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The persistency and volatility of the firm R & D investment: Revisited from the perspective of technological capability

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ABSTRACT

The persistency and volatility of firm R & D investment has been a popular research subject for the R & D management field; however, previous research has found mixed evidence concerning the persistency and volatility of firm R & D investment. This paper empirically reveals the reason for the conflicting arguments among researchers by considering each firm's technological capability. The influence of technological capability on R & D investment differs depending on positive and negative shocks, and this influence can be the key to understanding heterogeneous R & D behavior across firms.

The results show that technological capability amplifies the internal cash flow effect and cause volatility in R & D investment when sales increase over the sales of the previous year; positive shocks. However, technological capability offsets the internal cash flow effect and causes persistency in R & D investment when sales decreases from the sales of the previous year; negative shocks. These imply that R & D investment is not a dichotomous decision between persistency and volatility and is conditional on each firm's technological capability.

1. Introduction

As competition increases and technologies change rapidly, firms must secure competitive advantage through R & D activities for sustainable development. Increases in R & D investment, however, are limited because of resources and capability constraints; therefore, identifying optimal R & D investment has been one of the main research subjects.

Many previous studies have treated optimal R & D investment from a static perspective where the level of R & D investment is determined by the situation of the firm (Barge-Gil and López, 2014; Del Canto and Gonzalez, 1999; Cohen and Klepper, 1992; Galende and de la Fuente, 2003; Lee, 2003; Del Rio et al., 2011). Firms try to attain optimal R & D investment for profit-maximization, and R & D investment depends on internal and external factors (Dorfman and Steiner, 1954). For example, firm R & D investment is influenced by the firm's characteristics such as firm size, cash flows, and diversification (Cohen and Klepper, 1992) along with external factors such as market competition and technological opportunity (Levin et al., 1985).

Nevertheless, it is necessary to consider R & D investment from a dynamic perspective because current R & D investment is also influenced by previous investment. A major concern from a dynamic perspective is whether R & D investment is persistent or volatile. Persistency in R & D investment implies that the firm maintains the R & D investment levels of the previous year because of high adjustment costs and sunk costs in R & D investment. Firms attempt to maintain consistent levels of R & D investment over time, in spite of a changing external and internal environment, to minimize those adjustment and sunk costs (Brown and Petersen, 2011; Himmelberg and Petersen, 1994; Shin and Kim, 2011).

Some research argues to the contrary and suggests that R & D investment is independent of previous one that is volatile (Guellec and Ioannidis, 1997; Mudambi and Swift, 2011; DITR, 2007). According to DITR (2007), R & D investment is unstable at the firm level. Volatility in terms of the number of researchers as well as R & D investment is also observed. Volatility of R & D investment is mainly caused by dependency on internal financing as an R & D investment source. External financing is more expensive than internal financing because of high risk and asymmetric information in R & D investment, which causes R & D investment to be sensitive to shocks and to fluctuate.

Conflicting arguments concerning persistency and volatility in R & D investment are based on unrealistic assumptions. Previous research has typically assumed a homogenous reaction to shocks across firms and symmetric responses to positive and negative shocks. However, this

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oversimplifies firm behavior without considering heterogeneity across firms.

This paper aims to examine empirically the reason for the different arguments concerning persistency and volatility in R & D investment. To mitigate the strong assumption made by previous research, we suggest considering firm-specific technological capability. Technological capability related to firm-specific knowledge decides the firm's unique innovation actions (Del Canto and Gonzalez, 1999; Dosi et al., 2010; Lee, 2010, 2003). Higher technological capability typically guarantees a higher return on R & D; therefore, firms with higher technological capability have greater incentive to increase R & D investment (Hottenrott and Peters, 2012). By considering technological capability, we account for heterogeneity across firms; and explain asymmetric R & D investment under positive and negative shocks.

The remainder of this paper is organized as follows. Section 2 reviews the dynamic pattern of R & D investment, persistency and volatility, in previous research. Section 3 presents the theoretical framework and research hypotheses. Section 4 describes the empirical model and the method used to estimate the model. Section 5 presents empirical results. Finally, Section 6 discusses implications and concludes the paper.

2. Literature review

2.1. Persistency of R & D investment

R & D investment tends to maintain existing levels of R & D activity, minimizing variation (Brown and Petersen, 2011; Harhoff, 1998; Himmelberg and Petersen, 1994; Lach and Schankerman, 1989; Shin and Kim, 2011).

