

# EFFECTS OF GOVERNMENT R&D GRANTS ON IT ENTREPRENEURIAL FIRM PERFORMANCE: A NEW PERSPECTIVE ON EXPLORATION VS. EXPLOITATION

*Research-in-Progress*

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## **Abstract**

*Governments keep subsidizing R&D of IT entrepreneurial firms greatly. However, the effect of these grants remains unclear. Acknowledging this gap, this study provides a nuanced perspective to understand the influence of government R&D grants on IT entrepreneurial firm performance. Based on the literature on organizational learning, we categorize government R&D grants into two types: explorative vs. exploitative. Moreover, drawing on resource complementarity theory, we articulate how the two types of government R&D grants interact with firms' private R&D resources. In particular, we hypothesize that in the innovation stage, government explorative R&D grants complement a firm's internal exploration in influencing innovation performance, but substitute a firm's external exploration. We further posit that in the commercialization stage, government exploitative R&D grants complement a firm's innovation performance and internal exploitation in impacting financial performance, but substitute a firm's external exploitation. We advance a theory of public-private R&D interaction for IT entrepreneurial firms.*

**Keywords:** Government R&D grants, IT Entrepreneurship, exploration, exploitation, innovation

## **Introduction**

Governments around the world often subsidize IT entrepreneurial firm's R&D to promote technological and economic growth in their countries (Cumming 2007; Davidson and Segerstrom 1998). For example, in 2009, U.S. government invested more than \$26.9 billion to over 112,500 entrepreneurial firms through the Small Business Innovation Research (SBIR) program, with major focus on IT industry (The United States Government 2012). Similarly, in China, about 55% (\$36 billion) of high-tech R&D expenditure in 2008 came from government-subsidized programs, such as Innovation Fund for Small Technology-Based Firms (InnoFund) (OECD 2008), half of which has been allocated to IT industry (The Ministry of Science and Technology of China 2009). Despite the tremendous amount of government R&D grants awarded to IT entrepreneurship, the effect of government R&D grants remains unclear (OECD 2008).

Scholars, policy makers, and entrepreneurs have long tried to understand how government R&D grants influence IT entrepreneurial firm performance in terms of innovation and profits (Lerner 1999). Unfortunately, prior studies that examined the effect of government R&D grants have produced inconclusive results (David et al. 2000). Some believe that government R&D grants would stimulate firms' private R&D expenditure and lead to more R&D outputs, as government grants induce firms to invest in projects that they may not invest otherwise (Czarnitzki and Licht 2006; Gonzalez et al. 2005). Others, however, argue that government R&D grants would substitute private R&D expenditure in producing outcomes (Levy and Terleckyj 1983; Wallsten 2000). For example, Lerner (1999) suggests that government R&D grants may be exploited by the interest groups or politicians, which decreases the expected positive effects. Wallsten (2000) further found that government R&D grants crowd out firms' R&D expenditure.

Two possible explanations might account for the inconsistent results obtained in these earlier studies. First, prior studies have generally not systematically distinguished between government R&D grants at different foci of R&D activities and are thus at risk of aggregation bias. Ignoring the potential variance that exists across government R&D grants can lead to spurious results. Consequently, a more subtle understanding of the effect of government R&D grants necessitates a finer-grained analysis. We accomplish this by differentiating between two types of government R&D grants: grants to promote firms' searching of new product-market domains, namely, government explorative R&D grants, and grants to promote firms' improving of existing product-market positions, namely, government exploitative R&D grants. Given the distinct foci and objectives, these two types of grants are expected to influence IT entrepreneurial firm performance in different ways, as suggested by the exploration-exploitation framework of organization learning (Levinthal and March 1993; March 1991).

Second, the inconsistent results might be attributed to the complex interaction between government R&D grants (as public R&D resources) and firms' resources (as private R&D resources). According to the resource complementarity theory (Arora and Gambardella 1990; Hess and Rothaermel 2011), public resources might complement or substitute different types of firms' private resources, depending on the knowledge embedded in these resources. The public and private R&D resources cannot be fully understood if they are separately investigated (Hitt 2005). Nevertheless, very few prior studies have addressed the interdependence between public and private R&D resources (Mahoney et al. 2009). To advance this stream of research, we adopt an integrative lens by unveiling the complementary or substitutive relationships between public and private R&D resources.

