U.S. By opening the door to these low-productivity workers, Gordon and Dew-

Becker argue, average productivity is pulled down, at least until the economy adjusts to the new composition of the workforce.

Consequences of productivity growth

Two papers presented at the conference address some consequences of innovation and productivity growth. Bloom, Schankerman, and Van Reenen looked at the social returns to innovative activity, as measured by research and development (R&D) spending. The authors conceive of social returns to R&D as the technology spillovers flowing from R&D-performing firms to other firms, net of the social costs of having rival firms engage in parallel, duplicative research rather than working together. Using panel data on U.S. firms between 1981 and 2001, they find that both technology spillovers and market rivalry effects are quantitatively important, though the former dominate such that the net social returns to R&D are several times larger than the private returns. They argue that since large firms tend to produce greater technological spillovers and engender less rival R&D, their model implies that the current emphasis in U.S. R&D policy on small and medium-sized firms may not be the most effective use of government-provided incentives.

Hall and Jones consider the consequences of continued productivity improvements in the U.S. health-care industry. Much of the discussion over public policy in the U.S., according to these authors, assumes that the rapid growth in health spending in recent decades has been excessive. One argument, for example, is that the rise in health spending as a share of GDP is due to the lack of cost controls and misaligned incentives. Hall and Jones provide a plausible alternative, or at least an additional view, by developing an economic model of individual consumption behavior where life span is a function of health-care spending. Calibrating their model using standard parameters, they find that as income grows over time, the optimal share of spending on health also grows. Specifically, because individuals receive diminishing marginal utility from consumption in a given time period, they optimally respond to increases in income by putting a greater share of resources toward increasing the number of periods in which they can consume (longer life spans). That is, with rising incomes, individuals will choose to spend proportionately less on food, cars, housing, and so on, and more on health today so as to be able to consume in more tomorrows. Based on projections of aggregate income growth, their model suggests the optimal health share is likely to double over the next half century, exceeding 30% of GDP by 2050.

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Economist

Conference papers

Baily, Martin Neil, Diana Farrell, Ezra Greenberg, Jan-Dirk Henrich, Naoko Jinjo, Maya Jolles, and Jana Remes. "Increasing Global Competition and Labor Productivity: Lessons from the U.S. Automotive Industry."

Bloom, Nick, Mark Schankerman, and John Van Reenen. "Identifying Technology Spillovers and Product Market Rivalry."

Conley, Tim, and Christopher Udry. "Learning about a New Technology: Pineapple in Ghana."

Gordon, Robert, and Ian Dew-Becker. "Why Did Europe's Productivity Catch-up Sputter Out? A Tale of Tigers and Tortoises."

Hall, Robert, and Chad Jones. "The Value of Life and the Rise in Health Spending."

Jones, Ben. "The Burden of Knowledge and the Death of the Renaissance Man: Is Innovation Getting Harder?"

Skinner, Jonathan, and Douglas Staiger. "Technology Adoption from Hybrid Corn to Beta Blockers."

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