Program Report

The NBER Project on Industrial Technology and Productivity

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Project Coordinator

The NBER Project on Industrial Technology and Productivity was begun in 1994 with funding from the Alfred P. Sloan Foundation. Under the overall direction of NBER President Martin Feldstein, the project has three intertwined objectives. First, we seek to foster research on the fundamental determinants of productivity improvement, including the development and diffusion of new technology, investment in new plant and equipment, managerial and organizational innovation, and changes in employee relationships. Second, the project encourages economists studying these issues to supplement their traditional theoretical and empirical research methods with direct observation of business firms and conversations with managers and workers. Finally, the project provides a framework for communication among economists interested in productivity issues, researchers from other academic disciplines, and policymakers responsible for science and technology policy. We hope that this communication will allow policy to be informed by current research of social scientists, and allow researchers' agendas to be influenced by the priorities of the policy process.

The project to date has encompassed several different kinds of activity. First, we have commissioned a series of specific research projects, in which NBER researchers are investigating aspects of productivity, using plant visits or other forms of conversation with managers inside firms to help formulate and interpret their hypotheses and results. Second, we have organized meetings to present and discuss ongoing work that combines traditional research methods with site visits and other conversations with managers. Third, we have visited a number of firms, at which researchers interested in different aspects of productivity have heard from.

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managers about the productivity issues within their firms. Finally, we have begun a regular biannual meeting of a Science and Technology Policy Research Group, at which economists, other social scientists, and government officials discuss current policy problems, current research, and the relationship between the two.

Individual Research Projects

Currently, 39 researchers are engaged in 25 distinct research projects on many different issues related to productivity improvement. The projects can be grouped into five broad areas: modeling technology and productivity in manufacturing processes; investment and the adoption of new technology; the effect of organizations and organizational change; the effect of employee relations and compensation; and, the innovation process and the generation of new technology. Briefly I will discuss examples of projects in each of these areas to give a flavor for the kinds of research being pursued. In addition, Steven N. Kaplan is organizing a conference on the productivity impacts of mergers and other changes in corporate control.

Productivity and Technology in Manufacturing Processes

Wayne B. Gray is measuring the impact of environmental regulation on productivity, focusing on the paper industry. Simultaneously he is pursuing statistical analysis of the entire industry, using data on productivity and regulatory compliance costs from the U.S. Bureau of the Census, and detailed case studies.
of particular papemaking plants in New England. His statistical analysis indicates large negative effects on productivity relative to actual compliance expenditures, so the plant visits are designed to understand the relationship between the compliance cost information reported to the government and the actual costs of control technologies and process changes, as well as the overall interactions between compliance efforts and plant performance.

Samuel S. Kortum, Steven T. Berry, and Ariel Pakes are examining how product characteristics affect productivity in the automobile industry. Combining plant-level data from the Census of Manufactures and trade data on the production of particular models, they estimate a "hedonic cost function" for automobile production. Discussion with plant managers and examination of the production processes at particular plants will allow them to refine this model and to interpret the resulting parameters.

Investment and the Adoption of New Technology

Susan Helper is examining the sources of sustained cost reduction in manufacturing by focusing on the auto-parts supply industry. In particular, she is interested in why these manufacturers seem to be able to reduce costs continuously even on mature products. Her research is based on a detailed survey of automakers and their suppliers in the United States and Canada, along with visits to specific parts plants in Massachusetts, Ohio, and Michigan, and discussions with auto company engineers who are in charge of cost-reduction programs for specific components.

M. Greenstein are investigating the process by which large, data-intensive corporate users of computers have migrated from mainframes to client/server technologies. In particular, they are trying to understand the extent to which users seem to base their investment decisions on forward-looking evaluations of technologies' potential, and the extent to which transitions are slowed by users being "locked in" to existing hardware or software. Their research combines statistical analysis of a large dataset describing the computer hardware in place over time at central corporate computer facilities, combined with detailed interviews of information systems managers at companies in the retail, health care, accounting, and manufacturing sectors.

Organizations and Organizational Change

Ann P. Bartel is examining the sources of productivity improvement in the retail sector by looking at retail banking. She has made an arrangement with a large Canadian bank under which she will have access to systematic data on the performance and efficiency of all of the bank's branches. She will explore statistically the role of environmental and management factors in determining performance. This statistical analysis will be structured on the basis of her insights from a series of site visits in which she will interview managers and employees at "turnaround" branches, that is, branches that the company has identified as having changed from underperforming to overperforming.

Severin Borenstein and Joseph Farrell are investigating the extent to which manufacturing companies carry significant "fat" or inefficiency during prosperous times, which is then "lost" via explicit cost-cutting drives during hard times. Using a formal model of how equity markets value companies that are operating inefficiently, they are able to infer statistically the extent to which specific oil-refining companies carried "fat" at different times during the 1980s. They are testing these implications through discussions with specific managers involved in refining operations, in order to understand how decisions are made that costs need to be reduced, and what the consequences of these decisions are for the organizations.

Employee Relations and Incentives

Richard B. Freeman and Morris M. Kleiner are examining the effects of different kinds of "employee involvement" programs on productivity in specific companies. They have undertaken detailed analysis of the results of employee involvement initiatives at 20 plants in the aerospace, automotive, brewing, electronics, machine tool, and other industries. Each case study documents the nature of the employee involvement implemented, the preconditions and technology in place, the management and union input/effort to the process, and its degree of success. These case studies will form the basis for a larger survey of establishments that then will be used for statistical analysis of the determinants of success.