Hence, this study aims to answer an important research question: How do the two types of government R&D grants (i.e. government explorative R&D grants and government exploitative R&D grants) interact with firms' private R&D resources in shaping firms' innovation performance and financial performance?

## Theoretical Development and Hypotheses

### **Government R&D Grants**

In recent years, a burgeoning literature has suggested the significance of having government R&D grants for IT entrepreneurial firms. Government R&D grants are typically public funds distributed by government to firms for conducting specific R&D activities and raising firms' private marginal rate of return in such activities (David et al. 2000). As the social returns to firms' R&D may exceed firms' private returns, government is therefore more interested than venture capitalists in supporting firms' R&D (Lerner 1999). The R&D outputs expected by government are therefore different from venture capitalists' expected outputs, which are purely economic benefits oriented. The major intention of government is to induce private R&D investment, encourage technology innovation, and eventually enhance economic development. Moreover, government grants serve as a certification or recognition for awarded firms to other potential investors (Lerner 1999). Despite these positive expectations, empirical studies on government R&D grants have generated conflicting results (David et al. 2000; Gonzalez et al. 2005).

Proponents of government R&D grants posit that government R&D grants can contribute by stimulating private R&D expenditure and providing additionality effects (Lerner 1999). Such additionality effects of government R&D grants on private firms' innovation input (i.e. R&D expenditure) and innovation output (i.e. patent applications) are found in the case of Western and Eastern Germany (Czarnitzki and Licht 2006). Moreover, researchers suggest that small firms may not have engaged in R&D activities in the absence of government R&D grants (Gonzalez and Pazo 2008).

Opponents, however, argue that government's overhead reimbursement on private R&D spending reduces private outlays instead of inducing more (Levy and Terleckyj 1983). Wallsten (2000)'s study on the Small Business Innovation Research (SBIR) program in the U.S. further showed that the grants do not affect R&D employment, but crowd out firms' private R&D spending dollar for dollar. In other words, government R&D grants failed to induce firms' R&D efforts.

We argue that the inconsistency of prior results could be partially attributed to the fact that different types of government R&D grants focus on different components of R&D activity chain and thus have distinct effects. To solve the puzzle, we categorize government R&D grants into sub-types. As the fundamental nature of R&D activity is organizational learning, we build on the literature on organizational learning, particularly, March (1991)'s exploration-exploitation framework, and distinguish between government explorative R&D grants and government exploitative R&D grants.

### **Government Explorative R&D Grants vs. Government Exploitative R&D Grants**

March (1991)'s framework of organizational learning has identified two components of the R&D activity chain: exploration and exploitation. Exploration is about search, risk taking, experimentation, flexibility, discovery, and innovation, while exploitation is about refinement, production, efficiency, selection, implementation, and execution (March 1991). This typology recognizes that firms emphasize different outcomes in different components of the R&D activity chain: some R&D activities are conducted to identify new opportunities and explore new technologies, while others are used to exploit existing technologies in order to leverage known opportunities (Hoang and Rothaermel 2010). In terms of government's focus on these two R&D components, government R&D grants can be categorized into two types correspondingly: government explorative R&D grants and government exploitative R&D grants.

