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Does innovation policy attract international competition? Evidence from energy storage

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ABSTRACT

Though existing studies suggest that innovation-promoting public policies are associated with an increase in the number of inventions generated, these studies do not explore the geographic origin of such inventions. Though domestic policies aimed at developing innovation capabilities in a particular technological area may result in more innovation, such policies may also invite more competition from technologies developed abroad. In this paper, we describe the impact of two categories of innovation-supporting policies: those focused on the supply of a given set of technologies, and those focused on the demand for products based on these technologies. We argue that the latter will result in relatively more technology transfer into a given country from abroad. Using international panel data on the patenting of energy storage technologies, we explore the impact of these two policy types on domestic innovation and the inward transfer of foreign-invented technologies. Our results indicate that the transfer of such technologies into a given country increased significantly after demand-pull policies were put into place, but the same pattern does not hold for supply-push policies.

1. Introduction

Political leaders often promote innovation policies that seek to bolster a country's technological or industrial leadership by fostering national competitive advantage in an area of special economic or technological significance. For example, U.S. President Barak Obama declared that the development of "green" technologies in areas such as energy production would create a foundation on which the United States could "build the clean energy economy that is key to our competitiveness in the 21st century" (Finance Wire, 2009). Similarly, a European Commission press release described the benefits of air pollution reduction policy, including "measures to reduce air pollution will boost innovation and enhance European competitiveness in the field of green technology," (European Commission, 2016). Such statements are consonant with the currently favored strategy of government-supported "smart specialization" to promote focused development of key technological sectors (Foray et al., 2011; Foray, 2009; Foray and Goenaga, 2013). Existing studies provide partial support for the efficacy of this policy approach by demonstrating that firms increase their R & D expenditures and patenting rates in response to public policies intended to stimulate innovation (Hall and Van Reenen 2000; Bloom et al., 2002; Popp 2002; Newell et al., 1999; Jaffe et al., 2002; Johnstone et al., 2010; Horbach, 2008).

These studies do not investigate, however, whether such increases are attributable to domestic inventors—which would be consistent with the objective of building a country's technological and industrial leadership—or alternatively, whether they represent inventions developed outside of the country that are transferred into the domestic market. Evidence on the geographic origins of innovation is critical for understanding and anticipating the effect of policies on local market competitiveness. In the analysis below, we illuminate this topic by examining the extent to which national policies intended to promote local innovation actually increase domestic innovation, versus the extent to which these policies result in the transfer of technologies developed abroad into the policy-passing country.

Our understanding of the impact of innovation policies is guided by the national innovation systems literature, which recognizes that the innovativeness of a country depends on multiple interacting factors including demand conditions, knowledge resources, institutions, the competitiveness of markets, and the policy environment. Innovation-promoting public policies are frequently justified as a solution to a market failure inherent in the innovation process, and can target specific factors in the innovation system. For instance, policies can be broadly categorized into those that directly promote R & D investments

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and knowledge development, targeting the availability of knowledge resources, and those that indirectly promote innovative activity by increasing the demand for innovations. The first category, "supply-push," is intended to increase the supply of a particular technology type and includes measures such as direct R & D subsidies, tax credits for R & D, and financial support for R & D personnel. The second category, "demand-pull," aims to prop up demand for relevant innovations and includes mandated purchases, minimum purchase requirements, and targeted subsidies. The two types of policies leverage different mechanisms, but both may result in increased innovation.

Though the National Innovation Systems literature guides our thinking, this body of literature contains a significant gap—also reflected in studies documenting the impact of various policies on innovation rates more generally—that our study begins to fill. Prior research has either been agnostic about the geographic location of innovation, or it has focused exclusively on the domestic impact of a given policy, without considering the possibility that firms in other countries may also respond to this policy (Coenen et al., 2012; Quitzow et al., 2014). We argue that firms located elsewhere will respond to a given country's policy initiatives, and that supply-push and demand-pull policies will have different effects on such firms' decision to transfer their technologies abroad. Specifically, we contend that relative to supply-push policies, demand-pull policies will lead to a larger increase in the transfer of foreign technologies into the country implementing the policy.

The well-publicized recent bankruptcy of several federally-subsidized American solar energy firms, such as Solyndra, provides a suggestive example that helped motivate our research. Though the Obama administration and state level policy makers implemented a suite of policies intended to promote "green" energy innovation, including providing low interest rate loans to suppliers and requiring electric utilities to increase the provision of power generated using solar technologies, domestic solar energy firms still failed. The U.S. Congress attributed the failure of these firms to increased competition from Chinese solar panel manufacturers (Sweet and Tracy, 2011). Data from the Earth Policy Institute are broadly consistent with this claim: during the period 2000–2010, Chinese solar panel production grew by nearly 11,000 MW and U.S. production grew by only 1000 MW, despite the fact that installed solar generation capacity in the U.S. increased 65% more than solar generating capacity in China did during this time.[1] This anecdote is consistent with the contention that Chinese solar panel manufacturers responded to (and benefited from) U.S. policies promoting the adoption of solar generation technology, bringing such technology to the U.S. market to meet policy-induced demand.

