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Innovation: The interplay between demand-side shock and supply-side environment☆

Ivalina Kalcheva[a], Ping McLemore[b,*], Shagun Pant[c]

[a] University of California, Riverside, School of Business Administration, United States
[b] Federal Reserve Bank of Richmond, United States
[c] University of Iowa, Department of Finance, United States

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ABSTRACT

We study the interaction between supply- and demand-side factors and its effect on innovation. Employing a quasi-natural experiment, we show that a shift in demand has an impact on innovation and this effect is conditional on an enabling supply-side environment. Specifically, we exploit a shift in product demand generated by Medicare approvals for reimbursement coverage of medical devices. Using a triple-difference approach, we find that innovation is significantly greater for medical device firms that experience a positive shock to demand due to the Medicare approvals when the firms are exposed to a more favorable supply-side environment. The highest level of innovation is accomplished when all three of our supply-side factors: venture capital (industry), universities (academia), and National Institutes of Health grants (government) are concentrated in one place. These findings show that (i) a positive interaction between supply- and demand-side factors fosters innovation, and (ii) the trilateral intersection of industry, academia, and government creates the highest level of innovation.

1. Introduction

The idea that innovation plays a crucial role in economic growth dates back to Schumpeter, who states that "earning out innovations is the only function which is fundamental in history" (Schumpeter, 1939, p. 100). Innovation is a slow and gradual process, a result of a nexus of different factors. Through the years, two separate strands of academic literature have evolved that concern innovation – one studies the supply-side factors and the other investigates the demand-side factors (Shane and Ulrich, 2004; di Stefano et al., 2012; Chemmanur and Fulghieri, 2014). Notably, little integration has occurred between these two strands of literature and the interplay between the demand- and supply-side factors for stimulating innovation has been largely unexplored. On the empirical front, researchers who examine the effects of supply-side factors on innovation have controlled for potential market size but have not systematically explored the interaction effects between the demand- and supply-side factors (Toole, 2012; Blume-Kohout, 2012).[1] Our study fills this gap in the empirical literature. By taking advantage of a quasi-natural experiment, we simultaneously address the effect of both the supply- and demand-side factors on innovation. We find that a shift in demand has an impact on innovation and that this effect is conditional on an enabling supply-side environment. We contribute to this field of research by showing empirically that the interaction between a positive shift in demand and favorable supply-side factors leads to the highest level of innovation.

We examine the interaction between the supply- and demand-side factors on innovation in a quasi-natural experimental setting in the medical device industry. We utilize events where some medical devices

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* Corresponding author.
E-mail addresses: ivalina.kalcheva@ucr.edu (I. Kalcheva), ping.mclemore@rich.frb.org (P. McLemore), shagun-pant@uiowa.edu (S. Pant).

[1] Adner and Levinthal (2001) present a demand-based model of technology evolution that is focused on the interaction between technology development and the demand environment in which the technology is ultimately evaluated. They use simulations to suggest that demand heterogeneity is an important concern as firms move from product to process innovation. Zmud (1984) uses survey data and does not find evidence that innovation is most likely to occur when a need and a means to resolve that need are simultaneously recognized.

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receive Medicare national coverage reimbursement approvals (the treatment group) and some do not (the control group).[2] With the reimbursement approvals, a large portion of the cost to the consumer for these devices is covered through Medicare. As a result, the Medicare national reimbursement approval represents a positive exogenous shock to the demand for the device receiving the approval in all states in the United States. The increase in demand for a particular device is a potential trigger for innovation. Medical device firms operate in an industry that is characterized by high levels of competition and extensive patenting. As a result, firms need to innovate in response to the positive shock to demand if they are to keep their competitive edge. Notably, the exogenous shock to product demand represents a shift in the demand curve, which helps us analyze the effect of an increase in demand on innovation (Mowery and Rosenberg, 1979; Dosi, 1982).

Schumpeter (1939) defines innovation as "any 'doing things differently' in the realm of economic life" (Schumpeter, 1939, p. 80). Innovation is a multifaceted concept and measuring it is a daunting task for empirical research. We proxy for innovation with the number of filings for pre-market approvals (PMAs) and 510(k) clearances that medical device firms are required to file with the Food and Drug Administration (FDA) before the device can be sold on the U.S. market. Successful innovation occurs when new products or processes are introduced to the market. "Innovation occurs at the point of bringing to the […] market new products and processes arising from applications of both existing and new knowledge." (Greenhalgh and Rogers, 2010, p. 3) Our measure of innovation captures the output stage of the innovation process and, thus, is a measure of product innovation.

Next, we identify, define, and measure the supply-side environment. Our sample consists of private firms, which are usually small relative to publicly traded firms, in the medical device industry. To construct a measure of the quality of the supply-side environment, we rely on input factors that are important for medical device firms. We take advantage of the fact that the quality of the supply-side factors is naturally geographically segmented at the state level and define the supply-side environment for firms in our sample at the state level. Specifically, we consider National Institutes of Health (NIH) grants, availability of venture capital (VC), number of research universities, R&D investments, and Small Business Innovation Research (SBIR) funding.

