Companies learning to innovate in recessions☆

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ABSTRACT

Innovating in downturns can affect corporate success by improving a firm's position relative to competitors during the recovery period. However, increased uncertainty and more binding financial constraints complicate such innovation activity. I find that past experience with innovation during recessions improves a firm's ability to invest in R&D when a new downturn hits. This result holds controlling for traditional drivers of innovation as cumulated innovations and financial constraints, as well as mitigating endogeneity and selection concerns. Moreover, I find that past experience with innovation during recessions is beneficial to patent outcomes after a new recession. Overall, the paper provides novel evidence on how business cycles shape innovative capabilities.

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1. Introduction

A long-running literature has debated around two main theories on the innovation process. The first, based on the notion of *creative accumulation*, suggests that technological progress stems from the accumulation of knowledge and competences over time (e.g. Nelson and Winter, 1982). The second, based on the Schumpeterian notion of *creative destruction*, sees innovation as a disruptive process in which innovation generates monopoly rents that are, however, only temporary because easily-accessible knowledge attracts entrants that erode such rents.

As discussed in existing works (Filippetti and Archibugi, 2011; Archibugi et al., 2013), these theories predict a different profile of the firms that would be best equipped to ride out economic recessions: on the one hand, established firms that benefit from cumulated technological knowledge; on the other hand, young innovative firms able to exploit the technological discontinuities. This paper contributes to the literature on the determinants of corporate innovation during recessions by testing whether innovation experience cumulated during specific business cycle conditions, i.e. recessions, helps firms innovate when a new downturn hits.

I conduct the empirical analysis using data on US-listed companies matched with the NBER patent data set. The sample period includes three downturns of the US economy: the early 1980s, the early 1990s and 2001. I start by constructing a variable that measures large R&D increases during the early 1980s recession. I then use this variable to predict R&D expenditures during the two post-1980s recession periods,[1] after controlling for traditional drivers of innovation in hard times, e.g. financial constraints (Campello et al., 2010; Aghion et al., 2012; Paunov, 2012) and cumulated innovation output (Archibugi et al., 2013). These controls help address the concern that firms with innovation experience during past recessions may innovate more during a future one *because* they are less financially constrained and/or endowed with a larger stock of innovations.[2] Results indicate that having increased (reduced) innovative activities in the early 1980s recession has a positive (negative) and significant effect on R&D investment during subsequent recessions.

[1] This empirical setting is similar to Fahlenbrach et al. (2012), who use the stock market performance of banks during the 1998 crisis to predict bank performance during the 2008 crisis.
[2] Controlling for the stock of innovations is also important to rule out the possibility that firms innovating in past recessions had more existing patents that could be pledged as collateral, facilitating the credit access needed to fuel their innovation during the new downturn.

I validate this finding in several ways. First, I verify that results hold controlling for industry and industry-year specific effects, thus mitigating the concern that results may be driven by some firms operating in industries with counter-cyclical R&D. Second, I reduce survivorship and endogeneity biases using alternative estimation strategies. Third, I check that R&D in normal years does not have a similar effect. Fourth, I show that innovation-unrelated investment during past recessions does not predict innovation in subsequent recessions.

These findings are relevant in light of the above-mentioned debate on innovation theories as they suggest the presence of creative accumulation points along the business cycle. From a firm-level perspective, results are consistent with the notion of *strategic persistence* advanced by organizational and strategy scholars. This research suggests that past strategies have bearing on the present (Boeker, 1997) because, as result of organizational learning, firms tend to stick with actions that have worked in the past (Audia et al., 2000). Similarly, finance scholars have drawn on learning theories to understand how experience shapes investors' decisions and performance (see e.g. Kaustia and Knupfer, 2008; Seru et al., 2010; Chiang et al., 2011).

Adapting to the innovation context the arguments proposed in Chiang et al. (2011), I investigate the performance implications of my findings from a learning lens. On the one hand, having conducted innovative activities during past recessions may have spurred the development of recession-specific competencies, for instance related to reallocating projects, dealing with financial constraints and retaining/attracting key innovative employees. This *rational* organizational learning mechanism predicts that, relative to firms with experience of innovation during past recessions, firms with such experience are better able to invest in high-quality R&D projects during a new recession and should thus exhibit better subsequent performance. On the other hand, firms that gained experience of innovation during past recessions may have become overly optimistic about their ability to successfully innovate again in adverse situations. This *naïve* organizational learning mechanism would induce a dysfunctional persistence whereby firms that innovated in past recession invest in R&D projects of both high and low quality during a new recession, and may end up experiencing lower performance. Thus, both rational and naïve learning mechanisms predict that firms with experience of innovation in past recessions engage more in R&D during a new recession; however, the performance effect are potentially different.