There are theoretical perspectives on the causes of R & D persistency. First, R & D investment is accompanied by high adjustment costs (Bernstein and Nadiri, 1989; Hall, 2002; Himmelberg and Petersen, 1994; Lach and Schankerman, 1989). R & D activity depends heavily on researchers and embodies firm-specific implicit knowledge. Consequently, reducing research-based human resources results in a loss of accumulated knowledge that, in the worst scenario, can be transferred to rival companies (Pakes and Nitzan, 1983). Similarly, newly hired researchers require considerable time to learn and accumulate firm-specific knowledge. Bernstein and Nadiri (1989) show that the marginal adjustment costs of R & D investment is higher than that of physical investment. Second, R & D investment is accompanied by high sunk costs (Mañez et al., 2009). If an R & D project is interrupted before tangible results are achieved, previously invested funds cannot be collected (Guellec and Ioannidis, 1997). Therefore, there is a strong incentive to persist with ongoing R & D projects until tangible results manifest. Third, researchers also prefer to continue their own projects until results are obtained (Bernardo et al., 2001). Ending an ongoing project places a researcher at a distinct disadvantage with respect to performance appraisals and reduces researcher morale (Balachandra et al., 1996). Particularly, the bigger the R & D project, the stronger the incentive to persist with the project until completion. Finally, R & D investment has diseconomies of time compression, which means that consistency over the long run is more efficient than the same total investment over a shorter period (Dierickx and Cool, 1989). In other words, it is more efficient for a firm to accumulate knowledge over a certain period of time than it is to spend twice the amount of R & D over half the time period.

According to the empirical analysis, even when internal and external environments ceaselessly change, firms try to minimize the variation of R & D investment and maintain the level of investment (R & D smoothing; Brown and Petersen, 2011; Himmelberg and Petersen, 1994; Shin and Kim, 2011). Firms utilize cash holding for R & D smoothing. For instance, during recessions when R & D financing is less affordable, accumulated cash holding can be used to continue R & D investment, and investment can be expanded during economic expansion. Brown and Petersen (2011) show that around 75% of startups used cash holding for R & D smoothing during the stock market downturn from 1998 to 2002. According to an empirical analysis of Korean listed companies by Shin and Kim (2011), firms use cash holdings more often to smooth asset-counted R & D investment compared with cost-counted R & D investment because asset-counted R & D tends to have higher adjustment costs than cost-counted R & D.[1] Incentives on R & D persistency differs by context. The external conditions of a firm cause differences in incentives on R & D persistency (Woerter, 2014; Bloom, 2007). Woerter (2014) empirically proves that market competition leads to differences in incentives for R & D persistency. Incentive for R & D persistency was the strongest among 6–10 major competitors and was weakest under conditions with more than 50 competitors (inverted-U shape). Bloom (2007) analyses the relationship between persistency and uncertainty. He found out the higher the uncertainty, the stronger the incentive. This is because under uncertainty, firms are more likely to monitor changes, maintain the R & D investment (caution effect). Previous research contributed to discovering that persistency may have different incentives depending on the context, but limited effects of firm-specific factors.

2.2. Volatility of R & D investment

Many previous studies support the persistency of R & D investment based on adjustment costs and sunk costs; however, some research finds that firm R & D investment shows volatility (Guellec and Ioannidis, 1997; Mudambi and Swift, 2011; DITR, 2007). According to DITR (2007), R & D investment at the national and industry level shows little year-on-year change but it is unstable at the firm level. DITR (2007) finds that 75% of Australian firms exhibited highly volatile patterns of R & D investment over time. This volatility was also observed in the number of R & D researchers.

There are several theoretical perspectives on the causes of R & D volatility. First, the main cause of this volatility is a high dependency on internal financing as a source of R & D investment, which fluctuates over time. Dependency on internal financing in R & D exists because external financing is more expensive than internal financing in the incomplete financial market (Myers, 1977; Myers and Majluf, 1984). R & D investment is exposed to the asymmetric information problem. A firm has more information concerning the likelihood of R & D project success than investors (Hall and Lerner, 2010), and firm performance is difficult to evaluate by investors because of its intangibility. Transaction costs increase more due to limited access to information and the uncertainty of R & D investment (Williamson, 1981). Investors require higher risk premiums or greater collateral than ordinary investments to offset transaction costs, firms prefer internal funds to external financing as a source of R & D investment. Another cause of R & D investment volatility is proactive management (Mudambi and Swift, 2011; Swift, 2013). Rather than waiting for the outcome of an R & D project, top management should differentiate good and bad projects real time and put more resources into good projects. According to Mudambi and Swift (2011), firms with proactive management of exploitation and exploration in accordance with the environment show volatility in their R & D investment. R & D persistency occurs where firms fail in their top management governance and, therefore, cannot achieve proactive management. From an empirical analysis of 10,996 US manufacturing firms from 1997 to 2006, firms with volatility in R & D investment every year showed higher growth.

Many empirical studies also suggest R & D volatility occurs from

[1] Asset-counted R & D investment is a development activity that expects a concrete outcome. Therefore, asset-counted R & D investment is considered an intangible assets in the balance sheet. However, as an investment during the stage with unpredictable outcome, cost-counted R & D investment is considered a cost. As intangible assets have greater effect on firm economic value, firms tend to minimize the volatility of asset-counted R & D investment because it results in greater opportunity costs.