We employ a triple-difference regression model to study the relation between innovation, demand, and an organization's supply-side environment. The triple-difference model compares the difference in innovation between the device categories that are affected by the demand shock and those that are not, before and after the shock, across states with a more or less favorable supply-side environment.[3] The parameter of interest of the triple-difference model is the interaction term of the following three variables, which captures the three layers of difference: (1) treatment versus control group; (2) before versus after the demand shock; and (3) a more versus a less favorable supply-side environment.

Our tests address the question of whether the interaction between the demand and the organization's supply-side environment is an important component in nurturing innovation. We find that, indeed, both the supply-side environment and the demand for innovation are essential ingredients for firms to effectively innovate. In response to the increase in demand for medical devices, we observe more innovation in the treatment group that has access to a better supply-side environment. This finding implies that innovation takes place in the presence of both an increase in the market demand for innovation and a nurturing environment to innovate. Our results are robust to a series of sensitivity tests, which include but are not restricted to various empirical specifications, and various ways of constructing the measure for innovation, as well as the measure for the supply-side environment.

Our study relates to the strand of literature on public policy towards innovation. There is considerable evidence that innovation affects economic growth and researchers have looked at factors that impact innovation such as talent, federal programs, and research universities (Zucker et al., 2002; Iansiti, 2000). First, we show that an increase in demand through Medicare approval helps foster innovation in the medical device industry. This finding has implications for regulators to provide incentives (such as solar systems tax breaks, electric cars tax breaks, etc.) that lead to a positive shift in the demand curve. Second, we provide evidence that each of the supply-side factors: VC (industry financing), NIH (government involvement in programs that support research), and research universities (academia) are important for innovation. We further show that the intersection of these factors is vital for fostering innovation (e.g., the presence of research universities on its own is not as impactful as research universities combined with VC availability). The highest level of innovation is accomplished when all three supply-side factors are concentrated in one place. This finding speaks to the importance of the triple helix of university-industry-government (Etzkowitz and Leydesdorff, 2000).[4] While each factor is important on its own, the trilateral interrelation between academia, state, and industry creates the highest level of innovation. Third, we provide evidence that for private firms location (geographical proximity) matters. Firms in states that have access to all three supply-side factors are able to innovate and better respond to shifts in demand. Given this evidence, we contemplate that the formation of innovation clusters such as California, New Jersey, and Massachusetts is due to an intersection of factors: availability of financial resources (venture capital), government involvement, and university collaboration. Regulators may take initiatives to alleviate financial constraints, such as catering to venture capitalists and providing grants. Additionally, there is a need to establish and support the growth of research universities that train skilled labor, provide a platform to collaborate, and often serve as incubators for new firms.

The remainder of the paper is organized as follows. Section 2 presents the research design and provides institutional details. Section 3 describes the data, variable construction and methodology. Sections 4 and 5 present the main empirical findings and results of robustness tests, respectively. Section 6 concludes.

2. Institutional details and research design

The debate of whether supply-side or demand-side factors induce innovation started in the 1970s and by the 1980s the consensus among empirical researchers was that supply-side factors were the main drivers of innovation and that demand played only a complementary role (di Stefano et al., 2012). di Stefano et al. (2012) provide an extensive review of the most influential articles, based on bibliometrics, that have dealt with the aforementioned topic and conclude that demand is an important source of innovation. For example, there is some evidence that firms direct their R&D efforts, and ultimately innovation, toward the most profitable and largest markets (Schmookler, 1962, 1966; Acemoglu and Linn, 2004). Another strand of literature reports a strong positive relationship between innovation (more patents for energy-saving technology) and energy prices (Newell et al., 1999; Popp, 2002). Yet another strand of literature indicates that consumers are a crucial source of ideas (Adner and Levinthal, 2001; Von Hippel, 1986). To our knowledge, Zmud (1984) is the only study to look at whether innovation is most likely to occur when a need and a means to resolve that

[2] Phillips and Sertsios (2016) also exploit the event of Medicare national coverage reimbursement approvals of medical devices but study the differences in external financing sensitivities to investment opportunities for public versus private firms.

[3] Medical device categories receive Medicare approvals on different dates. This fact is advantageous for our study since it is less likely that our tests are affected by contemporaneous changes in economy-wide factors.

[4] This finding is supported by articles in the popular press. For example, "Silicon Valley is a unique amalgam of academia, private sector and US government research investment coupled with a population of (serial) entrepreneurs." in "Next Silicon Valleys: How did California get it so right?" by Neil Koenig 9 February 2014, BBC News. See: http://www.bbc.com/news/technology-26041341.