FRBSF ECONOMIC LETTER

Number 2004-07, March 12, 2004

Technology, Productivity, and Public Policy

This Economic Letter *summarizes papers presented at the conference "Technology, Productivity, and Public Policy" held at the Federal Reserve Bank of San Francisco on November 7–8, 2003. The conference was the inaugural event of the new Center for the Study of Innovation and Productivity (CSIP), which is organized within the Economic Research Department of the Bank.*

The study of productivity growth cuts across many of the fields and approaches in economics—microeconomics, macroeconomics, and international economics; theoretical and empirical analyses—and it is a subject for students of history as well as of current events. The seven papers presented at this conference highlight the breadth of questions and methodologies of recent research on productivity growth.

Three of the conference papers examine productivity growth at the macro economic level. Kahn and Rich propose a method that aims to improve our ability to identify breaks in trend productivity growth of the types that occurred in the 1970s and in the mid-1990s. While such breaks are easy to spot after the fact, they have proven difficult to recognize in real time. In a theoretical paper, Jones asks how production technologies are determined in the first place. He considers how new ideas affect the development of production possibilities in both the short run and the long run. Manuelli and Seshadri consider the link between innovations and the adoption of new production technologies directly. As a case study of technological diffusion, they examine the long time lag between the invention of the farm tractor and its wide adoption on American farms in the first half of the 20th century.

Two of the papers take a more microeconomic approach. In a theoretical paper, Scotchmer discusses when and why countries engage in intellectual property rights treaties and whether such treaties produce the optimal amount of innovative activity. Lach and Schankerman focus on whether university researchers respond to financial incentives when determining the effort they expend generating inventions. On the basis of these results, they discuss how universities might alter the current compensation system to produce more innovative effort.

The final two papers look at how technology and productivity differentially affect countries and individuals. Considering productivity in an international framework, Hsieh and Klenow examine the extent to which differences in the efficiency of producing investment goods can explain low rates of capital investment in poor countries. Autor, Levy, and Murnane use an array of data and statistical analyses to tie down the relationship between increased computer use in the workplace and the demand for skilled labor. They identify tasks for which computers can substitute for workers and tasks for which computers complement worker skills. They use their results to shed light on the changing relative demand for skilled workers in the U.S. over the last 30 years.

Detecting changes in trend productivity growth

Shifts in trend productivity growth are uncommon and difficult to recognize when they are actually occurring. Kahn and Rich propose and estimate a statistical model in which the rate of trend productivity growth unpredictably switches from a "low-growth" to a "high-growth" regime. Their econometric procedure detects a regime shift from high growth to low growth in the early 1970s, followed by a shift back to high growth in the late 1990s, with the difference between the mean annual growth rates in the two regimes of about 1.5 percentage points. They find that the economy tends to stay in one regime or another for about 20 years on average.

A key assumption of their method is that a common trend underlies long-run movements in real wages, consumption, and productivity. They further assume that this common trend undergoes infrequent shifts between the two growth rate regimes. Because we cannot directly observe which regime the economy is in at any point in time, it must be estimated along with other parameters of their model. They find that estimating a common permanent trend across all three variables does a better job of detecting trend shifts

CSIP NOTES *CSIP Notes* appears on an occasional basis. It is prepared under the auspices of the Center for the Study of Innovation and Productivity within the FRBSF's Economic Research Department.

in U.S. data than do methods that are based only on productivity data. They also find that their procedure identifies shifts in regime relatively quickly.

New perspective on production functions

Jones studies how the creation of new "ideas" affects the use of technology and productivity in the economy. In his model, research is directed at finding new ways to produce goods, and the resulting stream of innovations shapes the evolving aggregate production technology that relates inputs of capital and labor to output. At any point in time, producers choose from the available set of production technologies based on the relative costs of inputs. Over time, better ideas are created and the production possibilities frontier shifts out.

This model provides innovation-based microeconomic foundations for a long-run production function of the Cobb-Douglas form that has been widely used in the economics literature and has empirically supported long-run properties. Importantly, Jones's model implies a stable steady state with positive growth, even in the presence of falling relative prices of capital goods, a property that many other production functions fail to possess.

But, the standard Cobb-Douglas function also has some shortcomings at explaining short- and medium-run empirical regularities, which the Jones model has the potential to correct. For one, the Cobb-Douglas model implies that the share of income going to labor is constant over time; but, the empirical evidence, especially from European economies, suggests that this may not be the case, and the Jones model does not impose this restriction. Second, the Cobb-Douglas model implies that capital and labor are just as substitutable in the short run as in the long run. In contrast, the evidence suggests that the degree of substitutability of labor and capital is lower in the short run, a feature also consistent with the Jones model.