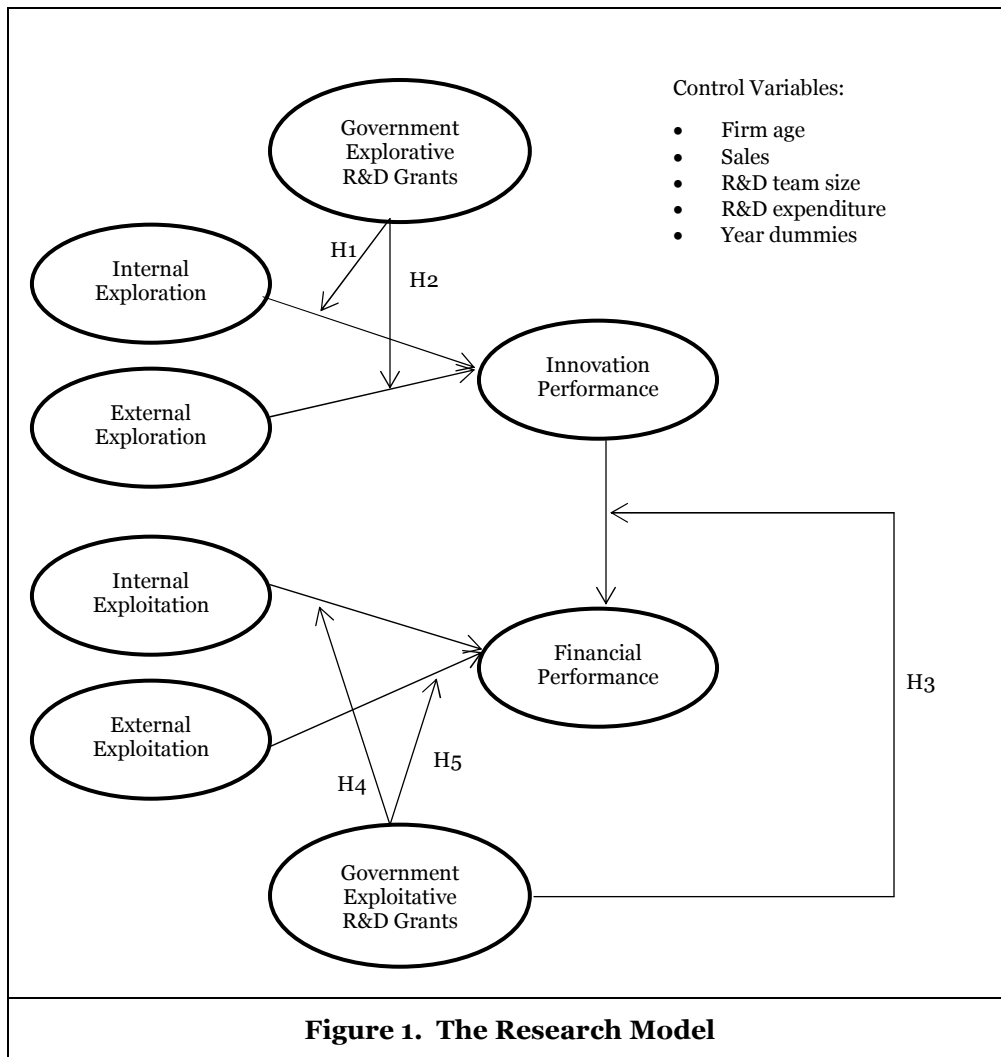
Government explorative R&D grants refer to the funds granted by government to induce firms' explorative R&D activities, typically developing new knowledge and technologies. For example, the U.S. Small Business Innovation Research (SBIR) program encourages small firms to engage in basic research (The United States Government 2012).

Government exploitative R&D grants refer to the funds granted by government to induce firms' exploitative R&D activities, typically commercializing new technologies and industrializing new products. For example, the U.S. Small Business Technology Transfer (STTR) program facilitates small firms to commercialize the innovations resulting from basic research (The United States Government 2012).

**A Unified View on Firm Performance: Public and Private R&D Resources**

In terms of firm performance, both innovation performance and financial performance of R&D are very important criteria for a firm’s R&D success (Cordero 1990; Hoang and Rothaermel 2010). Innovation performance is usually evaluated when a firm is exploring new knowledge at the innovation stage, whereas financial performance is evaluated when a firm is exploiting existing knowledge and realizing economic return at the stage of commercialization (Cordero 1990; Hess and Rothaermel 2011). Indeed, the stage of innovation and that of commercialization constitute the whole R&D activity chain.