Building on this example, we examine the international transfer of energy storage technologies, which are regarded as a key to ending the world's reliance on fossil fuels (*The Economist*, December 6, 2014). Advances in energy storage are considered necessary for the deployment of large-scale renewable energy facilities (Denholm et al., 2010), and they also represent "the most important thing we can do to make electric vehicles more prevalent," according to Tesla's Chief Technology Officer (*The Economist*, December 6, 2014). Technological uncertainty, the need for significant financial investment, and the market failures discussed below have led governments around the world to promulgate both supply-push and demand-pull policies intended to stimulate innovation in this area.

We examine the impacts of supply-push and demand-pull policies on domestic innovation rates, and we explore whether demand-pull policies do, in fact, produce a larger increase in the transfer of technologies[2] developed abroad into the policy-passing country than supply-push policies do. Our empirical analysis identifies 36 national policies related to energy storage passed in 11 OECD countries during the period 1990–2011. Of these policies, 16 represented demand-pull policies, 19 qualified as supply-push, and one had both supply and demand components. We combine the policy data with panel data on energy storage patents granted in 61 countries (but invented in over 75 countries) during the period 1990–2011. Based on the pattern of patent protection for the same invention across multiple national jurisdictions, we trace the protection of patented technologies as a proxy for the transfer of technologies across geographic markets (Eaton and Kortum 1996; Hascic and Johnstone 2011). Using the resulting dataset, we employ a difference-in-differences methodology to estimate the impact of policies on the transfer of patented energy storage technologies.

Consistent with prior research, our results demonstrate that the passage of policies to promote green energy-storage technology is associated with a subsequent increase in domestic innovation. Consistent with our predictions, we also find that the adoption of a demand-pull policy is followed by a significant increase in the importation of foreign technology into the policy-passing country, as reflected in domestic patent applications for relevant technologies originally developed and patented abroad. We find no such pattern for supply-push policies, however.

Our study provides novel evidence on the impact of different types of policies on the international transfer of innovations. From a public policy perspective, the results are valuable because they suggest that the increase in patenting typically observed after the passage of an innovation-promoting policy may be reflecting increases in both domestic innovation and inward international technology transfer. Thus, a domestic innovation-promoting policy may encourage product market competition from abroad even as it succeeds in spurring innovation domestically. Further, the method that we use to trace the international movement of patented technology—which holds promise for examining a range of research questions related to global innovation and cross-national technology flows—has not been widely exploited in innovation management research.

2. Theory and hypotheses

The process generating new inventions has long been understood as a system of feedback loops (Kline and Rosenberg 1986) connecting a set of interrelated factors that may promote or inhibit innovation. A country's innovativeness is seen as the outcome of a national innovation system comprised of demand factors (customers, tastes, customs, purchasing power), supply factors (technology, knowledge, research funding, universities, basic research infrastructure), formal institutions (government policies, regulations, infrastructure) and informal institutions (cultures, norms, expectations), as well as the firms engaged in innovation, the competitiveness of the market in which they compete, and the presence or absence of supporting industries (Nelson, 1988; Lundvall, 1988; Freeman, 1988; Porter, 1990, 1998; Mowery and Nelson, 1999; Furman et al., 2002). We leverage this theoretical framing to classify policy initiatives according to the elements of the innovation system through which they are intended to operate.

Research in the National Innovation System (NIS) tradition has utilized this framework to understand the drivers of innovativeness for firms, regions, and countries, examining the institutional structures that shape and augment underlying supply-push and demand-pull influences on the rate and direction of innovation (Nelson, 1993; Mowery and Oxley, 1995; Freeman, 1995; Pavitt and Patel, 1999). In general, where there exist effectively functioning systems whose component pieces promote innovation (such as skilled human capital or institutions that

[1] Installed solar generation in the U.S. increased by 856MW and that in China grew by 520MW.

[2] Throughout the paper, we use the term "technology transfer" to describe the geographic movement of patented technologies across national boundaries. This usage differs from that in research seeking to measure the movement of knowledge across geographic space by using patents and patent citations to represent knowledge flows. In this paper, "technology transfer" means that intellectual property protection for a specific technology is extended to an additional country.