I estimate a difference-in-differences model around recession years to discriminate between these two mechanisms. In particular, I interact a dummy variable set equal to 1 for the post-recession years with the variable measuring a firm's experience of innovation during previous recession. Results indicate that past experience with recession-R&D increases the quality of a firm's innovation outputs, as measured by future citations received (Trajtenberg, 1990), and innovative efficiency, as measured by citations per R&D dollar (Hirshleifer et al., 2013), following a new recession.

This paper relates to a large body of research on technological accumulation (e.g. Pavitt et al., 1989) and persistence of innovation (e.g. Geroski et al., 1997; Malerba and Orsenigo, 1997; Cefis and Orsenigo, 2001; Cefis, 2003; Peters, 2009) as well as investment and financing policies (Cronqvist et al., 2009). More specifically, the paper contributes to recent works on innovation in times of crisis (e.g. Filippetti and Archibugi, 2011; Paunov, 2012; Archibugi et al., 2013). For instance, Archibugi et al. (2013) show that compared with non-innovative firms, innovative firms implemented less extensive reductions in innovation activities during the economic crisis of 2008. I extend these insights by showing that the innovative capabilities most valuable for overcoming a new recession are those specifically built during past recessions. In other words, the accumulation of innovative experience over different

business cycle conditions strongly shapes future innovation performance.

Finally, the paper relates to a growing strand of research that documents how the exposure to recessions shapes individual risk aversion (Malmendier and Nagel, 2011), social preferences (Giuliano and Spilimbergo, 2014), CEO styles (Schoar and Zuo, 2012), and inventors' productivity (Shu, 2012). The closest paper here is Fahlenbrach et al. (2012), who adopt an organizational viewpoint and show that banks performing the worst in the 1998 crisis (following Russia's default on some debt obligations) were worst performers also during the 2008 crisis. I complement this finding by focusing on recession-specific technological knowledge as a specific mechanism that renders some firms better able to face economic downturns.

The paper is structured as follows. Section 2 describes the data and the construction of the key variables. Section 3 presents the empirical results linking R&D investment over different recession periods and studies the performance implications. Section 4 concludes.

2. Data and variables

Firm-level data come from the Compustat data set. I exclude companies with negative/missing values of revenues and R&D,[3] as well as companies operating in finance (SIC code 6000-6999) and government-regulated industries (SIC code > 9000), and headquartered outside the US. I then follow the procedure in Bessen (2009) to match Compustat firms with patent data from the NBER (National Bureau of Economic Research) data set. This data set contains information on all the patents awarded by the US Patent and Trademark Office (USPTO)—and on the citations made to these patents—for the period 1976–2006 (Hall et al., 2001).

To identify recession periods for the US economy, I use the official NBER business cycle dates and classify as recessionary a year in which at least two quarters were in recession. Given the time period covered in the NBER patent data set, the analysis includes three recession periods: the downturn of the early 1980s, which initiated in 1980 and, after a mild recovery in 1981, bottomed out in 1982; the early 1990s recession (from July 1990 to March 1991); and the tech bubble of 2001. One drawback of this approach is that US state business cycles are not perfectly correlated (for instance, in the early 1990s Texas experienced a much shorter recession than e.g. California) and firms headquartered in different states may have been affected heterogeneously by such state-specific recessions. To mitigate this concern, I follow Owyang et al. (2005) to identify recession years specific to a given US state.

For the empirical analysis, I need an explanatory variable measuring those innovation activities specific to a given recession. Patent applications filed during recessions may be helpful; however, it is hard to establish whether the innovative process behind the patent application was initiated in the same (recession) year of the application or, likely, in previous (non-recession) years. To overcome this limitation, I focus on innovation inputs. Specifically, I construct an indicator equal to one for firms that undertake an (average) relevant increase in R&D expenditures during the early 1980s recession relative to R&D in the previous non-recession year[4]; and equal to zero for firms that do not report any relevant increase in R&D investment (or also reporting zero R&D both during pre-recession and early 1980s recession years). Similar to Eberhart

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[3] In robustness checks, I verify that results are robust to treating missing-R&D firms in different ways as proposed by existing works.

[4] In constructing the R&D changes, I need to exclude firms that, either because of missing R&D or later entry, are not present in the sample in the year prior to the early 1980s recession.