As explained earlier, it will likely be futile to examine the effects of government R&D grants (i.e., public resources) on firm performance without considering their orchestration with a firm’s R&D resources (i.e., private resources). We herein introduce an integrative view by examining how explorative and exploitative government R&D grants moderate the relationships between firms’ R&D resources and firm performance, as shown in Figure 1. Since government explorative R&D grants focus on the development of new technologies, we argue that they will interact with a firm’s exploration activities in influencing firm performance at the innovation stage (i.e., innovation performance). Similarly, since government exploitative R&D grants are aimed to improve a firm’s commercialization of existing technologies, they are expected to interact with a firm’s exploitation activities in influencing firm performance at the commercialization stage (i.e., financial performance).



Moreover, as prior research on government R&D grants hints at the possibility of substitution between public and private R&D resources (Levy and Terleckyj 1983; Wallsten 2000), we mainly draw on the resource complementarity theory to examine the interaction mode of them at each stage. In general, resources/activities can be independent, complementary, or substitutive (Parmigiani and Mitchell 2009). Two types of resources/activities are complementary if doing more of one increases the marginal returns to the other (Milgrom and Roberts 1995). In contrast, if doing more of one reduces the marginal returns to the other, they are substitutive (Arora and Gambardella 1990; Hess and Rothaermel 2011). The complementary or substitutive relationship between bundles of R&D resources is a function of the sources of knowledge being combined (Hess and Rothaermel 2011).

In terms of differentiating the sources of R&D knowledge, prior research suggest two ways: by firm boundary (Cassiman and Veugelers 2006), and by value chain activities (Hess and Rothaermel 2011). By firm boundary, knowledge can be divided into internal and external knowledge. Cassiman and Veugelers (2006) suggest that firms' internal know-how increases the marginal return to external knowledge acquisition strategies. By value chain activities, knowledge can be divided into upstream and downstream knowledge. Hess and Rothaermel (2011) maintain that resources from different parts of the value chain are complements due to integration of non-redundant knowledge, whereas resources focusing on the same value chain activities are substitutes due to redundant knowledge.

Despite the wide empirical evidence available on the combination of different private R&D resources, the existing literature has paid little attention to the combination of public and private R&D resources. Drawing on resource complementarity theory, we propose a nuanced way to understand the combination of public and private R&D resources, particularly (1) the combination of government explorative R&D grants and firms' exploration at the innovation stage (complementarity by boundary), (2) the combination of government exploitative R&D grants and firms' innovation performance at the commercialization stage (complementarity by value chain), and (3) the combination of government exploitative R&D grants and firms' exploitation at the commercialization stage (complementarity by boundary).

**Innovation Stage.** As the innovation stage of R&D invites broad search of new knowledge, a firm's exploration is key to innovation performance. Two types of exploration have been identified by prior research: internal exploration and external exploration (Hoang and Rothaermel 2010). Internal exploration refers to a firm's engagement in basic research within its boundary, while external exploration depicts a firm's engagement in research alliance outside its boundary (Hoang and Rothaermel 2010). As both types of exploration strengthen a firm's absorptive capacity to accumulate cutting-edge knowledge, they are expected to contribute to firm's innovation performance (Frenz and Gillies 2009). Nevertheless, government explorative R&D grants will have opposing moderation effects on internal and external exploration.

The aim of government explorative R&D grants is to provide exploration-related resources and knowledge, such as external access to new basic knowledge, to foster firms' innovation. Internal exploration, however, serves as the major internal source of knowledge for exploration of IT entrepreneurial firms. According to the resource complementarity theory, a firm's internal knowledge resources usually complement external knowledge resources (Cassiman and Veugelers 2006). The exposure to novel learning contexts (e.g., government supported exploration) helps a firm broaden its search scope and thus enhances its capability to leverage the internal exploration. Hence, we propose that:

*H1: Government explorative R&D grants will amplify the positive effect of a firm's internal exploration on its innovation performance.*

On the other hand, external exploration provides firms with new knowledge that are originated outside firm boundaries. Firms uncover and share new knowledge with their upstream research partners (Hess and Rothaermel 2011; Rothaermel 2001). Similarly, government explorative R&D grants also provide firms with access to external new upstream knowledge. According to the resource complementarity theory, for two types of activities that provide the same resources, doing more of an activity to leverage the resource reduces the marginal benefit of the other (Arora and Gambardella 1990; Hess and Rothaermel 2011). Hence, government explorative R&D grants are expected to reduce the marginal benefit of firms' external exploration. We propose that:

*H2: Government explorative R&D grants will dampen the positive effect of a firm's external exploration on its innovation performance.*

**Commercialization Stage.** Along the R&D activity chain, a firm exploits its innovation outputs and introduces new products to market at the commercialization stage, in order to boost its financial performance. Although previous research suggested that innovation performance has a positive impact on firms' financial performance (Hill and Snell 1988; Rothaermel and Hill 2005), the effect of innovation on firms' financial performance cannot be examined alone. Instead, innovation outputs have to be "utilized in conjunction with other capabilities or assets" in generating economic returns (Teece 1986, p.288). These capabilities include marketing, manufacturing, and after-sales support, all of which are captured by exploitation (Teece 1986).

Exploitation also has internal and external sources (Hoang and Rothaermel 2010). Internal exploitation refers to a firm's engagement in technology commercialization within its boundary (Hoang and Rothaermel 2010). Internal exploitation capabilities have to be constantly updated to eliminate inefficiencies and allow firms to stay competitive in the industry (Zahra and Nielsen 2002). As a result, internal development of exploitation capabilities might be a costly and time-consuming process for IT entrepreneurial firms (Zahra and Nielsen 2002). Firms may seek external sources of exploitation capabilities, which are less costly and more flexible (Gil and De La Fe 1999). External exploitation refers to a firm's engagement in commercialization alliance outside its boundary (Hoang and Rothaermel 2010). As external exploitation strengthens a firm's capability to commercialize its innovation outputs, it is expected to contribute to the firm's financial performance (Frenz and Gillies 2009).

By and large, a firm's innovation performance, internal exploitation, and external exploitation together speak to a firm's financial performance. Similarly, we examine the moderation of government exploitative R&D grants on the relationships between these three factors and financial performance.

The aim of government exploitative R&D grants is to provide firms with funds and access to external knowledge to expedite the commercialization of innovations derived from the innovation stage. Activities from different components of R&D activity chain are generally complementary (Hess and Rothaermel 2011). The presence of extra exploitative resources (e.g., government supported exploitation) helps a firm realize the products through exploitation and thus strengthens the relationship between innovation performance and financial performance. We therefore propose that innovation performance and government exploitative R&D grants are complementary in shaping a firm's financial performance.

*H3: Government exploitative R&D grants will amplify the positive effect of a firm's innovation performance on its financial performance.*

On the other hand, a firm's internal and external exploitation are vital in its exploitation of knowledge. While internal exploitation depicts a firm's self-accumulated knowledge and competencies developed to realize economic returns, external exploitation expands a firm's exploitation capability by providing external resources to quickly realize profits from its innovations instead of handling them over to imitators. Given that government exploitative R&D grants denote external resources that help a firm better exploit innovations, they may partially overlap with the resources from external exploitation, thereby decreasing the marginal effect of a firm's external exploitation (Hess and Rothaermel 2011). In contrast, as the resources of government exploitative R&D grants and a firm's internal exploitation are rooted in distinct sources, they are expected to complement each other in shaping a firm's financial performance (Cassiman and Veugelers 2006). Hence, we propose:

*H4: Government exploitative R&D grants will amplify the positive effect of a firm's internal exploitation on its financial performance.*

*H5: Government exploitative R&D grants will dampen the positive effect of a firm's external exploitation on its financial performance.*

## Methodology

### Sample

We construct a unique panel dataset by utilizing the IPO prospectuses of listed IT firms in China that went public between 2009 and 2010. Our sampling frame is the WIND database, the mostly widely used database of Chinese public listed companies. China is chosen not only because it has issued tremendous government R&D grants to IT entrepreneurial firms (The Ministry of Science and Technology of China 2009), but also because IPO prospectus in China informs of how much government R&D grants a firm has received in the past 3 years before IPO. Hence, IPO prospectus of IT entrepreneurial firms in China becomes a public secondary data source suitable for our study.