Edward P. Lazear is undertaking a detailed analysis of the productivity impact of employee compensation at the Safelite Company, a maker of auto glass. Safelite has switched its "dealer associates" around the country from salary-based compensation to "variable
pay," tied directly and explicitly to sales performance. Using data from Safelite’s database on employee performance over time, Lazzar will be able to track closely the extent to which the change in the approach to compensation changes the performance of individuals and the organization as a whole.

Innovation and New Technology

Lynne G. Zucker and Michael R. Darby are studying the role of university scientists in biotech firms, and the pathways by which new scientific developments contribute to the commercial development of biotechnology firms. Their research combines a variety of quantitative data on the publication records of university scientists, their links to biotechnology firms, and the performance of biotechnology firms, with case studies of particular firms whose principals have been interviewed in depth.

James D. Adams, Michael S. Fogarty, and I am examining the flow of commercial technology out of federal labs. This project uses data on patents granted to federal labs (both intramural and contractor-operated), and the citations to those patents, to measure the extent, timing, and geographic location of the technological impact of government research. In order to illustrate and validate the use of patent citation information to measure technological impact, we are undertaking a detailed case study of the patenting and citation of a NASA lab in Cleveland that has a number of key inventions relating to the creation of new materials and modifications of the surface of those materials with ion beam techniques. Based on discussions with key NASA scientists, and scientists at firms that have used these technologies and/or cited the NASA patents in their own patents, we will document the pathways by which federally developed technology gets into the private sector, and the extent to which patent citations can be used to measure this diffusion process.

“Pin Factory” Visits

In honor of Adam Smith, we have dubbed our more generalized plant visits “pin factory visits.” In each case, we have visited a manufacturing plant in the Boston area. Plant management has made a presentation on how they measure productivity, what they are doing to try to increase it, and what changes in their production process or organization have had the largest impacts on productivity in recent years. After these presentations, we tour the facilities, and conclude with additional questions and discussions with management. These visits have been extremely useful for highlighting generic issues that either affect many research projects or suggest topics that merit detailed research. Just a few examples of observations from such visits:

- even in old-fashioned, mainline manufacturing, the fraction of labor and costs directly involved in production of goods is low, so that significant productivity improvements often must come from “overhead” functions such as engineering, marketing, and office operations.
- specific targets for yearly cost reduction, on the order of 3 percent per year (nominal), are common, and companies are often quite sophisticated in their monitoring and measurement; for example, dealing with the problem of changing product mix in ways similar to standard index number methods.
- the concepts of “capital” and “R and D” as we use them are clearly problematic. Equipment on the shop floor may be owned by customers; extensive technology-creating activities may not be called R and D.

Science and Technology Policy Working Group

This group has met twice, with another meeting expected this summer. Each one-day meeting has combined presentation of specific research results with discussions of current policy issues, and the research needs generated by policy concerns. Specific issues that have been addressed so far include: methods for evaluation of government funding of technology development; changing patterns of university research support; measuring the output of academic research; and the labor market for science and engineering Ph.D.s.

The Future Course of the Project

We continue to accept proposals for new individual research projects, and we expect that some of the researchers currently involved will begin new projects when those underway are completed. Currently we are evaluating how to proceed with pin-factory visits, including ideas for non-Boston area visits and possible combinations of research meetings with plant tours. The Science and Technology Policy Group will continue to meet on a regular basis.

Altogether, 60 or so economists have been involved in various as-
pects of this project. In addition to facilitating new research on an interesting and important set of problems, we hope that this effort will improve the quality and persuasiveness of economic research generally, by broadening and deepening the profession's base of general knowledge about economic institutions.


Research Summaries

Higher Education

Charles T. Clotfelter

Higher education in the United States is a costly enterprise. Measured by aggregate statistics, the expenditures by all of the 3400 colleges and universities amounted to some $164 billion in academic year 1992 (1991/2), or about 2.9 percent of the gross domestic product.

From the perspective of a family sending a child to college, it is no longer uncommon for the financial burden of a four-year program to reach six digits, making college the second biggest lifetime expense for many families, after the purchase of a house. Beginning around 1980 these costs, measured in real, inflation-Adjusted dollars, began to rise rapidly, especially at private institutions. Between 1980 and 1990 general educational spending per student in all colleges and universities grew at an annual real rate of 2.4 percent above inflation, and at a 3.4 percent rate in private institutions alone.

Tuition rose sharply as well during the 1980s, with especially steep increases in the private sector. Between 1960 and 1980 the average real tuition and fees rose at a scant 0.3 percent average annual rate in public universities and a 1.3 percent rate in the private ones. But after 1980 the growth rate for the public universities increased to 2.8 percent; among the private universities it jumped even more, to 4.5 percent a year. Even after accounting for growth in financial aid, the rates of growth in tuition and fees were high, about 2.7 percent annual real growth in the public sector and 3.9 percent in the private sector. For private universities between 1976 and 1992, the net-of-aid cost to students exceeded not only the overall rate of inflation but also the much-heralded inflation in medical costs.

The rapid rise in costs and tuition during the 1980s became a flash point that intensified an ongoing debate over the direction of higher education itself, serving for critics as evidence of the inefficiency, misdirection, and even greed of those institutions. Some critics viewed the run-up in costs as a direct result of an increasing emphasis on research at the expense of teaching. Others pointed to what they saw as excessive spending on frills and bloated bureaucracies. One very visible group of private institutions came in for particular attention: the handful of nationally known private "elite" research universities and liberal arts colleges. The Justice Department's antitrust case against several groups of institutions also focused on the elite institutions.

The Skyrocketing Costs

From the early 1980s to the early 1990s, internally funded expenditures grew at a 5.4 percent real annual rate at Harvard, 5.7 percent at Carleton, 6.6 percent at Chicago, and 6.8 percent at Duke. Faculty salaries, which accounted for a large portion of arts and sciences spending, grew in real terms, although less rapidly than total