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Introduction

This volume is the inaugural publication of the National Bureau of Economic Research (NBER) Innovation Policy and the Economy (IPE) group. The past few years have seen an increasing appreciation of the importance of innovation to the economy. The importance of innovation can be seen, for instance, in the market capitalization of technology-based companies, the number of patent filings by U.S. corporations, or the coverage of new innovations in the business press.

At the same time, there is active debate regarding the implications of rapid technological change for economic policy, and the appropriate policies and programs regarding research, innovation, and the commercialization of new technology. These debates encompass long-standing issues, such as the appropriate level and form of public support of research, as well as newer issues, such as the evolving role of intellectual property and the appropriate antitrust treatment of software and other industries where technology standards play a key role.

The IPE group seeks to provide an accessible forum to bring the work of leading academic researchers to an audience of policymakers and those interested in the role of public policy and innovation. Our goals are: (1) to provide an ongoing forum for the presentation of research on the impact of public policy on the innovative process; (2) to stimulate such research by exposing potentially interested researchers to the issues that policymakers consider important; and (3) to increase the awareness of policymakers (and the public policy community more generally) concerning contemporary research in economics and the other social sciences that usefully informs the evaluation of current or prospective proposals relating to innovation policy.

This volume contains the papers presented at the group's first meeting, held in Washington DC in April 2000. Subsequent volumes will contain the proceedings of annual meetings in Washington each spring.

In addition, the group meets annually in Cambridge for discussion of research in progress, and will hold occasional conferences on specific topics.

The papers in this volume demonstrate the importance of issues related to innovation in current policy debates, the value of the insights that economic analysis can bring to these problems, and the breadth of interest of economics in innovation-related issues. The first two papers highlight the interaction between public policy and innovation in a specific but important sector—the life sciences.

Motivated by the extraordinary rise in public expenditures on the life sciences over the past 30 years, Iain Cockburn and Rebecca Henderson initiate the volume by assessing the relationship between public investment in life sciences research and the rate and extent of innovation in the pharmaceutical industry. Though the social benefits provided by basic research are notoriously difficult to quantify, economic research on the industry has identified several specific mechanisms through which public funding may spur innovation and the commercialization of new therapies. For example, public funding of basic research in molecular biology has provided critical elements of the foundation of rational drug design—a more efficient drug discovery technique whereby researchers investigating new compounds are guided by scientific evidence about the biochemical basis of disease. Building both on case histories of specific drugs as well as evidence based on patenting and publication data from the industry, the paper assesses the returns to public expenditure in this sector. While noting the limitations and assumptions associated with individual studies, their review suggests that prior econometric research "makes a quite convincing case for a high rate of return to public science."

Michael Kremer's paper, on the other hand, examines an arena where private pharmaceutical companies do very little research: the development of vaccines for tropical diseases. He argues that the reluctance of pharmaceutical companies to undertake research to develop vaccines for diseases such as malaria, tuberculosis, and African strains of HIV is a consequence of severe market failures. In particular, companies fear that were they to develop such products, governments would force prices down to a level that would not allow them to earn a satisfactory return. To address this problem, he proposes that public agencies commit to buying vaccines at a set price if a satisfactory vaccine can be developed by the private sector. Kremer suggests that such an initiative could address market failures far more effectively than alter-

native approaches, such as government subsidies for basic research in this area.

Carl Shapiro focuses on the increasingly important issue of the interaction between intellectual property protection and competition policy. He notes that in several important technology areas, such as biotechnology, semiconductors, and software, commercial innovation often requires use of numerous potentially overlapping or conflicting patent rights. A particularly important circumstance in which such problems often arise is where standard setting is an essential part of the process by which new technologies are commercialized. Parties can use a variety of contractual mechanisms to resolve these problems, including cross licensing, package licensing, and patent pools. Such agreements, however, are sometimes challenged by antitrust authorities, particularly when they occur between or among horizontal competitors. Shapiro offers several suggestions as to how agreements that facilitate innovation can be distinguished from those with serious anticompetitive effects.

Shane Greenstein's paper asks the question: why did the commercialization of the Internet go so well? This question is intriguing and also important, because most historical examples of technology transfer from the public to the private sector have involved confusion and delay. In contrast, the technologies that make up the Internet diffused rapidly and pervasively shortly after the National Science Foundation relaxed the regulations restricting private use in 1992. Drawing upon his own research on Internet Service Providers, Greenstein identifies four drivers of this unusually quick diffusion process: (1) the absence of significant technical or commercial hurdles; (2) the economic and technical malleability of the Internet; (3) the potential for customization on a number of key dimensions; and (4) the fortuitous coincidence that the Internet was commercialized at the same time that the World Wide Web was developed. The diffusion of the Internet yields two policy insights. First, the Internet experience may allow for better identification of the conditions under which technology may be transferred successfully from the public to the private sector. Second, the Internet has had a ubiquitous impact on the telecommunications industry in particular, perhaps necessitating a rethinking of the regulatory institutions underlying this sector of the economy.

The last two papers in the volume examine the different facets of the relationship between academic institutions and innovation. The first of these, by David Mowery and Arvids Ziedonis, examines a direct

impact: the commercialization of academic discoveries by the private sector. Drawing on in-depth studies of three leading research universities—Columbia, Stanford, and the University of California—the authors examine the impact of the policy reforms of the early 1980s on technology transfer activities. Disentangling the impact of this policy change from the contemporaneous shifts in federal funding of research and patent policy is challenging. But the results suggest that, at least at these three schools, the reforms of federal technology transfer policy served as a significant boost to commercial activities. This suggests that the Bayh-Dole Act of 1980 is helping to achieve its stated goal of increasing the transfer of commercially useful technology from universities to the private sector.

Although commercialization of university technology is important, most scholars agree that the primary contribution of academia to commercial innovation is its training of scientists and engineers. In the last paper of this volume, Paul Romer notes that, in principle, government policy to foster innovation could act on both the demand and supply sides of the R&D investment process. He argues that, historically, policy has focused more on the demand side, using instruments such as R&D tax credits or other subsidies. If the supply of R&D resources—primarily technically trained people—adjust only very slowly to changes in policy, then such policies will raise the wages of scientists and engineers without increasing research much. Romer then analyzes how the structure and incentives of post-secondary and graduate education in the U.S. affect the supply of technically trained people to the commercial sector. He concludes that undergraduate education discourages students from majoring in science or engineering, and that post-graduate programs are structured to produce Ph.D.s oriented toward teaching rather than commercial research. He then considers several government policies that might counter these tendencies, thereby increasing the supply of scientists and engineers and ultimately the rate of commercial innovation and economic growth.

These six essays highlight the role that economic theory and empirical analysis can play in evaluating key policies impacting innovation. Together, they offer the prospect that contemporary research in economics can usefully inform the evaluation of current and prospective innovation policy alternatives.

As a final note, we gratefully acknowledge several key actors who have helped to launch the IPE group and this inaugural volume. Kirsten Davis and Rob Shannon of the NBER Conference Department

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