Since IT entrepreneurial firms are defined as those young firms that discover, evaluate, and exploit opportunities of information technologies to create new goods and services (Shane 2000), only IT firms listed in China's SMEs board (for small and medium enterprises) and second-board market (China's Nasdaq for entrepreneurial firms) are selected. Moreover, only the listed firms that went public from 2009 to 2010 are chosen because the IT industry in China grew much faster since 2009 and data from recent years is much more reliable.

Based on the procedure described above, a list of 106 IT entrepreneurial firms is generated. We download these firms' IPO prospectuses from the WIND database. Besides depicting IPO outcomes, a typical IPO prospectus reports a 3-year window of information about a firm before IPO. We collect all information of firms from these IPO prospectuses, including firm characteristics and government R&D grants received.

### Measurement

Consistent with prior research (Hillman 2005; Rothaermel and Hill 2005), our dependent variable, firms' *financial performance*, is measured by a reflective construct composed of two items: annual ROA and ROE in each year during the 3 years before IPO as well as the IPO year (hereafter, in each year). While ROA measures the profitability of a firm relative to its total assets, ROE measures the profitability of a firm by revealing the portion that is generated from shareholders' investment. These two items are often highly correlated and supplement each other in reflecting the financial performance of a firm.

As for firms' *innovation performance*, prior research suggests that the number of patent applications can be a good proxy (Ahuja 2000; Rothaermel and Hess 2007; Stuart 2000). Hence, we code the number of patent applications of a firm in each year (including the 3 years before IPO and the IPO year) to measure the firm's innovation performance.

Government R&D grants is computed using the disclosed information of government R&D grants that a firm received in each year. Each time a firm received a government R&D grant, we code the purpose of the grant and the amount of it. If the purpose of a government R&D grant is to help a firm explore new knowledge (e.g. research, discovery, exploration), it is coded as *government explorative R&D grants*. If its purpose is to help a firm commercialize and industrialize existing knowledge (e.g. exploitation, commercialization, industrialization), it is coded as *government exploitative R&D grants*.

Following prior research, a firm's *internal exploration* is measured by its past internal R&D efforts (Hoang and Rothaermel 2010). In particular, it is assessed by the cumulative number of R&D projects that a firm initiated in each year. Similarly, a firm's *external exploration* is measured by its past R&D alliance (Hoang and Rothaermel 2010). In particular, it is assessed by the cumulative number of R&D alliance projects that a firm had with universities and other research institutions in each year.

Consistent with prior research, a firm's *internal exploitation* is measured by the percentage of sales derived from existing core technologies in each year (Hoang and Rothaermel 2010). Its *external exploitation* is assessed by the percentage of outsourcing manufacturing cost in the total operating cost of a firm in each year.

In addition, we include a detailed set of additional control variables to account for potential heterogeneity at the firm level: firm age, sales, R&D team size, R&D expenditure, and year dummies (Gulati and Higgins

2003; Higgins and Gulati 2006; Stuart et al. 1999). The unique panel dataset described above is under construction, and will be analyzed soon.

### ***Estimation Procedure***

Hypotheses 1 and 2 will be estimated using negative binomial regression since the dependent variable (i.e., the number of patent applications) is a count variable that can only take on nonnegative integer values (Hess and Rothaermel 2011). Moreover, to reduce unobserved heterogeneity, we will apply a Hausman specification test, and conduct either a fixed-effects or random-effects specification based on the results of Hausman test. In the same vein, Hypotheses 3 to 5 will be estimated using regression with either a fixed-effects or random-effects specification based on the results of Hausman test.

