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Innovation Policy and the Economy 7

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Adam B. Jaffe, Josh Lerner, and Scott Stern

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Innovation Policy and the Economy: Introduction to Volume 7

This volume is the seventh publication of the National Bureau of Economic Research (NBER) Innovation Policy and the Economy (IPE) group. The appreciation of the importance of innovation to the economy has increased over the past decade. At the same time, there is an 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. This debate has only intensified with the economic and security challenges that our nation has recently faced.

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 interaction between public policy and innovation. Our goals are:

- to provide an ongoing forum for the presentation of research on the impact of public policy on the innovative process;
- to stimulate such research by exposing potentially interested researchers to the issues that policymakers consider important;
- 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 in the group's meeting in Washington, DC, in April 2006.

The first two papers take complementary yet contrasting approaches towards biomedical innovation. The first paper focuses on the apparent slowdown in new drug approvals and research productivity in the pharmaceutical industry. Despite a dramatic rise in public and private

pharmaceutical R&D expenditures, new drug introductions seem to have experienced a decline since the mid 1990s. Amid expressions of alarm by the media and policymakers, Iain M. Cockburn offers a more systematic assessment of the apparent pharmaceutical R&D productivity crisis. Cockburn suggests that the measurement of the inputs and outputs of pharmaceutical R&D is more subtle than standard measures might suggest, and the pharmaceutical productivity crisis is, at the very least, overstated. There are inherent difficulties in linking the inputs and outputs of pharmaceutical R&D: all drugs are not equal, incremental learning and innovation are important sources of quality improvement, and there are long time lags between discovery and commercialization. Indeed, the rapid rise in expenditures on early stage discovery (and public research) bodes well for a sharp uptick in new drug approvals and therapies over the next decade.

With that said, the lack of capacity in translational medicine (bringing the "bed and bench" together) and the increasing prevalence of intellectual property disputes among those engaged in the drug discovery process pose significant challenges going forward. While the strident claims about a productivity crisis may be overblown, there seems to be significant scope for policy initiatives aimed at enhancing the impact of public funding and public policies encouraging the development and diffusion of pharmaceutical innovation.

The second paper investigates a central challenge raised by Cockburn—the proliferation of formal intellectual property rights over knowledge traditionally maintained in the public domain. Fiona Murray and Scott Stern focus attention on the prevalence and challenges raised by *dual-purpose knowledge*—when a single discovery simultaneously contributes to scientific understanding and yields potential commercial applications. Over the past decade, a sharp policy debate has emerged over the role of patents protecting dual-purpose knowledge. According to the anti-commons perspective, patents may "privatize" the scientific commons, imposing a significant tax on cumulative scientific discovery. At the same time, patents may facilitate disclosure and trade in the "market for ideas," encouraging cumulative innovation.

Murray and Stern review recent qualitative and quantitative evidence to adjudicate this debate, highlighting three overall findings. First, from the perspective of individual researchers, patenting does not seem to come at the expense of scientific publication, and both respond to the

process of scientific discovery. Second, patent grants may reduce the extent of use of knowledge: the citation rate to a scientific article describing a dual-purpose discovery experiences a modest decline after patent rights are granted over that knowledge. Finally, the impact of patents may be indirect; rather than directly impacting behavior through patent enforcement, scientific conduct may be affected through related mechanisms such as material transfer agreements. Taken together, academic science has remained an adaptable and resilient institution; rather than subverting the nature of academic science, patents seem to have been incorporated into the overall process of scientific exchange and cumulative discovery.

The third paper in the volume, by Paula Stephan, examines the placement of new PhDs in industry. She argues that while the licensing of academic technology has gotten considerable attention, these flows of individuals are an important and neglected mechanism for transmitting knowledge from universities to industry.

Stephan finds some striking geographic patterns. Two of these are as follows.

- Geographic mobility is very common. Only 37 percent of PhDs trained in science and engineering stay in the state where they earn their doctorate. Almost one out of five new PhDs going to work for industry heads to the San Jose metropolitan area; 58 percent go to work in one of 20 cities.
- Midwestern universities educate over 26 percent of all PhDs going to industry, but in many cases, a very considerable fraction of those students leave the state for employment on the coasts.

She ends the paper with the thought-provoking argument that as the traditional U.S. industrial base shifts, Midwestern state legislatures are likely to be unwilling to continue to subsidize the education of scientists and engineers who work for firms elsewhere. She suggests that a highly trained workforce will only be maintained if the Federal government steps in to provide financial support for graduate education.

Erik Brynjolfsson and Xiaoquan (Michael) Zhang then consider how to provide incentives for producers of digital goods. Unlike traditional products, digital goods can be reproduced without cost. While a price equal to the marginal cost—that is, free distribution—might be economically efficient for consumers, such a pricing scheme would eliminate the economic incentives for creating such goods in the first place.

A variety of policy proposals to address this dilemma have been proposed in recent years.

The authors suggest that manufacturers of digital goods can solve this dilemma without help from policy-makers. In particular, they propose a new mechanism which solves this problem, essentially decoupling the price of digital goods from the payments received by innovators. The proposal incorporates two key elements, including the use of massive bundling and the use of "random" coupons. By bundling access to a wide variety of digital goods in a single package, it is possible to significantly reduce the deadweight losses arising from monopoly pricing. As well, by selectively limiting access to a very small share of the bundle for individual consumers, it is possible to infer the overall value placed by consumers over that portion of the bundle, and so appropriately reward different suppliers for their individual contributions to the bundle. This system appears to work better in stimulating innovation and encouraging widespread use than either giving the digital goods away for free or charging all consumers a premium price and consequentially sharply limiting their distribution.

In the final paper in this volume, Daniel Diermeier, Wallace J. Hopp, and Seyed Iravani turn our attention towards the challenges facing both public and private organizations that need to respond quickly and effectively to unanticipated events. As dramatically highlighted in experiences ranging from the September 11th attacks to Hurricane Katrina, the ability of public sector organizations to respond to crises varies dramatically, and seems to depend on their resiliency and adaptability. In offering foundations for a science of crisis management, Diermeier, Hopp, and Iravani integrate recent research on social networks with a flow network approach from production systems modeling to model performance under crisis conditions. Instead of preparing for specific scenarios (i.e., contingency planning), responding to the "unimaginable" may be enhanced by cultivating the ability to respond quickly and adaptively to unfamiliar situations, requiring both individual skills *and* effective collaborative relationships. In other words, the effectiveness of an organization in a crisis depends less on formal hierarchy (which may be unavailable or congested) than on the ability of individuals to trust, learn, and coordinate with each other.

Using agent-based simulation methods to evaluate alternative network structures, it turns out that overall performance depends on the interaction between the structure of a social network and the ability to learn and propensity to adapt by individuals within that network.

While the authors emphasize that the science of crisis management is at an early stage, the use of a formal analytical structure in this domain points the way to enhancing the design and performance of organizations faced with circumstances and events outside of their planning and experience.

While the issues involved are undoubtedly difficult, the essays highlight the role that economic theory and empirical analysis can nonetheless play in evaluating key policies impacting innovation. They suggest that contemporary research in economics can usefully inform the evaluation of current and prospective innovation policy alternatives.

Adam B. Jaffe, Josh Lerner, and Scott Stern