Technological diffusion

Manuelli and Seshadri look at one important example of innovation, the tractor. They argue that the gradual diffusion of tractor use on U.S. farms from 1900 to 1960 can be explained by technological improvements in tractor design and by the path of real wages during this period. Empirical studies of the diffusion of new technologies have documented that there can be a long time lag between the introduction of a new technology and its wide adoption. Other researchers have argued that there are many impediments to the immediate adoption of new and more productive technologies; in contrast, this paper aims to explain the slow diffusion in the case of tractors without relying on such frictions.

They find that low farm wages through the 1930s reduced the incentive for farmers to switch from horses to tractors during that period. Real farm wages fell by half during the Great Depression, which further slowed the adoption of tractors on American farms. It was not until the 1940s, when wages experienced rapid growth that tractors become widely adopted. In addition, increases in urban wages during this period caused less-skilled farmers to leave the agricultural sector and, as a result, the average skill of the remaining farmers improved over time. This resulted in concentrations of land in favor of larger-sized farms, which also made the adoption of tractors more profitable. Finally, they find that improvement in the quality of tractors over time, especially after the 1940s, played an important role in encouraging the adoption of tractors.

Intellectual property treaties

In 1995 the World Trade Organization passed the Agreement on Trade Related Aspects of Intellectual Property (TRIPS) which set minimum standards for intellectual property rights protections across countries. Scotchmer considers whether the extension of minimum intellectual property rights, like those embodied in TRIPS, produces socially efficient outcomes. Specifically, she asks whether intellectual property agreements improve consumer welfare by enhancing the cross-border exchange of ideas. Scotchmer addresses this question by developing a theoretical model of bilateral intellectual property rights treaties and then investigating the circumstances under which countries enter or do not enter agreements.

She finds that countries may not independently engage in the socially optimal level of intellectual property rights. For example, when countries are not the same size or have different levels of innovativeness, the desire for intellectual property protections may differ, with smaller or less-innovative countries wanting fewer protections. In such cases, harmonization policies, such as TRIPS, can improve social efficiency by increasing protections that fuel innovative activity.

Incentives and inventions in universities

Lach and Schankerman examine whether university researchers respond to financial incentives when determining their innovative effort. Specifically, the authors ask whether academic researchers would create more and/or higher quality inventions if they were allowed to keep a larger share of the revenues generated from licensing the new technologies. The authors set up a simple model of the research effort decision of aca-

demic scientists that allows scientists to direct effort toward creating a greater number of inventions or a higher quality of invention.

Taking this model to the data, they find that scientists do respond to financial incentives, but only on the quality component of their effort decision. Scientists who were permitted to keep the largest share of royalties generated the highest quality inventions, all else equal. Financial incentives had no measurable impact on the number of inventions scientists created. Lach and Schankerman also found that the relationship between royalty share and invention quality was strongest at private universities. With this in mind, they support greater financial remuneration for scientists contributing to the innovative process.

Relative prices and relative prosperity

Hsieh and Klenow examine a well-established relationship between countries' per capita incomes and investment rates in physical capital (equipment, buildings, etc.), evaluated at international prices. The standard story suggests that poor countries have lower purchasing power parity (PPP) investment rates than rich countries because poor countries have low savings rates, due to high tax rates, etc. Hsieh and Klenow argue against this explanation. Using a theoretical model and the predictions from it, they examine an array of nonpolicy alternatives to explain differences in investment across countries.

First, the authors show that investment rates in poor countries only appear low when evaluated at international prices; when valued in the country's own currency, poor countries save and invest at the same rate as rich countries. Second, they argue that the low PPP investment rates in poor countries are not due to low savings rates or to high tax rates or tariffs on investment, but rather owe to low efficiency in poor countries in producing investment goods or exports that can be traded for investment goods.

Skill levels and technological change

Autor, Levy, and Murnane examine the impact of workplace computer use on the demand for different types of workers. They detail what computers are used for and how they substitute for or complement various worker skills. Specifically, they distinguish between routine cognitive or manual tasks that can be performed by following a set of rules and nonroutine problem-solving and communication tasks that require situational thinking and decisionmaking; computers replace the former and complement the latter. They use their measure of job content and data on increasing computer use over time to explain the rising demand for college-educated workers between 1960 and 1998. They find a strong relationship between shifts in job tasks and the adoption of computer technology over the period; specifically, increased computerization reduced labor input for routine tasks and increased labor input for nonroutine tasks. This pattern occurred both within and across industries and occupations. Based on these calculations, they argue that nearly two-thirds of the relative increase in demand for college-educated workers can be explained by rising workplace computer use. Interestingly, they find that about half of the measured impact of rising workplace computer use owes to increasing requirements within occupations over time; for example, the tasks and requirements for a secretarial job in 1998 involved a much higher level of skills than a secretarial job in 1960, contributing to higher demand for skilled workers in the latter period.

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Conference Papers

Papers are available in pdf format at http://www.frbsf.org/economics/conferences/0311/index.html

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