NBER Innovation Policy Working Group Post-Doctoral Fellowship Proposal

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My research is broadly focused on the relationship between international flows of goods or knowledge and technological progress. Within this, my current research agenda focuses on three topics. First, I study the impact of changes in the costs of traded inputs to production on the rate and direction of technological progress (directed technical change). Second, I study learning or technology spillovers between industries and their implications for trade and the location of economic activity. Third, I am interested in innovation patterns in less developed countries, such as India, as they transition from imitators to knowledge producers. These interests seem to be a good fit for the goals of the NBER Innovation Policy Group, with numerous connections between my research and the research of current Innovation Policy Group members and other NBER researchers. Below, I describe each of these interests in more detail and outline ongoing research in each area.

A common theme in my research on all of these topics is gathering and using detailed new data, particularly previously unexploited patent data. Patent data provide a rich source of information on innovation. In much of my research, these data are combined with natural experiments, which allows me to provide causal evidence on factors which affect innovation patterns. One reason that gathering additional patent data is valuable is that it expands the set of circumstances under which we can study innovation patterns.

Directed Technical Change

Directed technical change is the idea that a change in the relative availability of inputs to production can influence the direction of technological progress. This idea is enshrined in a substantial theoretical literature starting with the work of Hicks (1932). Since then, the theory has been extended by Kennedy (1964), Samuelson (1965), and Drandakis & Phelps (1966) and more recently by Acemoglu (2002, 2007). The idea has also been applied to explain economic phenomena including skill-biased technical change and trends in wage inequality (Acemoglu (1998), Kiley (1999)), industrialization in Britain and the U.S. (Habakkuk (1962), Allen (2009)), and the impact of environmental regulations (Acemoglu *et al.* (Forthcoming)). Yet the predictions emerging from this theoretical literature remain largely untested empirically.

In my paper, "Necessity is the Mother of Invention: Input Supplies and Directed Technical Change", I seek to test the two main predictions emerging from the leading theory of directed technical change, developed in Acemoglu (2002). First, when inputs are sufficiently substitutable, the theory predicts that a change in relative input supplies will generate technical change directed towards the inputs which become more abundant. Second, if technical change is strongly directed towards the more abundant inputs, the relative price of these inputs will increase – the strong induced-bias hypothesis. My paper provides the first empirical test of these predictions using a large exogenous shock to the cotton textile industry

in 19th century Britain caused by the U.S. Civil War (1861-1865). I extend the theory to a setting in which input quantities are endogenous and affected by international transport cost shocks, such as that caused by the war. Using detailed new patent data, I show that there was a burst of cotton textile innovation in Britain during the war directed towards taking advantage of one input – Indian cotton – which became relatively more abundant. Next, I show that the relative price of Indian cotton first declined and then rebounded, consistent with the strong induced-bias hypothesis. These results provide support for the theory. My extended model also predicts that technical change directed towards the more abundant input will be magnified by a higher elasticity of input supply. This may explain why inventors chose to focus on innovations for Indian cotton, rather than Brazilian or Egyptian cotton, since I find evidence that the elasticity of supply was higher for Indian cotton.

In another project, I aim to test the suggestion, offered by Acemoglu & Zilibotti (2001), that, if new technologies are invented in developed countries, and tailored to the inputs available there, they may be mismatched with the inputs available in developing countries. This theory suggests that directed technical change may help explain the large productivity differences observed between developed and developing countries. Yet this idea has proven difficult to test empirically. One implication, however, is that a shock that makes the inputs available in developed and developing countries more similar will cause developed-country innovators to generate machines which are better adapted to conditions in the developing world, reducing cross-country productivity differences. To test this prediction, I again consider the impact of the U.S. Civil War on innovation in the British cotton textile industry, which caused British textile producers to switch to using Indian cotton. My study looks at whether this switch caused British inventors to invent machines better suited to using Indian cotton, whether these new technologies flowed to India, and whether this reduced the productivity gap between British and Indian textile producers. The results of this project will help us evaluate the extent to which directed technical change and technology mismatch can explain cross-country productivity differences.

Inter-industry spillovers

I am also interested in learning or technology spillovers between industries and their implications for trade and the location of economic activity. Inter-industry spillovers were first suggested by Marshall (1890) as one potential cause for the spacial agglomeration of economic activity. Today, they remain one important explanation of agglomeration economies and the existence of cities. These spillovers have always been difficult to observe, but recently economists have made significant advances in measuring these spillovers. My working paper, "Industry Connections and the Geographic Location of Economic Activity", combines these advances with a large exogenous shock in order to assess the causal impact of inter-industry connections on location decisions. The paper provides the first causal evidence that inter-industry connections can influence the geographic location of economic activity. To do so, it takes advantage of a large, exogenous, temporary, and industry-specific shock to the 19th century British economy. The shock was caused by the U.S.

Civil War, which sharply reduced raw cotton supplies to Britain's important cotton textile industry, causing a four year recession in the industry. The impact of the shock on towns in Lancashire County, the center of Britain's cotton textile industry, is compared to towns in neighboring Yorkshire County, where wool textiles dominated. The results suggest that this trade shock reduced employment and employment growth in industries related to the cotton textile industry, in towns that were more severely impacted by the shock, relative to less affected towns. The impact still appears over two decades after the end of the U.S. Civil War. This suggests that temporary shocks, acting through inter-industry connections, can have long-term impacts on the distribution of industrial activity across locations.

In further work on this topic, I consider the relationship between trade and economic growth in a model that incorporates technological spillovers between industries. In many trade models, trade acts to reallocate industries across countries. A growing empirical literature suggests that certain pairs of industries may share economically important spillovers. When such spillovers exist, and trade causes one industry to switch locations, this movement will have dynamic implications for other industries in both locations. This project introduces a dynamic trade model which allows me to explore the impact of trade on economic growth in an economy characterized by inter-industry spillovers, and in particular, industry clusters.

Innovation in the Developing World

While innovation patterns have been heavily studies in developed countries, particularly the U.S. and Europe, relatively little research has been done to learn about innovation in less developed countries. One reason for this focus is data, specifically, the availability of large and detailed patent datasets which can be used to understand innovation patterns in the U.S. and Europe. Such data has generally not been available for less developed countries. However, this is beginning to change, with large numbers of patents being filed in developing or middle income countries such as China, Brazil, and India.

My current work on this topic focuses on collecting, cleaning, and analyzing, patent data from India. Using a small seed grant from the CIBER Institute at the Columbia Business School, I recently went to India to collect a complete set of Indian patent data spanning 1995-2005 and all patents granted from 1995-2008. These data include over 175,000 patents and provide details on the type of invention being patented and the name and location of the inventor and patent holder. The aim of the project is to use these data as a window into innovation in an economy which is transitioning from one which absorbs foreign technology, to one which is a technology producer. The data can also be used to study the factors affecting the decision of firms in developed countries to patent their technology abroad. While I will use the data to conduct my own research, I also plan to make them available to the broader research community, as was done previously with the U.S. patent data. Currently, I am in the process of cleaning these data, and the next step is to begin linking them to other data sets, such as the PROWESS firm-level data or patent data from the U.S. and Europe.

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