Apart from reducing unobserved heterogeneity, we further attempt to dispel any concerns regarding other potential endogeneity. Some may wonder whether an IT entrepreneurial firm may engage in exploration/exploitation and gain superior performance due to its policy alignment propensity (i.e., the propensity to align with the government policy to gain government R&D grants). To address this issue, we will employ 2SLS (two-stage least squares) regression using IV (instrumental variables) estimation. Suitable instruments would be exogenous factors that are correlated with firms' exploration/exploitation but uncorrelated with the error term of innovation/financial performance. In particular, we select *R&D organization structure* as the instrument variable. Following Argyres and Silverman (2004), we code each firm as having a centralized, decentralized, or hybrid R&D organization structure, based on the organizational structure figure disclosed in IPO prospectus. On the one hand, R&D organization structure influences the search breadth and depth of a focal firm (Argyres and Silverman 2004), which in turn determine exploration/exploitation activities (Katila and Ahuja 2002). On the other hand, R&D organization structure is unlikely associated with the number of patent applications or ROA/ROE since there is no general superiority of one R&D structure over another (Argyres and Silverman 2004). Therefore, R&D organization structure is a good instrument for controlling the potential endogeneity issue due to policy alignment propensity.

### **Conclusion**

This study examines the effects of two types of government R&D grants (explorative vs. exploitative) on IT entrepreneurial firms' innovation and financial performance. We propose that government explorative R&D grants interact with firms' internal and external exploration in affecting firms' innovation performance, while government exploitative R&D grants interact with firms' innovation performance, internal exploitation, and external exploitation in shaping firms' financial performance.

### ***Potential Theoretical Contribution***

This study makes several potential theoretical contributions. First, this study builds theoretical underpinnings with tenets from the literature on organizational learning and resource complementarity theory to investigate the role of government R&D grants. This is critical because the body of literature on government R&D grants tends to lack theoretical depth (David et al. 2000). By providing value-laden arguments with strong theory basis, this study adds great value to the literature on public policy.

Second, most previous research has regarded government R&D grants as a generic concept. They did not distinguish among different types of government R&D grants, nor did they examine the effect of each type. However, different types of government R&D grants, as shown in our proposed study, may affect IT entrepreneurial firm performance in different ways. Our research takes an initial step to systematically dichotomize government R&D grants into two types – explorative and exploitative. It opens the black box of government R&D grants, thereby sharpening our understanding of the complex effects of government R&D grants. To our best knowledge, this is the first study to examine the effect of each type of government R&D grants on IT entrepreneurial firm performance.

Third, scholarship (including IS fields) is increasingly interested in the complex interdependences between private and public resources (Mahoney et al. 2009). However, quite scarce studies have investigated the interaction between the two (Walsham et al. 2007). Most prior studies focus on either



public (i.e., government R&D grants) or private resources (i.e., firms' exploration and exploitation). Our research goes beyond past research by advancing a theory of public-private R&D interaction (Mahoney et al. 2009). To do so, our study looks simultaneously at government explorative and exploitative R&D grants as well as firm's exploration and exploitation to understand the success of IT entrepreneurial firms.

Finally, it enriches the growing research in IT entrepreneurship strategy by developing a contingency perspective on private and public R&D resources. Drawing on the resource complementarity theory, this study compares the different moderation effects of government explorative and exploitative R&D grants along the R&D activity chain. These interesting hypotheses complete our understanding by providing a nuanced perspective on how different public R&D resources modify the effects of different private R&D resources (Whetten 1989).

### ***Potential Practical Contribution***

This study also has important potential practical implications. First, it provides insights to governments that have significantly invested in IT entrepreneurial firms but have yet to see the clear effect of their investment. Our study demonstrates how government R&D grants interact with firms' private resources along the R&D activity chain and result in different outcomes. More specifically, it suggests to governments how different types of grants could help different activities of entrepreneurial firms and which type of grants turn out to be more effective at different stages of R&D. Based on our study, governments could refine the grant selection criteria of firms to increase effectiveness of grants' utilization and therefore accelerate the pace of economical development of their country and society.

Second, this study provides valuable knowledge to IT entrepreneurial firms that have received significant amount of government grants but have yet to maximize their usage. IT entrepreneurial firms have limited access to resources. Therefore, government grants, as a significant portion of public resources, become very critical to them. If firms are able to fully utilize these resources to the greatest potential, they are capable of achieving superior performance and outperform others in the extremely competitive environment. Our study offers insights on how to fully utilize government resources by better understanding different types of private and public resources as well as their interaction effects.

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